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Mathematics anxiety as a function of multidimensional self-regulation and self-efficacy

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ABSTRACT

This study tested the veracity of a model of Mathematics Anxiety as the end-point of related self-regulatory and self-efficacy processes. Data were collected in India from 232, eighth grade students on the Motivated Strategies for Learning Questionnaire and the Mathematics Anxiety Scale. Demographic information such as student's gender, age, marks scored in last mathematics exam and occupation of both parents was also collected. The measures in the study were tested to ascertain their psychometric properties, including any effect that gender had on these properties. A Structural Equation Model of Mathematics Anxiety was then constructed and evaluated based in the measures tested in the related measurement models.

1. Introduction

Mathematical understanding is typically conceived of as being crucial to occupational success and effective personal management in everyday life. For this reason, mathematics is seen a core discipline in education across primary, secondary, and higher education curricula (Baloglu & Koçak, 2006). Moreover, achievement in mathematics constitutes a significant element in decisions concerning student placement, selection, and admission across most educational systems (Nasser & Birenbaum, 2005).

Mathematics anxiety, however, is a key affective variable can impede both learning (Fiore, 1999; Stuart, 2000) and performance (Hembree, 1990; Ho et al., 2000; Liebert & Morris, 1967; Richardson & Suinn, 1972; Wigfield & Meece, 1988) in mathematics and, hence, can have deleterious effects on schooling (Betz, 1978; Felson & Trudeau, 1991), occupational (Trice & Ogden, 1987) and overall life outcomes. Researchers exploring student difficulties with mathematics courses (e.g., Hembree, 1990; Skiba, 1990) have identified affective and motivational factors as prominent predictors (Ai, 2002; Hall, Davis, Bolen, & Chia, 1999; Pintrich, 2002; Schreiber, 2002). Suinn and Edwards (1982), for example, suggested that about half of the variance in mathematics achievement could be explained by factors other than intellectual ones, but not until relatively recently have mathematics educators become more interested in exploring affective influences on mathematics performance and achievement (Mulenga, 1990).

Mathematics anxiety may be exacerbated by an increase in the ambient academic pressure on American students as a result of the 'No Child Left Behind Act' (Owen, 2005). However, identified problems concerning negative affective reactions to mathematics precede current debates. For example, Jackson and Leffingwell (1999) indicated that only 7% of Americans report having positive experiences with mathematics from kindergarten through college. Similarly, Burns (1998) contends that two thirds of adults in the United States "fear and loathe" math.

1.1. Previous research on mathematics anxiety

Mathematics anxiety has been defined as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). Similarly, Bandalos, Yates, and Thorndike-Christ (1995) defined math anxiety as a combination of debilitating test anxiety, low self-confidence, a fear of failure and a negative mind-set towards mathematics learning. Contributing to anxiety states relating to mathematics, many people conceptualize mathematics as a punishment and/or a significant stressor (Zaslavsky, 1994), and math anxiety can even develop into pervasive math avoidance and math phobia (Tobias, 1978).

Mathematics Anxiety (MA) does not appear to have a single cause. MA may be symptomatic of an inability to handle frustration, excessive school absences, poor self-concept, internalized negative parental and teacher attitudes toward mathematics, and an emphasis on learning mathematics through drill without "real" understanding (Norwood, 1994; Singh & Broota, 1992). Proximally, math anxiety often arises from a lack of confidence when working in mathematical situations (Stuart, 2000), which, in turn, is often related to inappropriate methods of teaching mathematical skills.

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Some studies have, in fact, associated mathematics anxiety with student's prior experiences of formal instruction in mathematics (Harper & Daane, 1998; Jackson & Leffingwell, 1999).

The symptoms of math anxiety can be diverse, including nausea and stomachache, a 'blank' mind, extreme nervousness, inability to hear the teacher and/or noise sensitivity, inability to concentrate, and negative self-talk (Kitchens, 1995). Thus, math-anxiety represents a bona fide anxiety reaction (Faust, 1992) with immediate cognitive implications that can also affect a student's future educational goals and aspirations.

1.2. Contributions and limitations of previous research

Despite the importance of research investigating MA, several key limitations of MA research exist. These limitations are detailed below. In detailing these limitations, however, we also recognize the contribution of previous studies, and indicate how these contributions relate to the limitations identified.

Most previous MA research has focused on the relationship between MA (as the independent variable of interest) and mathematics achievement (as the dependent variable of interest), typically finding that MA reduces math achievement (Ho et al., 2000; Liebert & Morris, 1967; Richardson & Suinn, 1972; Wigfield & Meece, 1988). For example, Hembree's (1990) meta-analysis, incorporating the results of 151 studies, was predicated on stipulating mathematics achievement as dependent, with MA as independent. In contrast, relatively few studies have focused on MA as a dependent variable, examining other variables that might act as antecedents to MA (Cemen, 1987).

