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Psychometric Examination of the QUEST-25: An Online Assessment of Intellectual Curiosity and Scientific Epistemology

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Abstract**—**The current study reports an examination of the QUEST-25 (Q-Assessment of Undergraduate Epistemology and Scientific Thinking) online version for assessing the dispositional attitudes toward scientific thinking and intellectual curiosity among undergraduate students. The QUEST-25 consists of scientific thinking (SIQ-25) and intellectual curiosity (ICIQ-25), which were correlated in hypothesized directions with the Religious Commitment Inventory, Curiosity and Exploration Inventory, Belief in Science scale, and measures of academic self-efficacy. Additionally, concurrent validity was established by the resulting significant differences between those identifying the centrality of religious belief in their lives and those who do not self-identify as being guided daily by religious beliefs. This study demonstrates the utility of the QUEST-25 for research, evaluation, and theory development.

Keywords**—**Guided-inquiry learning, intellectual curiosity, psychometric assessment, scientific thinking.

I. Introduction

EPISTEMOLOGY is a specialty of philosophy that examines the nature of knowledge and how it is knowable. “What is knowledge?" “How do we know?” These are higher-level questions that undergraduate students should be asking in preparation for their academic and professional lives, yet pedagogically we focus too often on facts, methods, and skills. A crucial constituent of the “scientific mind” is intellectual curiosity, defined long ago as the "drive to know" [1]. Once an individual envisions what is knowable and how to know it, one must be motivated to know. This is the essence of being a scientist. Research has demonstrated these dispositions toward scientific thinking and curiosity can be developed from elementary to higher education [2], [3].

The purpose of the current study was to validate the online version of the Q-test of Undergraduate Epistemology and Scientific Thinking (QUEST) [4]: a new measurement of intellectual curiosity and dispositions toward scientific epistemology. The QUEST utilizes Q-sort methodology [5], requiring respondents to rate how each of 38 statements describes them in a forced distribution resulting in a total score for Scientific Thinking and Intellectual Curiosity. The major benefit of using this approach to assessing epistemological dispositions is its capability of accounting for the relative valence of beliefs and attitudes. Certain beliefs/attitudes of a person are more central to their identity formation than others. The Q-sort methodology, utilized by QUEST, mirrors this relative importance of defining dispositional identity by requiring respondents to define which statements describe them more or describe them less than other statements.

Problem-based learning (PBL) is a pedagogical approach that has proven successful for improving student outcomes across multiple fields. Arguably, the greatest impact of PBL on students is to develop and instill a “disposition-to-inquiry.” Often linked to lifelong learning, a disposition is defined by Webster’s Dictionary as “prevailing tendency, mood, or inclination; temperamental makeup; the tendency of something to act in a certain manner under given circumstances.” [6]. This disposition to inquiry is constituted by two fundamental elements: (1) Scientific Epistemology and (2) Intellectual Curiosity. In order to fully evaluate the impact of PBL on student development and success, it is necessary to reliably and validly measure disposition-to-inquiry. The QUEST-25 represents the only measurement of the two constituent components, scientific epistemology and intellectual curiosity, which constitute a disposition-to-inquiry.

PBL is an approach to education that is student-centered, requiring learners working in small groups to solve problems which do not have defined solutions [7]. PBL is designed to increase knowledge in a content area by the process of asking questions, collecting and analyzing data, and then arriving at solutions based on evidence and hypothesis testing [8]. This is exactly the process that scientific scholars use regularly. To fully engage in the PBL process, it is necessary for learners to develop a scientific mind including seeking robust questions about the topics being examined. Fostering intellectual curiosity is a central feature of the lifelong learning goals of PBL. By nurturing curious learners who utilize critical analysis based on evidence to solve problems throughout their lives, the PBL approach influences student outcomes well beyond traditional student success measures [9]. These broader student outcomes must be measured in order to fully demonstrate the effectiveness of PBL applications.

II. Method

A. Participants

A total of 129 undergraduate students volunteered to complete the study survey online. Of the 129 who started the survey, a total of 122 participants completed the entire study

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instrument for use in psychometric analysis of the QUEST instrument. The students were recruited from general psychology course sections as well as general education courses across the campus of a mid-sized, public university in the Southeastern region of the United States. All participants were required to actively agree to their consent for participation and the use of their aggregated responses for research purposes. Active participation was obtained by requiring participants to respond in the affirmative to a question at the beginning of the study survey.

B. Measurement Instruments and Survey Platform

The study survey was developed and designed using the Qualtrics® online survey platform. The Qualtrics platform is an online survey and experimental program widely used by academic and business researchers.

