Development of a scientific attitude measurement instrument for Dharmacariya department students at STABN using the Fishbein and Ajzen model

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ABSTRACT

This study applies the Fishbein and Ajzen model to develop a Scientific Attitude Measurement Instrument for Students, focusing on attitudes, beliefs, and intentions towards scientific behaviors. The quantitative research employs an instrument development method, initially constructing dimensions reflecting various scientific attitudes such as attitudes towards the scientific method, collaboration, openness to knowledge, criticality, respect, honesty, independence, and interest in data analysis. The instrument measures students' scientific attitudes across three main dimensions: attitude, subjective norms, and behavioral control, aligning with the Fishbein and Ajzen model. It covers key aspects like attitudes towards the scientific method, emphasizing rigorous approaches like Popper's Falsification concept, and the importance of social interaction in scientific collaboration. Validity and reliability analyses confirm the instrument's adherence to high-quality standards, making it relevant for assessing scientific attitudes and contributing to educational quality and student development in science. It provides a comprehensive view of students' perceptions and responses to scientific attitudes. Factor Loadings in the Rotated Component Matrix, with loadings above 0.50, indicate a strong correlation within the model. Cronbach's Alpha values range from 0.922 to 0.941, ensuring internal consistency and reliability. Exploratory Factor Analysis with student participants established the construct's validity and reliability, with a Kaiser-Meyer-Olkin (KMO) value of 0.747, indicating suitability for factor analysis. Most items showed high analytical validity, but items B22 and B13 require further review or adjustment.

INTRODUCTION

Students' scientific attitude is a pivotal factor in determining the quality of higher education in addressing the intricate demands across various academic and professional fields (Osborne et al., 2003a). Scientific attitude encompasses the integration of thinking processes used to comprehend issues with observation or inquiry procedures, followed by formulating scientific hypotheses, and testing these hypotheses to seek solutions to a given problem. (Zulkipli et al., 2020). According to Balbi et al. (2022), with the rapid advancements in technology and information, students must possess a robust scientific attitude to complex research, learning, and intellectual development challenges. Dewi (2016) elucidated that a scientific attitude is one of the keys to success in learning and personal development. Students with a scientific mindset find it easier to learn new concepts and solve problems (Sakliressy et al., 2021). Additionally, students with a scientific disposition tend to be more critical, and objective, and uphold greater integrity (Koballa & Glynn, 2013).

Scientific attitudes drive students to cultivate critical and analytical skills essential for evaluating the information they encounter during their studies (Wildan et al., 2019). In an age rife with easily accessible online information, students must discern valid from invalid content. Those with a scientific attitude are better equipped to tackle myriad challenges. They learn to view problems from various angles, hypothesize, and derive solutions based on evidence and data. A scientific attitude provides a sturdy foundation for ongoing learning since it propels students to assimilate external knowledge and actively seek, test, and deepen their understanding.

Furthermore, a scientific attitude fosters a more critical stance toward statements or views encountered daily. Scientifically inclined students tend to question information before accepting it as the absolute truth (Sharon & Baram-Tsabari, 2020). They display greater objectivity when understanding others' perspectives, endeavoring to perceive an issue from multiple vantage points before concluding. This inclination helps students sidestep hasty judgments or preconceived notions and urges them to seek robust evidence and arguments before making decisions or staking out positions. Thus, a scientific attitude fosters individuals more amenable to critical thinking, constructive debate, and devising superior solutions to society's complex challenges. Additionally, it enables students to make positive contributions in various academic and professional dialogues, enhancing the exchange of productive and sustainable ideas.

Yet, many students still need to fully grasp or internalize this attitude, which can hinder their academic and professional progression. This challenge often arises from curricula that insufficiently emphasize cultivating a scientific disposition, a lack of education on research ethics, or limited access to resources and opportunities to engage in scholarly projects (Noor, 2020). Furthermore, pressure to achieve specific academic milestones can divert focus from the essential development of a scientific attitude, which should be higher education's primary emphasis (Oviyanti, 2016). Students often fall into the trap of viewing academia merely as a task-completion exercise, rather than genuinely appreciating the scientific learning process. A deficient supportive academic environment and inadequate educators skilled in fostering a scientific attitude can also be barriers. Students without ample guidance may feel lost or unmotivated to nurture a scientific outlook.

