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THE 13TH INTERNATIONAL INNOVATION, INVENTION & DESIGN COMPETITION 2024

EXTENDED ABSTRACTS

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INNOVATIVE SCORING SYSTEM FOR STATISTICAL REASONING, LITERACY, AND THINKING (REaLITI) ASSESSMENT INSTRUMENTS

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ABSTRACT

Developing statistical abilities, including literacy, reasoning, and critical thinking, has become a crucial concern in statistical education. However, many students encounter challenges in mastering these abilities. A critical issue here is determining how to assess these statistical skills so that students can comprehend and excel in their statistics courses. To address this issue, the Statistical Reasoning, Literacy, and Thinking (REaLITI) Assessment Instrument was developed to assess these abilities. This paper outlines the development process of the REaLITI instrument scoring system assessment. This project aims to identify the measurement model that best captures the constructs of these skills while meeting good psychometric properties. The results indicate that the REaLITI instrument effectively measures statistical literacy, reasoning, and thinking with high-reliability scores. Furthermore, this instrument allows for students' performance to be categorized into groups such as "Poor and in need of attention," "Satisfactory, requiring some effort," or "Excellent in Statistics."

Keyword: Assessment; Statistics Learning Goals; Scoring; Statistical Literacy; Statistical Reasoning

1. INTRODUCTION

Despite a significant emphasis on developing instruments to assess the desired outcomes of introductory statistics courses, inherent challenges persist in statistical abilities assessment. Statistical literacy and reasoning, alongside statistical thinking, are three statistical abilities recognized as pivotal learning objectives in introductory statistics courses (Garfield & Ben-Zvi, 2008). In conjunction with that, many assessments have been introduced to measure statistical learning objectives based on overlapping definitions of these terms between and within statistics learning goals (Chance, 2002; delMas, 2002; Garfield & Ben-Zvi, 2007, 2008; Jones et al., 2004). Besides, numerous statistical educators and scholars have endeavored to define and describe these three statistical abilities terms (Garfield & Ben-Zvi, 2007, 2008; Mahmud et al., 2018). However, no consensus has been reached regarding these term definitions. The lack of consistency in different definitions supports the idea that the study regarding these issues is still evolving. Moreover, it is important to use quality instrument assessment to provide important information related to students' learning objectives. There is a need, therefore, for a new system that can concurrently measure statistical ability outcomes, and at the same time, help clarify the

definitions of terms between three statistical abilities. This study aimed to develop an innovative assessment scoring system to measure statistical literacy, reasoning, and thinking.

2. METHODOLOGY

The REaLITI assessment is an innovative scoring system thorough instrument that is a holistic tool crafted to gauge students' literacy, reasoning, and thinking abilities in statistics courses. Featuring a user-friendly interface, it comprises a concise set of assessments, and students can effortlessly engage with the platform. Scoring analysis capability empowers instructors to monitor and evaluate their students' statistical abilities closely. Concurrently, it facilitates the identification of potential challenges students may face. This scoring mechanism plays a pivotal role in shaping effective support strategies for student learning development by evaluating statistical abilities. The instrument scoring system is designed based on the ADDIE model. This model is widely adopted by instructional designers for developing modules, models, software, and courseware aimed at instruction and learning (Morrison, et al., 2010). A-D-D-I-E stands for Analysis, Design, Development, Implementation, and Evaluation as shown in Figure 1.
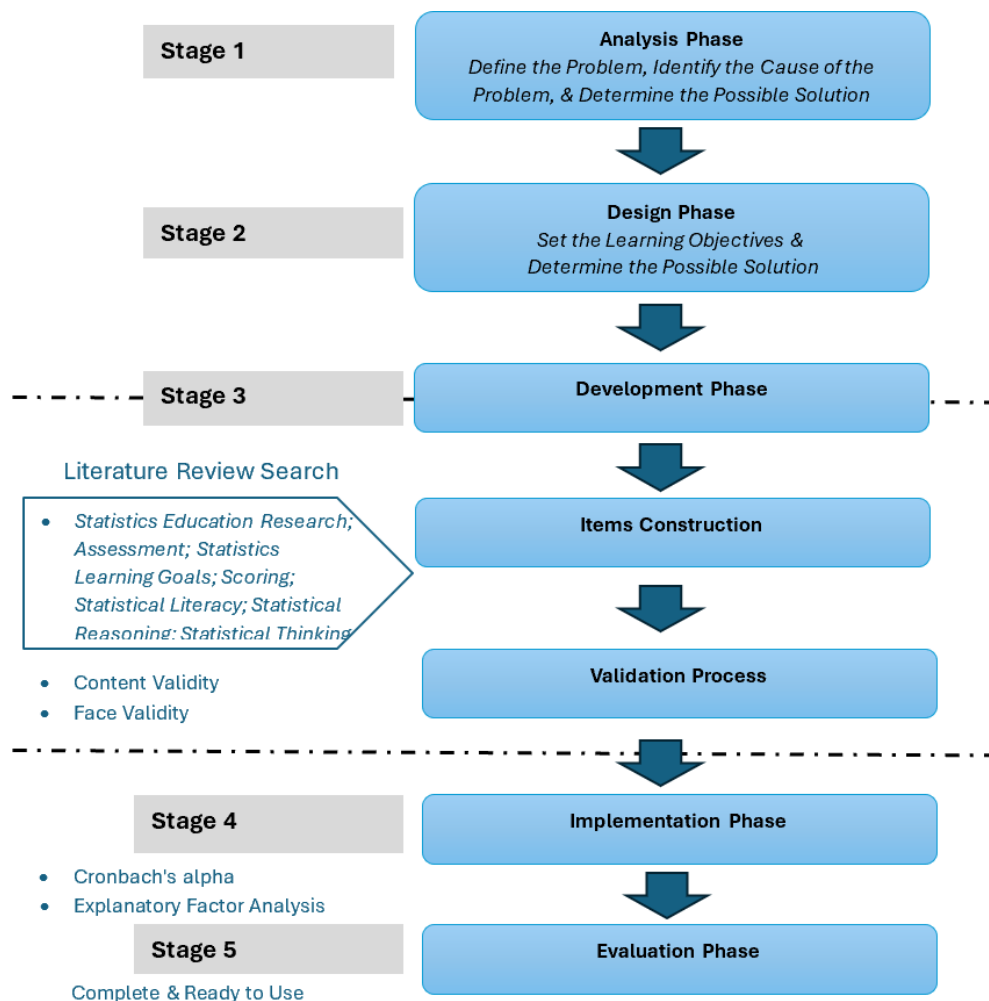
Figure 1 Flow chart of Research Development according to the phases of the ADDIE model

