

CHALLENGES ASSESSING STATISTICS ATTITUDES: OPPORTUNITIES AND COSTS

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Eccles and colleagues' Expectancy-value theory (EVT; 1983) has been widely-used in education research, and the cost component of this framework has recently been the subject of increased research. While advances in measuring the cost component have been made (e.g., Flake et al., 2015), an on-going instrument development project for measuring attitudes in statistics education has encountered difficulties that motivate a deeper look at this construct. An overview of cost in EVT, the current state of measuring it in statistics education, and plans for a new study are described. The first project-specific data are to be collected in Spring 2020.

Introduction

Affective constructs have long been of interest to statistics educators and instruments have been available for measuring constructs such as *attitudes* (e.g., Wise, 1985) and *anxiety* (e.g., Cruise, Cash, & Bolton, 1985) for decades. Following increased calls for attention to affective constructs as outcomes in statistics education (e.g., Gal, Ginsburg, & Schau, 1997), a bevy of instruments assessing a multitude of germane constructs have been developed (Ramirez, Schau, & Emmioğlu, 2012). However, there have increasingly been critiques of existing instruments (e.g., Whitaker, Unfried, & Bond, 2019b), and there have also been attempts to more carefully define constructs such as anxiety that have heretofore not been properly distinguished from other affective constructs (e.g., Chew & Dillon, 2014). This is the context in which a new instrument for measuring student motivation for learning statistics is being developed: the Student Survey of Motivational Attitudes toward Statistics (S-SOMAS). This instrument is being developed using expectancy-value theory (EVT; Eccles et al., 1983) as the framework guiding the development process (Whitaker, Unfried, & Batakcı, 2018). However, during the development process, the EVT construct *cost* seemed to be more difficult to develop appropriate items for than other constructs. This observation is consistent with documented difficulties with measuring cost (Flake, Barron, Hulleman, McCoach, & Welsh, 2015). To that end, a more focused examination of measuring cost in the context of statistics education is proposed.

This work is in the preliminary stages, and the first project-specific data is expected to be collected in spring 2020. This manuscript provides an overview of cost in the EVT framework and a review of the current state of measuring cost and cost-related constructs in statistics

education. Then a few specific challenges to measuring cost encountered during the development of the S-SOMAS that have not yet been addressed by the current literature on cost (e.g., Flake et al., 2015; Jiang, Rosenzweig, & Gaspard, 2018; Wigfield, Rosenzweig, & Eccles, 2017) are explained. Finally, a brief summary of preliminary S-SOMAS pilot results (Unfried, Kerby, & Coffin, 2018) germane to cost is given along with a sketch of plans for using non-Likert-type items (e.g., Cacioppo, Berntson, Norris, & Gollan, 2012) to measure cost, with preliminary data collection to begin in spring 2020 from students enrolled in an introductory statistics course in Canada.

Literature Review

Cost in Expectancy Value Theory

Contemporary expectancy-value theory (EVT) is a theory of achievement motivation that stems from the work by Eccles and her colleagues (e.g., Eccles et al., 1983). In EVT, the choice of task, performance on the task, and persistence on the task are affected by one's expectancies and values; expectancies and values are constructs through which all other potential variables and constructs are mediated (Eccles & Wigfield, 2002). EVT draws on social exchange theory which defines cost as "any factors that operate to inhibit or deter the performance of a sequence of behavior" (Thibaut & Kelley, 1959, p. 12). Cost is viewed as "especially important" to the choices made by students (Wigfield et al., 2017, p. 124). However, cost has also been described as a "forgotten component of expectancy-value theory" (Flake et al., 2015, p. 232) due to the limited way in which it has historically been measured, though there has been an increase in research recently (Wigfield et al., 2017). In arguing that cost has not been adequately assessed in EVT research, Flake et al. (2015) clarified previous attempts to measure the construct, clarified and expanded the dimensions of cost, and developed an instrument that measures each of the four constructs using Likert-type items.

In the original conceptualization of Eccles and colleagues' EVT framework (1983), three dimensions were ascribed to cost: effort, loss of valued alternatives, and psychological cost of failure. There are other types of costs – such as economic or social costs – but these are still less-studied in relation to EVT (Wigfield et al., 2017). Eccles and colleagues hypothesized that interactions among the dimensions of cost and other EVT constructs were important for determining the value of a task. Moreover, the ratio of costs to benefits was posited as being related to achievement behaviors rather cost in isolation (Eccles et al., 1983). Based on the

growing cost literature and focus groups about motivation conducted with college students, Flake et al. (2015) identified and defined four dimensions for cost: the emotional cost and loss of valued alternatives cost (previously identified by Eccles and colleagues (1983)) and two effort dimensions (task effort cost and outside effort cost).