The higher education curriculum does not sufficiently stress the significance of nurturing a scientific disposition (Dewi & Dantes, 2023). An excessive emphasis on imparting information or mastering specific subjects can overshadow the development of critical and analytical skills (Hayati, 2020). Moreover, research ethics play a vital role in nurturing a proper scientific attitude, and insufficient education about conducting research with integrity and respecting others' intellectual property can lead to harmful ethical violations for both the individual and the academic community (Bell & Bryman, 2007).

Students often lack ample access to resources and opportunities to engage in research and scholarly projects (Febrianti & Silvia, 2021), impeding the development of practical skills essential for assimilating a scientific attitude. Therefore, understanding the scientific attitude becomes imperative to pinpoint the factors influencing students' scientific inclinations and devise strategies to enhance them.

A way to identify a scientific attitude is through valid and reliable measurement tools (Hillman et al., 2016). Developing an assessment instrument for this attitude is a strategic step in gauging how deeply students or learners have internalized the values and perspectives underpinning scientific thought. Valid and reliable assessment tools accurately depict the extent to which students have incorporated a scientific attitude and the factors influencing its evolution. The instruments developed should be effectively implementable in higher education settings, making them applicable for measuring students' scientific attitudes across educational institutions. One such measurement instrument development model is the Fishbein & Ajzen (2021). This framework analyzes attitudes and behaviors based on beliefs, subjective norms,

and behavioral control. In the context of developing a scientific attitude assessment tool for students, it can assist in gauging the factors influencing their attitudes toward science and scientific methods (Summers & Abd-El-Khalick, 2018).

The research aims to develop a student scientific attitude measurement tool using the Fishbein and Ajzen model, covering multiple facets. Besides instrument development, this research can assist in identifying factors influencing students' scientific attitudes, like evaluative beliefs, normative beliefs, and control beliefs, in alignment with the Fishbein and Ajzen model. Additionally, this research aims to ensure that the instrument possesses high validity and reliability, instilling confidence that the tool truly and consistently measures the intended attributes.

RESEARCH METHOD

This study adopts a quantitative approach using a developmental method. The developmental research aims to create a measurement instrument based on the Fishbein & Ajzen Model to construct students' scientific attitudes. The development of this instrument seeks to systematically measure and identify variables within the context of scientific perspectives. The Fishbein & Ajzen Model, also known as the Planned Behavior Model, was chosen to provide a conceptual framework for understanding how an individual's attitudes form and influence behavior. To develop the student's scientific attitude assessment instrument, the Planned Attitude Model can be applied by identifying the primary variables relevant to scientific attitudes: attitude, Perceived Behavioral Control, and Subjective Norm (Wen et al., 2022).

The development of a scientific attitude assessment tool, guided by the Planned Attitude Model, adopts a structured scientific approach. Initially, this involves delineating the essential variables: attitude, perceived behavioral control, and subjective norm. Corresponding items are then meticulously crafted to effectively capture students' viewpoints, their perception of control, and the influence of societal norms. This nascent instrument undergoes a pilot phase with a targeted student group, a critical step for detecting and resolving potential issues. Subsequent phases encompass thorough data analysis for verifying the instrument's reliability and authenticity, augmented by expert feedback for further refinement. The process culminates in an extensive evaluation using a varied and larger student sample, ensuring the tool's relevance and effectiveness across diverse educational scenarios. This methodical and scientific procedure ensures the development of an instrument that is not only theoretically sound but also practically significant in educational research. The development of instruments in this study began with the creation of instrument items contained in Table 1. These items were designed to depict the extent to which students have a positive belief about the outcomes of adopting a scientific attitude, the area they feel societal pressure supporting a scientific perspective, and how much control they believe they have in applying a scientific philosophy in their academic activities.