Based on preliminary studies in Stage 1 (Analysis Phase), statistics is a challenging subject that is reported to have numerous failures. This scenario's primary issue is that students fail to grasp the statistical abilities required to master the course. Meanwhile, in Stage 2 (Design Phase), learning objectives are established to construct items in instruments that cover learning objectives related to statistical literacy, reasoning, and thinking abilities. Operational definitions were crafted to distinguish between these statistical abilities.

An instrument was created in Stage 3 (Development Phase) by developing statistical literacy, reasoning, and thinking ability items. A literature search was conducted using Google Scholar, Science Direct, the National Library of Medicine (PubMed), and Scopus covering "Statistics education research; Assessment; Statistics learning goals; Scoring; Statistical literacy; Statistical Reasoning". The items were then reviewed and validated for their content validity by three expert panels consisting of Senior lecturers and professors with experience in teaching statistics for more than 15 years, and one expert in teaching pedagogy with knowledge of ample and respectable. They were asked to read items based on the measured domain and then judge the item's relevance. Face validation was conducted after content validation to check for clarity of instructions and language.

The implementation stage in Stage 4 reflects the item's continuous modification to ensure maximum efficiency and positive results are obtained. The reliability of the research instrument was tested in a pilot study, consisting of 30 undergraduate students who had completed basic statistics courses. This phase involves testing the developed item to ensure that it achieves the learning objectives. This study used Cronbach's alpha to test the measurement instruments. The results showed that Cronbach's alpha coefficient for all domains greater than 0.8, was considered good. Next, an exploratory factor analysis of the item was performed using a principal component analysis (PCA) with varimax rotation. This PCA was conducted to determine the factor structure of the items in the scale. Then, the last stage is the Evaluation Phase, where the system is ready to use.

3. FINDINGS

The Principal Component Analysis (PCA) results indicate that the items assessing these abilities are presented in Table 1.

Table 1 Component of Item Instrument

Domain	Definition (Mahmud et al., 2018)	Indicator	Item
Statistical literacy	The ability to understand and use the basic language and tools of statistics	Statistical term/Terminology, Symbol, Formula/Equation, Calculate without any error, Handle statistical software, Statistical concept, Read statistical output.	7
Statistical reasoning	The ability to choose, generate, and properly interpret appropriate descriptive and inferential methods and make inferences, and justify conclusions.	Interpret the value from the calculated statistical findings, Explain results from statistical software output, Choose the correct formula, Choose the correct statistical method/procedures, Generate statistical output from statistical software, Interpret statistical information published online.	6
Statistical thinking	Understanding why and how statistical investigations are conducted and knowing when and how to apply statistical knowledge and procedures.	Evaluate the results of a problem solved or a statistical study critically and evaluate scientific the problem	2

For scoring, median splits were used, as suggested by other researchers (Sikander, Khan, & Batool, 2024; Roff et al., 1997). The cut-off point for student-perceived scores was determined as displayed in Table 2.

Table 2 System Scoring Classification

Score cut points	Indication
15 - 30	Poor and needs attention
31 - 45	Satisfactory, required some effort
46 - 75	Excellent

4.   CONCLUSION

The development process of the REaLITI instrument indicates strong evidence of score reliability and good psychometric properties. Furthermore, this study also provides solid and research-based definitions of statistical literacy, reasoning, and thinking that can be used to bring unity to the research in statistics education. As a result, the scoring system based on the REaLITI instrument can be used for many different purposes: to facilitate student learning, to provide feedback for students, to inform instructors regarding students' achievement, and to evaluate courses. Additionally, this system will make a meaningful contribution to statistics education.

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