The QUEST online instrument was originally developed and tested in 2016 as a paper-and-pencil instrument. The original QUEST could be administered individually or in groups. This instrument contained a total 34 statements. After initial testing of the paper-and-pencil, 34-item QUEST, an online version was developed and tested (Zagumny, Kazanas, & Clabo, 2018). From these analyses a total of nine items were deleted to arrive at the current 25-item online version.

The QUEST-25 includes 10 items affirming a disposition toward scientific thinking, for example "I value scientific evidence over personal belief" and "I trust scientific evidence." The item scores are summed to arrive at a score for scientific epistemological dispositions called the Scientific Index and abbreviated as SIQ-25. There are 10 items that measure unscientific thinking, such as "I use intuition to make decisions about my life" and "I reject ideas that contradict my beliefs." The final five items of the QUEST-25 are statements affirming a disposition for intellectually curious people including items like, "When learning about something new or experiencing something new, I often lose track of time" and "I like learning new things even if I don't need them for school or my job." These items scores are summed to calculate the Intellectual Curiosity Index or ICIQ-25.

The QUEST methodology requires respondents to select those statements that describe them the most or the least in a force-choice distribution illustrated in Fig. 1.

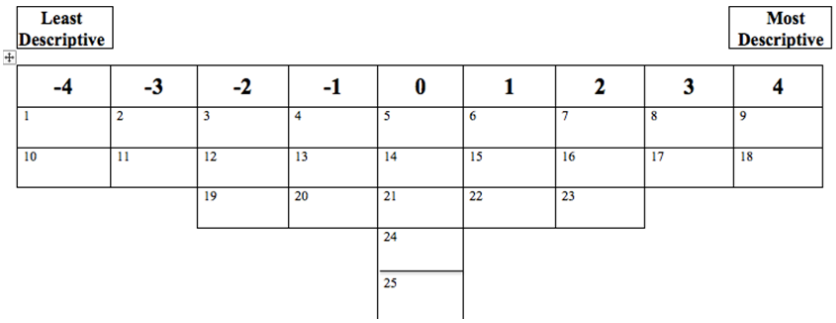

Fig. 1 QUEST-25 scoring distribution form

After the QUEST-25, participants completed the Curiosity and Exploration Inventory (CEI) [10]. The CEI is a 7-item instrument using a Likert-type scale that asks respondents to reply on a 7-point Agee-Disagree scale. The CEI includes items that assesses a person's intellectual curiosity (e.g., "When I am actively interested in something, it takes a great deal to interrupt me.") and exploration of new concepts (e.g., "I am not the type of person who probes deeply into new situations or things.").

Participants were then asked to complete the BIS Scale [11]. The BIS is a 10-item scale using a 7-point Likert-type response format (Strongly Agree-Strongly Disagree) that measures a person's belief in science. It was created within the framework of research conceptualizing the BIS analogous to belief in religion in stressful, anxiety-provoking situations. Sample items are "Scientists and science should be given more respect in modern society" and "Science is the most efficient means of attaining truth."

Next, the Religious Commitment Inventory (RCI-10) was administered [12]. The RCI-10 is a 10-item scale assessing "the degree to which a person adheres to his or her religious values, beliefs, and practices and uses them in daily living" (pg. 85). The RCI uses a 5-point response scale ranging from 1=Not at all true of me to 5=Totally true of me. Example items include "My religious beliefs lie behind my whole approach to life" and "I enjoy spending time with others of my religious affiliation."

The participants were next presented with a modified version of a measure of the Academic Stress and Self-Efficacy Scale (ASES) developed by Zajacova, Lynch & Espenshade [13]. The ASES includes 13-items measured on a scale ranging from 0=Not at all confident to 10=Extremely confident. Items include academic behaviors such as "Asking questions in class" and "Understanding my professors."

Finally, participants were asked to provide their "average grades at university" on a 0-100 scale. Demographic information was also collected including estimated grade point average, age, gender, marital status, year in school, race, international student status, major, and religious tradition (affiliation).

C. Procedure

The researcher sent an email message to general education

instructors at a medium-sized, public university in the Southeastern region of the United States, requesting that the instructor forward the message to students registered for their course. The online survey link was included in the email message. When students volunteered to complete the survey, they would click on the survey link to navigate to the Qualtrics website.

Participants first actively consented to their participation in the study and the use of their aggregated responses for research purposes. Next, the student would progress through the online scales in the following order: QUEST-25, CEI, BIS, RCI, SSES, school performance, and demographic items. At the end of the survey they were given the opportunity to sign-up (on a separate online survey) for extra-credit in their university course.