After successfully constructing the instrument, the next step involved its developmental planning. This planning process included selecting potential respondents, composing the instrument's scale, and preparing the instrument's blueprint. The subsequent phase involved the initial product development of the instrument, which comprised item assembly and expert validation. Five experts contributed to this phase, including one in Psychology, two in Measurement and Evaluation, one in Education, and one in Research and Evaluation. These experts, encompassing measurement specialists, thought experts, and practitioners and cadres, played crucial roles. The expert assessment data were analyzed using Aiken's formula, with an instrument item deemed valid if the computed V-Aiken value exceeded 0.90 (Aiken, 2000; Azwar, 1997).

After expert validation of the instrument, the next step was a limited trial to gain insights into the instrument item's characteristics and to simplify them. The sample involved in this limited trial consisted of 44 students of Dharmacariya Department from STABN Sriwijaya. In this study, due to the highly specific nature of the population, the researcher was compelled to use a small sample, in line with the guidelines provided by Hoyle, R. H., & Kenny (1999). Data from this trial were analyzed using Exploratory Factor Analysis. The results from the limited trial could be further analyzed if they met the KMO-MSA criteria > 0.5. An instrument item was also deemed valid if its AIC and Factor Loading values were > 0.5. A broader scale trial aimed to validate the instrument and measure its reliability. An instrument item was considered valid if its factor loading value was > 0.3 and CR > 0.7 and was deemed reliable if the Cronbach's Alpha value was > 0.7 (Ghozali, 2016).

Table 1. Measurement Instrument Framework

Scientific Attitude Aspects	Attitude (Items)	Perceived Behavioral Control (Items)	Subjective Norm (Items)
Attitude towards the scientific method	The measurement instrument assesses the value of empirical evidence, the importance of replicability, and the belief in science as a knowledge system.	Ease of applying scientific methods	
Attitude on Scientific Collaboration			the impact of peer influence on collaboration and the role of cultural norms in shaping attitudes towards teamwork.
Attitude towards Openness to knowledge		An individual's confidence in sharing research findings and their ability to receive and process constructive criticism effectively.	Social support for open discussions
Criticality		Skills in critically evaluating sources, questioning assumptions, distinguishing facts from opinions, and analyzing data objectively.	
Respect & Scientific Honesty			The influence of ethical guidelines, expectations of honesty in reporting, and the pressure to adhere to ethical norms in scientific practice.
Independence in adopting a scientific attitude	Self-motivation in learning	The extent of control over learning choices, autonomy in exploring topics, and the ability to pursue independent research.	Influence of mentors or lecture
Interest in Data Analysis	Enthusiasm for data interpretation, curiosity in uncovering patterns, and engagement in critical thinking during analysis.	Accessibility of analysis tools and the perceived complexity of data analysis.	

FINDINGS AND DISCUSSION

Findings

This research commenced with developing the instrument's dimension construction for measuring Students' Scientific Attitude using the Fishbein and Ajzen Model. The initial step involved constructing the dimensions of the Fishbein and Ajzen model to comprehend human behavior based on attitude, subjective norms, and behavioral control. This process required an in-depth understanding of how attitude, subjective norms, and behavioral control are perceived to influence students' behavior regarding scientific attitudes. The formation of these dimensions is illustrated in Table 2. This step aided in identifying the primary dimensions to be measured in the students' scientific attitude measurement instrument. Each dimension encompasses relevant variables and indicators for its measurement. This was the foundation for developing questions or items within the measurement instrument.

Table 2. Distribution of Scientific Attitude Aspects

Scientific Attitude Aspects	Attitude	Perceived Behavioral Control	Subjective Norm
Attitude towards the scientific method	1,2,3	4	
Attitude on Scientific Collaboration			5,6
Attitude towards Openness to knowledge		7,9	8
Criticality		10,11,12, 17	
Respect & Scientific Honesty			19,20,21
Independence in adopting a scientific attitude	22	13, 14, 15	23
Interest in Data Analysis	16,18, 26	24, 25	

The construction of scientific attitude begins with the first aspect: attitude towards the scientific method, which relates to how an individual perceives and appreciates the scientific methodology in research. A pertinent theory is Popper's Falsification Falsification is an epistemological concept introduced by Karl Popper, positing that a scientific theory should be testable and potentially refutable. This underscores the importance of rigorous scientific methodology (Dochmie, 2018). The second aspect is the scientific collaboration attitude, referring to one's capability and willingness to collaborate with peers on scientific projects. (Sandi-Urena et al., 2012) emphasize the significance of social interaction and collaboration in classroom learning activities. The third is the Attitude towards Openness to Knowledge, reflecting the extent to which someone is willing to accept new ideas and change based on evidence. A related theory might encompass open-mindedness, illustrating an individual's ability to embrace new ideas without prejudice (Sandi-Urena et al., 2012).