To operationalize this notion of the negative appraisal, many of the items on their instrument include the phrase *too much*, as in “This class is too much work” (Flake et al., 2015, p. 242). By defining cost only in terms of negative appraisals, Flake et al. distinguished the dimensions of cost from other related constructs such as difficulty or general effort. As a demonstration of the efficacy of these definitions, Flake et al. also developed a 19-item instrument that measures the four cost dimensions. Flake et al. (2015) collected data from undergraduate students in introductory calculus classes using the final version of their instrument and observed correlations consistent with the EVT framework: the cost dimensions were strongly, positively correlated among themselves and were moderately negatively correlated with measures of expectancy, values, interest, and achievement.

Affective Constructs in Statistics Education

The Survey of Attitudes Toward Statistics (SATS; Schau, 1992, 2003) and Statistics Anxiety Rating Scale (STARS; Cruise et al., 1985) instruments are among the most widely used instruments measuring affective constructs in statistics education (Chew & Dillon, 2014; Ramirez et al., 2012). There is more validity evidence available supporting the use of the SATS and STARS instruments than for other instruments assessing similar constructs (Nolan, Beran, & Hecker, 2012; Onwuegbuzie & Wilson, 2003), and this is one likely reason why these instruments have been more widely-used than others. However, this widespread use of the SATS and STARS combined with imprecise construct definitions guiding their initial development (Chew & Dillon, 2014; Ramirez et al., 2012) has resulted in construct ambiguity in practice, though there have been attempts to clarify the construct definitions (e.g., Chew & Dillon, 2014; Onwuegbuzie, Da Ros, & Ryan, 1997). For example, the STARS instrument includes six subscales; of these, three subscales measure anxiety constructs and three measure attitude constructs (Chew & Dillon, 2014). Owing in part to documented challenges to the use of the SATS instruments in new research contexts (e.g., Whitaker et al., 2019b), work has begun on a new family of instruments for measuring statistics attitudes. To support the development of the student version of the Survey of Motivational Attitudes toward Statistics (S-SOMAS), a

theoretical framework based on EVT has been developed (Whitaker et al., 2018). This theoretical framework is guiding the development of the S-SOMAS instrument a priori, in contrast to the SATS instruments which were aligned to EVT a posteriori (Ramirez et al., 2012).

Current Work

This current work on measuring cost has been informed by the work of Flake et al. (2015), but there are four areas that have been identified as areas for further study. These areas relate to both how cost has been defined for operationalizing in instruments and in specific ways that current instruments, though indicative of remarkable advances in the understanding of the cost construct, are not aligned with ways in which the S-SOMAS instrument is expected to be used. These four areas are reviewed, and then current efforts to address them are reviewed. There are two research questions guiding this work: (1) How can the EVT cost construct be measured in the context of learning statistics? and (2) How can non-Likert-type items be used in the measurement of cost? Note that much of this work is preliminary: while some data have been collected, they have not been focused specifically on cost. New items are currently being written with a planned pilot in early 2020.

Challenges to using existing cost scales

First, Flake et al.'s (2015) cost scale measuring four dimensions explicitly positions the respondents as students who are enrolled in a course: each of the 19 items uses the phrase *this class* and asks students to respond to statements about the class. In the development of the S-SOMAS instrument, one goal is to develop an instrument that can be used with respondents who are not enrolled in courses to facilitate longitudinal research (even though most respondents are expected to be students enrolled in a course). While the term *this class* might be replaced with another phrase such as *learning statistics*, it is not clear that a simple substitution would perform well. Flake et al. viewed the class as the experience to be evaluated for cost and their focus groups and subsequent instrument development used this assumption. Moreover, students are asked to respond to statements that may not be appropriate early in a semester. For example, items such as “This class takes up too much time” or “this class is too exhausting” (Flake et al., 2015, p. 241) may not be meaningful to students on or before the first day of class. It is anticipated that the S-SOMAS instrument might be administered several times in a semester, including on the first day of classes. Many items that were included on Flake et al.'s (2015) cost scale are not suitable for the intended uses of the S-SOMAS instrument.

While Flake et al. (2015) suggested that their definitions of the cost dimensions distinguish them from related constructs (e.g., difficulty or general effort), the data that they collected did not include items or scales measuring such closely-related constructs. More research about the extent to which these cost dimensions are empirically distinguishable from other closely-related constructs is needed. Additionally, the original EVT framework refers to one's value of a task being affected by the ratio of costs to benefits (Eccles et al., 1983), and in qualitative work Flake (2012) found that effort can be perceived by students as positive or negative in their most motivating and least motivating classes, respectively. Contemporary work on cost has focused on its role as a construct that is negatively correlated with others, and instrument development work for cost has used definitions of cost frame all costs as negative (e.g., Barron & Hulleman, 2015; Flake et al., 2015; Jiang et al., 2018). This ignores any potential positive costs (benefits), which may not be accounted for by other EVT components such as values.