III. Scoring

An average scale score was used for the CEI, BIS, RCI, and SSES instruments. This resulted in scores ranging from 1 to 7 for the CEI and BIS, 1 to 5 for the RCI, and 0-11 for the SSES with lower scores representing less of the construct measured and higher scores representing more of the construct. The QUEST-25 is scored based on the scoring distribution form presented in Fig. 1. Each of the 25 statements are assessed a score ranging from -4 to +4 based on the degree that the statement describes the respondent. The five items assessing intellectual curiosity (i.e., Curiosity Index) are scored by adding each item score resulting in a scoring range from -16 to +16. The Scientific Index is created by scoring each statement supportive of scientific epistemology (e.g., "I think that evolution is responsible for biological diversity.") based on the scoring distribution. This results in scores ranging from -23 to +23.

IV. Results

A. Construct Validity

Construct validity is the degree to which a measurement instrument measures the variable that it purports to measure. This is one of three measurement validities in the classic model of psychometrics. The other two validities are content validity and criterion validity. To establish construct validity it is necessary to demonstrate convergence and discrimination of the measurement instrument. Convergent and divergent validity is typically demonstrated by the multitrait-multimethod matrix proposed by Campbell and Fisk [14]. Using this approach, convergent validity can be demonstrated when the measure being validated is positively correlated with measures of the same construct measured by different instruments or methods. Divergent validity is demonstrated when the measure being validated is not correlated with different but similar constructs. The smallest correlations should be between the new measure and measures of constructs that are very different than the construct measured by the new instrument [15].

To assess convergent validity the Scientific Index of the QUEST-25 (SIQ-25) was correlated with scores on the BIS. The QUEST Scientific Index was significantly correlated with the BIS, $r\ (83) = 0.60$, $p < 0.001$,

Divergent validity was tested with the SIQ-25 by correlating scores with the RCI and the CEI. Results showed the SIQ-25 was and negatively correlated to the RCI, $r\ (83) = -0.43$, $p < 0.001$ and nonsignificantly correlated with CEI.

The QUEST Intellectual Curiosity Index (ICIQ-25) was tested for convergent validity by correlating it with scores on the Curiosity and Exploration Index (CEI). Results showed a significant correlation between the ICIQ-25 and the CEI, $r\ (83) = 0.38$, $p < 0.001$.

The divergent validity of the ICIQ-25 was tested by correlating ICIQ-25 scores with score on the RCI. Results showed that ICIQ-25 was not significantly correlated with the RCI. See Table I for the construct validity correlation matrix.

TABLE I
Construct Validity Correlation Matrix

Scale	BIS	CEI	RCI
SIQ-25	0.60**	0.16	-0.44**
ICIQ-25	-0.18	0.38**	0.18

SIQ-25 = Scientific Index QUEST-25; ICIQ-25 = Intellectual Curious Index QUEST-25; $^{**}p < 0.001$.

B. Concurrent Validity

Concurrent validity is one of two types of criterion-related validity along with predictive validity. Concurrent validity allows test developers to establish the ability of the measurement instrument to accurately identify participants grouped on some outcome measure related to the construct being measured. A test of leadership skills, for example, should reflect differences in supervisors and subordinates in the workplace.

Concurrent validity of the Scientific Index of the QUEST-25 was examined by testing for significant differences between student participants grouped based on their responses to the following item from the RCI: "Religious beliefs influence all my deals in life." The RCI uses a 5-point response scale ranging from "Not at all true of me" to "Totally true of me." In order to assess concurrent validity of the SIQ-25, responses were recorded into two groups. Those who responded that the statement was "Totally true of me" or "Mostly true of me" were grouped into the "Religious" group (n_R=35). Those who responded to the RCI item with "Not at all true of me" or "Somewhat true of me" were grouped into the "Unreligious" group (n_U=35). If the SIQ-25 was accurately measuring dispositions to scientific thinking then a significant difference should be observed in SCIQ-25 scores between the "Religious" and "Unreligious" groups. Results of the independent samples t-test showed a significant difference in SIQ-25 scores between the Religious ($M = 6.17$, $SD = 10.13$) and Unreligious ($M = -2.34$, $SD = 8.62$), $t\ (68) = 3.79$, $p < 0.001$. (See Fig. 2).

Further evidence of concurrent validity of the SIQ-25 is supported by the finding that the Unreligious group had significantly higher BIS scores ($M = 3.7$, $SD = 1.03$) than the Religious group ($M = 2.53$, $SD = .92$), $t\ (68) = 5.01$, $p < .001$. See Fig. 3.