Fourth, criticality is the critical attitude in science essential for carefully evaluating theories and evidence. Fifth, respect & scientific honesty pertains to research integrity and adherence to scientific ethical standards. A related theory might encompass Research Ethics, which considers the moral principles in research (Menapace, 2019). Sixth, independence in adopting a scientific attitude refers to taking initiative and acting independently in scientific research. This can be linked with the Theory of Independence in psychology, which explores an individual's motivation and capacity to function autonomously (Yang & Chen, 2023). Seventh, an interest in data analysis underscores the importance of critically analyzing data (Candera et al., 2021).

Following the establishment of measurement dimensions for developing student scientific attitude instruments with the Fishbein and Ajzen Model, a rater test was conducted

with expert assessments. Experts in this instrument assessment include measurement specialists and academics, consisting of five experts using V-Aiken. The Aiken validity is a tool utilized in social research contexts to assist researchers in evaluating the validity of questions used in questionnaires or survey instruments. The ratings provided by these experts are in the form of a Likert scale, ranging from one to five. After all evaluations are collected, the results can be used to measure the overall validity of the instrument or questions. Statements or questions receiving high scores are considered more valid, while those with low scores might. In the analysis, each item (from B1 to B26) represents a question or statement used in the measuring tool. The assessment results indicate that the lowest calculated V-Aiken value is 0.933, and the highest is 1.00. All instrument items are valid since the calculated V-Aiken value is > 0.75 (Azwar, 2012).

Table 3. Aiken Validity

Number of Items	V-Aiken Counted	Description	Number of Items	V-Aiken Counted	Description
B1	0,90	Valid	B14	0,90	Valid
B2	0,90	Valid	B15	0,91	Valid
B3	0,89	Valid	B16	0,90	Valid
B4	0,91	Valid	B17	0,90	Valid
B5	0,91	Valid	B18	0,90	Valid
B6	0,90	Valid	B19	0,89	Valid
B7	0,91	Valid	B20	0,90	Valid
B8	0,91	Valid	B21	0,90	Valid
B9	0,92	Valid	B22	0,90	Valid
B10	0,91	Valid	B23	0,91	Valid
B11	0,91	Valid	B24	0,91	Valid
B12	0,89	Valid	B25	0,91	Valid
B13	0,91	Valid	B26	0,90	Valid

In the Table 3, V-Aiken values above 0.75 indicate that all instrument items are considered sufficiently valid and reliable for data collection. This means that, according to the assessments of experts involved in the Aiken Validity assessment, the questions effectively measure the concept or variable.

Subsequently, following the validation of V-Aiken, the measurement items were distributed to 55 student respondents to confirm construct validity and reliability. In the validity analysis of this study, Exploratory Factor Analysis is used, which aims to test the extent to which the indicators within the variable are still consistent with the factors identified or expected in the proposed model. In this context, "consistency" refers to how the indicators genuinely measure or represent the concept or factors intended in the model.

This process often involves testing the proposed confirmatory factor model against empirical data from the study or research. The goal is to examine how much the model aligns with the available data. The results can indicate whether the indicators used in the model are still relevant and aligned with the proposed factors. If the Exploratory Factor Analysis results show that the indicators are no longer consistent with the intended factors, it may be necessary to consider adjustments or modifications to the model. This is crucial to ensure that the model used in the Exploratory Factor Analysis provides an accurate representation of the concepts under investigation.

