Approaches Towards Revising Instrumentation-Based Reliability Coefficients

Introduction

An analysis of Cronbach's alpha reliability indicated negative reliability coefficients within two constructs of our research instrument. When confronting negative construct correlations that demonstrate operationalized multidimensional tendencies, our primary impetus was establishing transparency for improving instrumentation when irregularities threaten the reliability of investigated social dimensions. Therefore, reflection and acknowledgment are vital to the learning process to understand our practices and limitations when reporting all facets of research methodology (McKibben et al., 2024). A field test of a researcher-developed questionnaire investigated agriculturalists' adoption and diffusion of artificial intelligence in secondary agricultural education classrooms in Alabama. Reliability, either through item or construct analysis, should consistently reflect the measured items in the research instrument (Field, 2024). Typically, researchers (Field, 2024; Kline, 1999; Nunnally, 1978) have suggested that acceptable reliability ranges [lower limit] of $\alpha = .70$ to [upper limit] $\alpha = 1.00$, although upper limits impose their own set of irregularities and are not within the scope of this study. If these limits are the ubiquitously set boundaries for what is acceptable and what is not, specific and inherent concerns warrant considerable justification for their use. Nunnally (1978) posited that the acceptable lower limits could be extended to $\alpha =.50$ if the research and associated instruments are in the early stages of development and testing. This lower limit offers the researcher additional respite, albeit cautionary, acceptable limits; apprehension should accompany lower limits at or below the $\alpha =.50$ level (Field, 2024). In comparison, (Green et al., 1977; Spector, 1992; Vaske, 2008) operationalized an alpha of $\alpha =.65$ - .80 is considered adequate for a scale used in human dimensional research.

Rogers' diffusion of innovations theory (2003) framed the theoretical approach for the design and analysis of the instrumentation. Roger's theory suggests that the individuals being studied may be aware of the topic[s] under investigation, but there are no assurances of adoption or rejection (Sahin, 2006). To better understand the interpretation of reliability analysis, Field (2024) presented a unified approach for establishing the parameters of reliability acceptance. As mentioned, the commonly accepted lower and upper limits associated with reliability coefficients are contingent upon specific factors: correlation between each instrument item and the aggregated instrument score, the total number of items on the scale, and the presence of reverse phrasing yielding a reverse coding type scenario.

Procedures

Developing new and often untested research instruments is vital to iterative instrumentation improvement in the social sciences (Dillman et al., 2014). This brief is the first in a series of analyses addressing reliability coefficients in social science. Construct and instrument reliability coefficients were conducted using SPSS (Field, 2024) to analyze a limited data set, as is typical small-scale field tests for instrumentation reliability. Using established methods and processes for instrumentation development (Croom et al., 2023; Dillman, 2018), we framed the creation of a questionnaire to address agriculturalist's adoption and diffusion of artificial intelligence models. Potential field test participants included all currently practicing SBAE teachers in

Alabama with more than one year of experience and members of the Alabama Association of Agricultural Educators. Ten (*N* = 10) participants were chosen using a stratified random sample. The relatively low sample size concerning the population of SBAE teachers is appropriate for an exploratory study (Hancock et al. 2024). Reliability data were analyzed to examine the internal consistency of scale-based instruments (Lindner & Lindner, 2024; Vaske et al., 2017). Interval measurement scales determined responses from the participants and included 1) strongly agree, 2) agree, 3) neither agree/disagree, 4) disagree, and 5) not strongly disagree in the constructs (Lindner & Lindner, 2024; McKibben et al., 2023).

Results

Addressing negative Cronbach's alpha coefficients is vital for the transparency and improvement of research instruments. Our analysis identified constructs two, perceived benefits and drawbacks, $\alpha = -.01$ (Table 1), and three, access and infrastructure, $\alpha = -.56$ (Table 2), as potentially multidimensional and violating the fundamental principles of Cronbach's alpha to calculate coefficients of unidimensional data. Construct two (Table 1) presented coefficients with the potential for reverse-scored items. Specifically, items four, five, six, and seven are multidimensional when compared to the unidimensional nature of statements one, two, and three.

Table 1

Inter-Item Correlation Matrix: Construct Two

Statement	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1. I believe artificial intelligence tools will change how I design lessons.	1.00						
2. I am familiar with AI tools used in agricultural education.	.72	1.00					
3. I believe AI has potential benefits in my agricultural education classroom.	.81	.89	1.00				
4. I believe that overreliance on AI tools could hinder the development of student's critical thinking skills.	-.27	-.08	-.27	1.00			
5. I believe relying on AI will reduce student's critical thinking skills.	-.34	-.22	.30	.90	1.00		
6. I believe relying on AI will reduce my skills as an agricultural educator.	-.75	-.80	-.85	.00	.24	1.00	
7. I believe caution should be used when using AI in my ag ed classroom.	-.27	.08	-.27	.60	.50	.27	1.00

Construct two analyses (Table 2) identified statements one, two, and three as unidimensional and statements four and five as multidimensional. The directionality of negative statement construction produced negative averages among the item's covariance. When addressing statement two, our analysis indicated that this statement did not consistently measure the same construct as the other statements. We examined the theme of the statement to determine its overall fit with the construct theme or if the statement would have more consequences in different constructs.

Table 2

Inter-Item Correlation Matrix: Construct Three

Statement	*1*	*2*	*3*	*4*	*5*
1. The technology infrastructure in my school is adequate (e.g., internet access, computers/tables) for using AI tools.	1.00				
2. My students have equitable access to the technology to use AI tools effectively.	.156	1.00			
3. I have equitable access to the technology needed to use it effectively.	.824	-.098	1.00		
4. I am concerned that using AI tools could worsen existing technological inequalities for my students.	-.183	.055	-.139	1.00	.
5. I lack the time to use AI tools in my lesson development.	-.586	-.117	-.538	.373	1.00

Discussion

The analysis of the field instrument allowed us to visualize the bi-directionality of the statements within the two constructs. Failure to address negative coefficients leads to underestimating the impact of the instrument and gives a potentially false reliability of the instrument, overlooking the errors of the coded data. The negative coefficients identified problems with reverse-coded items. This error of instrumentation design has specific consequences when participants agreeing with certain statements likely disagree with other statements in the construct. This negative relationship between statements would lead to negative Cronbach's alpha coefficients. Reverse coding procedures were conducted to score the negatively worded items and recalculate Cronbach's alpha. Specific implications of addressing negative reliability in a public forum may be attributed to instrumentation errors in analysis, data entry, or scale construction. Further rationale for not being explicitly transparent is a potential fear of embarrassment, rejection, or conditioned training during post-graduate studies. Recommendations may include establishing guidelines for reporting data collection, analysis, and scale construction errors, as well as addressing how efforts were redirected for success. The impetus of our work and the impacts of our legacies are within the depths of our abilities to find improvement in the face of perceived failure.

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