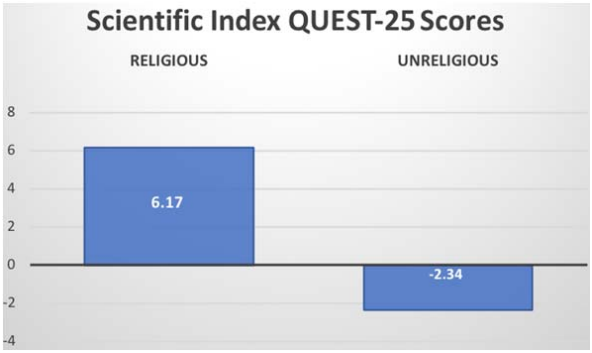

Fig. 2 QUEST-25 Scores of Religious and Unreligious Respondents

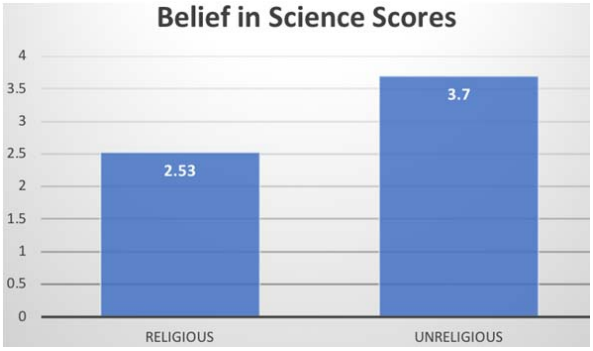

Fig. 3 BIS Scores of Religious and Unreligious Respondents

C. Self-Efficacy Correlations

In order to establish the utility of the QUEST-25, both SIQ-25 and ICIQ-25 subscales were correlated with the Academic Self-Efficacy Scales. Results showed that ASES scores were significantly correlated to the Intellectual Curiosity Index [r (83) = 0.31, p = 0.004] but was unrelated to the Scientific Index. See Table II.

TABLE II
ACADEMIC SELF-EFFICACY CORRELATION MATRIX

Scale	Academic Self-Efficacy
SIQ-25	.16
ICIQ-25	.31**

SIQ-25 = Scientific Index QUEST-25; ICIQ-25 = Intellectual Curious Index QUEST-25; $^{**}p = 0.004$.

V. CONCLUSIONS

The current study was designed to establish the measurement validities of the shorter online version of the QUEST. This shorter version includes 25 items instead of the original 38 items. The shorter version is not only more advantageous for research participants to complete the instrument, it also allows for a more user-friendly interface when the QUEST is accessed on a mobile device. Many of the research participants (i.e., college students) who have participated in the development of the QUEST instrument have completed the study scales on a mobile phone. The 38-item, original version, presented the items in a long list which then had to be sorted into two "piles," describing the participant most or least. Interacting with the long list made it difficult to navigate the list and place each item in one of the two categories. The 25-item is not as long and is easier for navigation on a mobile screen. This is logistic issue is important to assure valid responses by participants.

The other advantage of the shorter QUEST-25 version is the utility for use among higher education institutions for evaluative purposes. To establish the QUEST-25 as a multi-discipline measure useful for program evaluation and student assessment, it is necessary to develop a measurement tool that can be easily and quickly completed by large groups of students. The QUEST-25 achieves this goal by reducing the completion time from approximately 20 minutes for the QUEST-38 to approximately 12 minutes for the QUEST-25. As a measure of the desired dispositional outcomes of PBL efforts, the QUEST-25 offers a new and valid measurement tool useful in formative evaluation of PBL instruction as well as to establish broader program effectiveness during summative evaluations.

The development and refinement of the QUEST instrument has proven useful for theoretical and empirical scholarly work [16]. The finding that the ICIQ-25 was significantly related to academic self-efficacy also suggests that this scale is highly related to behaviors necessary for success in academic environments. The utility of the QUEST-25 for scholars and practitioners in the PBL domain has been well demonstrated by the results reported here. However, there are two limitations of the current study that need to be addressed in future research. The first limitation is the small sample size, due in part to the large number of items and the time to complete the entire study survey, there were a number of participants who started the survey but did not complete all of the scales. This presents two issues: 1) limited representative samples and 2) potential mortality threats to internal validity. The second issue of mortality is particular important to address in future research since students with lower levels of intellectual curiosity and scientific thinking may have dropped out of the study at a disproportional rate compared to those with higher levels of these dispositions.

The second limitation is the lack of distinctly different groups for the concurrent validation of the QUEST-25. In the future, research must examine SIQ-25 and ICIQ-25 differences between participants studying or employed in scientific fields and those in fields not requiring high level of scientific thinking or intellectual curiosity. It may be difficult to identity such groups but it is necessary to examine these groups to further establish the validity of both the QUEST-25.

The current study supports the quality and utility of the QUEST-25 for research and evaluation proposes in PBL classrooms and programs. Quality, valid assessment of these constructs (i.e., scientific thinking and intellectual curiosity) is necessary to demonstrate the value of PBL approaches. In addition to content knowledge improvement, PBL approaches are designed to foster life-long learning and curiosity. These important learner outcomes can now be reliably and validly assessed by using the QUEST-25.

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