Exploratory Factor Analysis (EFA) was utilized in this study to investigate the underlying structure of the assessment instrument. This method identifies the potential factors that represent the correlations among the items. The V-Aiken values, ranging from 0.89 to 0.92 for items B1 to B26, confirm the high validity of each item within the instrument. Expert assessments in the Aiken Validity analysis suggest that the questions effectively capture the

intended concepts or variables. Subsequent to this validation, the items were administered to 55 student respondents to further establish construct validity and reliability.

EFA aims to uncover the latent structures within the data set, exploring the possible dimensions that reflect the constructs being measured. It provides an understanding of how the indicators relate to one another and to the underlying factors they are intended to measure. This process is critical for ensuring that the instrument accurately reflects the theoretical constructs it aims to assess. Disparities or unexpected factor loadings may indicate the need for further refinement of the instrument, including revisiting the items, modifying the structure, or reassessing the theoretical underpinnings. The overall validity and reliability of the research are contingent upon the accuracy with which the model reflects the intended constructs. While individual item validity provides a solid starting point, the coherence of these items within the overall structure is crucial for the instrument's effectiveness in assessing the intended concepts. Therefore, a well-aligned structure, as revealed through EFA, is essential for confirming the instrument's efficacy.

Table 4. The results of the Exploratory Factor Analysis

Exploratory Factor Analysis	Result
KMO-MSA	0,747
Approx. Chi-Square	703,716
df	325
Sig.	0,000

The Kaiser-Meyer-Olkin (KMO) value is used in factor analysis to assess whether the data is suitable for factor analysis. The KMO value ranges from 0 to 1. A higher KMO value indicates better suitability of the data for factor analysis. The KMO value obtained from the measurement results, which is 0.747, indicates that the data is sufficiently suitable for factor analysis.

Table 5. Measure of Sampling Addequency

Item	Anti-image Correlation	> 0,5	Item	Anti-image Correlation	> 0,5
B1	0,878a	Valid	B14	0,860a	Valid
B2	0,797a	Valid	B15	0,741a	Valid
B3	0,793a	Valid	B16	0,807a	Valid
B4	0,741a	Valid	B17	0,724a	Valid
B5	0,829a	Valid	B18	0,825a	Valid
B6	0,790a	Valid	B19	0,805a	Valid
B7	0,742a	Valid	B20	0,785a	Valid
B8	0,850a	Valid	B21	0,642a	Valid
B9	0,782a	Valid	B22	0,445a	Invalid
B10	0,907a	Valid	B23	0,501a	Valid
B11	0,718a	Valid	B24	0,859a	Valid
B12	0,775a	Valid	B25	0,792a	Valid
B13	0,411a	Invalid	B26	0,784a	Valid

A high Anti-image Correlation value or Measure of Sampling Adequacy (greater than 0.5) indicates that an item is suitable for analysis, while a low MSA value (less than 0.5) suggests the thing is not applicable. Related variables may need to be removed, or the analysis should be repeated with a larger or more appropriate sample. Furthermore, in factor analysis,

the Factor Loading Rotated Component Matrix or Principal Component Analysis (PCA) is carried out to identify patterns of relationships among various variables or indicators within the data. The primary purpose of PCA is to reduce the dimensionality of the data by combining interrelated variables into main components that are linearly independent. PCA represents as much variation as possible in the original data with fewer components. Therefore, PCA can help identify the underlying factors or dimensions of the data. In addition, this analysis employs varimax rotation, a factor rotation method used to enhance the interpretability of factors. This rotation maximizes the squared variance of factor loadings, making factor loadings larger or closer to zero.

Table 6. Factor Loading Rotated Component Matrix[a]

Item		Component
B1	0,523	
B2	0,691	Attitude towards scientific
B3	0,529	methods
B4	0,803	
B5	0,715	Attitude towards scientific
B6	0,624	collaboration
B7	0,728	Attitude towards openness to
B8	0,520	knowledge
B9	0,589	
B10	0,815	
B11	0,712	Criticism
B12	0,571	
B17	0,745	
B13	0,808	
B19	0,803	Respect and Scientific
B20	0,763	Integrity
B21	0,555	
B14	0,596	
B15	0,750	Independence in Scientific
B22	0,843	Attitude
B23	0,513	
B16	0,751	
B18	0,573	
B24	0,687	Interest in Data Analysis
B25	0,560	
B26	0,609	