When studies have focused on MA as a dependent variable, they have (like the present study) often focused on *reducing* MA. However, in doing so, these studies have typically focused on *instructional* variables (such as teacher behavior, task structure, and classroom context) that may lead to a reduction in MA (see Arem, 2003; Furner & Duffy, 2002; Jackson & Leffingwell, 1999; Newstead, 1998). The present study, in contrast, intentionally focuses on *psychological* variables that may lead to reduction in MA. Some previous studies have adopted this general approach (e.g., Hadfield & McNeil, 1994) identifying antecedent psychological variables to mathematics anxiety such as student attitude, lack of persistence, self-doubt, lack of confidence, and a lack of perceived usefulness of mathematics. However, these studies often investigate these variables in a general or theoretical sense, without direct psychological measurement or modeling (e.g., Cemen, 1987; Miller & Mitchell, 1994), and/or using weaker methodologies such as case studies (e.g., Jones, 2001). This study, in contrast, examines antecedent psychological variables of MA by directly modeling MA as the casual outcome of a network of these variables. In this way, this study follows the more rigorous approach of more recent MA studies (e.g., Ma & Xu, 2004), but extends these studies by focusing on psychological antecedents of MA rather than, for example, focusing on previous mathematics achievement as an antecedent (as was the case in the Ma & Xu study).

The simple effects of age and sex on MA have been quite widely investigated (Tapia & Marsh, 2004; Woodward, 2004). However, the moderating effects of age and sex on a causal network antecedent variables explaining variation in MA have not been systematically explored. In other words, previous studies have typically used ANOVA techniques to identify group (age and sex) differences with respect to MA, with the latter being modeled as a single dependent variable. In contrast, the current study investigates the moderating effects of age and sex on MA, with MA modeled as a fully-networked 'downstream' variable.

Finally, with some recent exceptions (e.g., Baloglu, Abbasi, & Masten, 2007; Ho et al., 2000; Yenilmez, Girginer, & Uzun, 2007), few studies have investigated mathematics anxiety in non-Western contexts. This is a critical limitation in the literature because hypotheses concerning factors affecting mathematics anxiety may not hold across cultural contexts, even if there is support for such hypotheses in research emanating from Western contexts. For example, one very recent cross-cultural study in a Turkish context (Yüksel-Şahin, 2008), did not find that MA increased with age, despite this being a common finding in the Western literature.

1.3. The present study

For the reasons above, we sought to investigate MA: (a) as a dependent variable, (b) in a non-Western context, (c) using sophisticated latent variable modeling approaches, (d) with a focus on identifying a network of interrelated antecedent variables that may reduce MA, and (e) taking into account the extent to which these variables are influenced by age and sex.

India was chosen as the cross-cultural context for the present study because, despite being a key emerging global economy supporting a population of more than one-billion people (or one-sixth of the world's population), very little educational or cross-cultural psychology research conducted with Indian samples has been reported in the Western literature. Given the global strategic, economic and cultural influence that India is likely to exert in the 21st century, it is critical that a greater understanding and appreciation of Indian society at all levels, including with respect to Indian education and educational processes, be generated in the West.

Acknowledging the limitations of previous research, this study also examines the extent to which multidimensional self-regulation and self-efficacy (modeled as interacting antecedent variables) affect students' math anxiety at middle school level, taking into account the influence of age and gender. More specifically, we propose to test a model hypothesizing that multidimensional self-regulation leads to enhanced self-efficacy and, subsequently, reduced anxiety, i.e.,

$$\text{Self-regulation} \rightarrow \text{enhanced self-efficacy} \rightarrow \text{reduced mathematics anxiety}.$$

In providing a rationale for this proposed model we first describe and define the antecedent and mediating variables in model (self-regulation and self-efficacy) and then go on to explicate the causal ordering of the model.

1.4. Self-regulation

In its more general sense, self-regulation refers to self-directed cognitive and metacognitive activity including the propensity to set goals, plan strategies, and evaluate and modify ongoing behavior (Cervone & Pervin, 2008). With more specific reference to learning and learning processes, *academic* self-regulation implies conscious awareness and coordination of one's cognitive and metacognitive thinking processes and strategies, and typically involves selecting and deploying appropriate strategies in order to achieve explicit or implicit learning goals (Duncan & McKeachie, 2005; O'Neil and Abedi, 1996).

Commonly cited strategies implicated in academic self-regulation include basic (rehearsal) and complex (elaboration and organization) strategies related to the processing of information. In a number of studies these strategies have been shown to be broadly representative of the domain academic self-regulation, and also to be directly related to student's mathematics self-efficacy and performance (Brown & Hirschfeld, 2007; Cervone, Shadel, Smith, & Fiori, 2006; Tanner & Jones, 2003). Rehearsal strategies (e.g., repeating, reciting, naming) are used primarily for storing information in the working memory rather than in the long term memory