S-SOMAS Pilot

As part of the larger development of the S-SOMAS instrument, seven items measuring cost were written and reviewed by subject matter experts. These items are part of a larger pool of 92 items assessing several EVT constructs administered in the pilot survey. Unfried, Kerby, and Coffin (2018) report results of an exploratory factor analysis (EFA) for this initial pilot survey. The EFA used the varimax rotation and parallel analysis to identify the number of factors (Unfried et al., 2018). The cost items were administered with items assessing academic self-concept, statistics self-concept, expectancies, difficulty, and attainment value; 134 undergraduate statistics students responded to this form (Unfried et al., 2018). Data collection has continued since Unfried et al.'s work, and more detailed work using the larger dataset will be presented.

The cost items used on the S-SOMAS pilot were not written using the same definition requiring a negative appraisal nor an emphasis on "too much" as in Flake et al. (2015). While the sample of 134 is somewhat small for the identified five-factor solution, a few preliminary findings were noted: it was difficult to empirically distinguish the cost items from items written to measure difficulty (a recognized similar construct) and attainment value (Unfried et al., 2018). A similarity between the cost construct and an attainment value construct has not been suggested to the extent of other noted construct similarities. As more data are collected and analyzed, we will examine these factor loadings and consider revising or writing new items.

Application of Other Measurement Types

Existing scales for measuring cost constructs have used Likert-type items (e.g., Flake et al., 2015; Jiang et al., 2018; Unfried et al., 2018; Whitaker, Unfried, & Bond, 2019a). Bipolar response scales (e.g., Likert-type items) imply a reciprocal relationship between the poles: as disagreement with an item becomes stronger, agreement with the item necessarily becomes weaker (Cacioppo et al., 2012). However, as observed by Flake (2012) the perception of cost dimensions such as effort may be perceived negatively – or might be perceived positively. Furthermore, because the understanding of cost is evolving and its exact relationship with other EVT constructs is unknown (e.g., Barron & Hulleman, 2015; Wigfield et al., 2017), it may not be prudent to focus solely on cost as a negative. To address this, a set of items is currently being developed to measure cost that will have respondents assess both their negative perception and positive perception of the task using two unipolar scales. This is consistent with the evaluative space model (Cacioppo et al., 2012) wherein items use a two-dimensional grid to indicate how negative and how positive respondents are toward an item. Once data is collected from these cost items, it will be possible to determine to what extent the reciprocal relationship implied using a bipolar scale is appropriate for cost. If a bivariate relationship is better-suited, this information may help clarify the relationships that cost has with other EVT constructs.

Bivariate items may be written in several ways. Respondents are presented with a statement or question to respond to and shown a grid that they will use to respond. In the pilot data collection, items will use a response grid modeled on those used by Audrezet, Olsen, and Tudoran (2016). Each axis will include the values 1-5, and the horizontal axis will include a positive label statement, and the vertical will contain a negative statement. A consensus for how to label the horizontal and vertical axes has not been established (e.g., Audrezet et al., 2016; Borriello, 2017), and so several other pairs will be used such as *How POSITIVE/NEGATIVE does this make you feel?* or *How SATISFIED/DISSATISFIED does this make you feel?* Examples of statements included in the data collection that accompany such a grid include: using statistical software (e.g., Minitab or R), interpreting a confidence interval, interpreting a graph, or spending a long time doing a statistical analysis for homework but feeling like you got it right. Several different types of statements will be included in the data collection.

Discussion & Conclusion

While affective constructs have long been studied in statistics education research, there is

still a growing need to clarify constructs and determine how best to measure them. Cost has been particularly difficult to assess as evidenced by the historical lack of research on it. Flake et al. (2015) were able to develop an instrument that can be used to measure cost with students enrolled in a specific course, but to do so they defined cost solely in terms of negative appraisals of activities. Historical EVT research (e.g., Eccles et al., 1983) has usually identified the ratio of costs to benefits as having an effect on one's values and ultimately achievement-related behaviors rather than costs in isolation. This distinction may be particularly important in settings with both a high cost and a high benefit – perhaps, for example, in difficult, upper-level courses closely connected to one's field of study and future career. The use of Likert-type instruments to measure cost (e.g., Flake et al., 2015; Jiang et al., 2018) imposes a reciprocal relationship: as one's negative appraisals of an activity increase, the positive appraisals decrease by the same amount. It is plausible that this may not be the case for cost, and the proposed study will examine a variety of other item types, including bivariate items using a two-dimensional grid (Cacioppo et al., 2012). The results of this study should clarify the appropriateness of Likert-type items for measuring cost and suggest how the construct might be assessed in statistics education.

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