Extraction Method: Principal Component Analysis,
Rotation Method: Varimax with Kaiser Normalization,
a, Rotation converged in 9 iterations,

The rotated component matrix table indicates that all indicators have factor loadings greater than 0.50 and are grouped within a single factor, suggesting that the indicators used are consistent within that variable. Factor loadings exceeding 0.50 indicate a strong relationship between the indicators and the formed factor. When indicators are grouped within a single factor, all original variables exhibit high consistency in measuring the same factor. This can be interpreted as all indicators contributing uniformly to the formed factor. Overall, the results of this analysis demonstrate that all hands are consistent in measuring a single solid factor, and these factors can be well interpreted within the context of the data analysis conducted.

After establishing construct validity, the next step involves assessing the reliability of the items using Cronbach's Alpha. Cronbach's Alpha measures the reliability or internal consistency of a measurement instrument or scale employed in research or assessment. It quantifies the extent to which various items or questions within the measurement tool consistently measure the same concept or characteristic being assessed. Values above 0.70

indicate good reliability, though a value of 0.60 may also be acceptable depending on the research context (Mardapi, 2014).

Table 7. Cronbach's Alpha

Item	Cronbach's Alpha	Item	Cronbach's Alpha
B1	0.923	B14	0.923
B2	0.927	B15	0.924
B3	0.924	B16	0.923
B4	0.923	B17	0.926
B5	0.924	B18	0.923
B6	0.925	B19	0.926
B7	0.924	B20	0.926
B8	0.924	B21	0.926
B9	0.926	B22	0.929
B10	0.924	B23	0.929
B11	0.925	B24	0.924
B12	0.925	B25	0.922
B13	0.941	B26	0.924

The Table 7 contains two columns, each containing items (B1 to B26) and their corresponding Cronbach's Alpha values. The Cronbach's Alpha values displayed to the right of each item reflect how much the item correlates or is consistent with other items within the same measurement instrument. The higher the Cronbach's Alpha value, the better the reliability of the measurement instrument. From the table, all items (B1 to B26) have high Cronbach's Alpha values ranging from 0.92 to 0.94. This indicates that the measurement instrument or scale used exhibits very strong internal consistency, and its items can measure the desired variable or construct. This suggests that the measurement instrument can be relied upon to measure the variable or concept under investigation. High reliability indicates that the measurements obtained are dependable and can be well interpreted. Therefore, the results of this analysis support the internal validity of the measurement instrument used in the research or assessment.

Discussion

The development of a measurement instrument for assessing students' scientific attitudes, grounded in Fishbein and Ajzen's model and fulfilling stringent criteria for content validity, construct validity, and reliability, yields a reliable instrument for empirical research or evaluative studies concerning students' scientific attitudes (Banjarnahor, 2021). Regarding relevant research in this area, studies have been conducted that align with the development of such measurement instruments. For instance, there has been work on the modified Attitudes Toward Science Inventory (mATSI), which is a streamlined and validated version of the original Attitudes Toward Science Inventory. This instrument, initially developed for elementary school children, has been widely used in student science attitude research due to its validity and reliability across various demographic groups. It includes subscales such as perception of the teacher, anxiety toward science, and value of science to society (Tai et al., 2022).

This instrument serves as a pivotal tool for the precise quantification and comprehension of their scientific outlooks, thereby informing superior decision-making processes and curriculum enhancement. According to preliminary investigations, the instrument gauges seven key facets of scientific attitudes: disposition towards the scientific

method, inclination for scientific collaboration, receptiveness to scientific knowledge, criticality, ethical integrity and respect within a scientific context, autonomy in manifesting a scientific stance, and enthusiasm for data analytics. The measurement incorporates the dimensions elucidated by Fishbein and Ajzen: namely, 'Attitude,' 'Perceived Behavioral Control,' and 'Subjective Norm.' Employing a valid and reliable metric of this nature allows for a nuanced analysis and understanding of the evolution of students' scientific attitudes, which reciprocally contributes to elevating the quality of educational programs and fostering students' potential in scientific endeavors.

In the Fishbein and Ajzen model, attitude is conceptualized as an internal evaluation that reflects an individual's affective disposition, whether positive or negative, towards a specific behavior. For scholarly enrichment, the Fishbein and Ajzen model forms an integral part of the Theory of Planned Behavior, which extends from the Theory of Reasoned Action, offering key insights into the role of attitudes in shaping behavioral intentions and actions (Richard-Davis et al., 2022).

This attitude plays a pivotal role in various scholarly aspects, ranging from an individual's subjective perspective on the validity and relevance of scientific methodology, to the appraisal of the significance of collaboration in research activities, and to the willingness to share and assimilate new knowledge. An analytical approach, known colloquially as criticalism, also constitutes an integral component of the scientific disposition, coupled with an appreciation for honesty and integrity in research. This is complemented by an individual's ability to independently defend their scientific viewpoints and a profound interest in data analysis.

Subsequently, there exists the dimension of Perceived Behavioral Control, which highlights how individuals perceive their ability to execute specific behaviors. This concept is integral to the understanding of human behavior within both social and scientific contexts. It speaks to the degree of ease or difficulty an individual believes they will encounter in acting, and this perception can significantly influence both their intention to engage in the behavior and the behavior itself. In the realm of scientific research, this concept is pertinent to the extent that it may influence a researcher's decision to embark on complex projects, collaborate with others, or explore novel methodologies.

Perceived Behavioral Control is a component of the Theory of Planned Behavior, formulated by Icek Ajzen, which argues that an individual's intention to perform a behavior is a function of their attitude towards that behavior, subjective norms, and perceived behavioral control (Kaur & Singh, 2023). In the development of scientific understanding, students apply a scientific attitude in their studies and research. Equally important is the construct of subjective norms, which refers to an individual's perception of social pressure to perform or avoid a particular behavior (Humida et al., 2022).

Within the setting of a scientific attitude, this concept closely relates to how students view the expectations from peers, mentors, and the broader scientific community concerning what is considered to be an ideal scientific attitude (Kim et al., 2021). The concept of subjective norms acts as a social mechanism that shapes and is shaped by collective beliefs, which in turn influences individual actions and motivations (Barbera & Ajzen, 2020). In academic settings, this social factor can have a profound impact on research culture, affecting decisions such as whether to engage in collaborative work, to adopt particular methodologies, or to pursue certain lines of inquiry. The interplay between subjective norms and scientific attitude manifests in nuanced ways (Barbera & Ajzen, 2020). For example, if the scientific community highly values transparency and data sharing, students who are socialized into this community are more likely to adopt these norms. Conversely, in environments where competition and secrecy are the norm, a scientific attitude may veer towards individualism and proprietary control over information.

The development of the scientific attitude encompasses several key elements (Osborne et al., 2003b) . First, there is the attitude towards the scientific method, which reflects one's views and appreciation for research methodology (Hjerm et al., 2020). This is grounded in Popper's concept of Falsification, emphasizing the importance of testing and the refutability of scientific theories. Second, the scientific collaborative attitude describes the capability and willingness to collaborate on scientific projects, focusing on social interaction and teamwork in learning (Sandi-Urena et al., 2012). Third, openness towards science reflects readiness to accept new ideas and change based on evidence, with reference to open-minded thinking (Sandi-Urena et al., 2012). Fourth, criticalism is a crucial attitude in carefully evaluating theories and evidence (Nicol, 2021). Fifth, respect and scientific honesty encompass integrity in research and adherence to scientific ethics, relating to research ethics principles (Menapace, 2019). Sixth, independence in scientific attitude involves the ability to take initiative and act independently in research, linked to the concept of autonomy in psychology (Percy et al., 2012). Lastly, interest in data analysis underscores the importance of critical data analysis skills (Candera et al., 2021).

Regarding the instrument's construction, Aiken's V analysis confirms both content and construct validity. Calculated Aiken's V values, ranging from 0.70 to 1.00 and exceeding the table Aiken's V threshold, ensure content validity by indicating alignment between aspects, indicators, and statements within the instrument (Shrotryia & Dhanda, 2019). Additionally, the construct validity is reinforced by the strong correlation observed between the instrument's measurements and the theoretical constructs they are intended to represent (Clark & Watson, 2019). This correlation underscores the instrument's ability to accurately capture the conceptual dimensions it purports to measure, thereby lending further credibility to its overall validity (Schnackenberg et al., 2021). Such robust validation processes are crucial in ensuring that the instrument is not only theoretically sound but also practically applicable in its intended field of research.

In terms of construct validity, factor loadings between 0.4 and 0.85, surpassing the 0.5 benchmark, validate the items and contribute to a robust construct. This is bolstered by a Rotated Component Matrix (RCM) value greater than 0.5, which endorses convergent validity, signifying that the unobservable latent variables are accurately measured through the item-instruments. Thus, the responses to these items authentically represent the intended construct variables. The factor loadings and RCM values in this research suggest that the responses to the items authentically represent the intended construct variables, thus providing a strong foundation for the validity of the constructs measured in this study (Kalpita, 2021). However, continual assessment and validation across different aspects of the study are essential for a holistic understanding and interpretation of the results (Rose & Johnson, 2020).

The instrument's reliability is further established, evidenced by a Cronbach's Alpha value exceeding 0.7. This indicates that the instrument maintains consistency and can reliably measure responses beyond the initial sample in developmental research (Aiken, 1985). These analytical outcomes underscore the instrument's theoretical and practical applicability in effectively capturing and representing scientific attitudes in broader research contexts.

The meticulous development and validation of this measurement instrument, anchored in the established theories of Fishbein and Ajzen and rigorously tested for content, construct validity, and reliability, represent a significant advancement in the field of educational research. It provides a comprehensive, reliable tool for the empirical examination and evaluation of students' scientific attitudes. This instrument, embodying a blend of theoretical robustness and practical applicability, stands as a testament to the ongoing evolution and sophistication in the measurement of educational constructs. Its deployment in diverse educational settings promises not only to enhance our understanding of students' scientific attitudes but also to contribute significantly to the shaping of more effective and responsive educational strategies and policies. The insights garnered from such instruments are invaluable in nurturing a

scientifically literate and critically thinking future generation, equipped to navigate and contribute to an increasingly complex and science-driven world.

CONCLUSION

The deployment of a 24-item student scientific attitude measurement instrument, developed using Fishbein and Ajzen's model, signifies an important step in the quantifiable assessment of student attitudes towards science. While the mechanism satisfies key criteria in terms of validity and reliability, it highlights two items needing refinement or removal. This raises important considerations about the ongoing validity and reliability of such measures, a point well-supported in psychometric literature. The construction of scientific attitude dimensions, such as attitudes towards the scientific method, scientific collaboration, openness to science, criticalism, respect, and scientific honesty, autonomy in holding a scientific stance, and interest in data analysis, allows for a nuanced understanding of the multi-faceted role of scientific attitudes in student development. These dimensions, underpinned by theoretical constructs like Popper's Falsification, open-minded thinking, and research ethics, encompass the pivotal elements of what constitutes a "scientific attitude." Fishbein and Ajzen's model traditionally includes three main dimensions: 'Attitude,' reflecting an individual's positive or negative evaluations of a particular behavior; 'Perceived Behavioral Control,' relating to one's belief in their ability to perform a specific behavior; and 'Subjective Norm,' describing the social pressure one feels to engage or not engage in a conduct. In the context of scientific attitudes, Perceived Behavioral Control could potentially be linked to students' belief in their capability to apply a scientific approach in their research activities. On the other hand, 'Subjective Norm' could relate to how students view the expectations from peers, mentors, or the scientific community concerning an ideal scientific attitude. These components collectively highlight crucial elements such as Popper's Falsification, social interaction, open-minded thinking, research ethics, autonomy in psychology, and data analysis skills. Given its strong content and construct validity, confirmed through a rigorous statistical analysis, as well as its high reliability, as evidenced by a Cronbach's Alpha value > 0.7, this instrument stands as a potential cornerstone in efforts to enhance educational quality and foster student potential in the scientific domain.

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