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Predictors of numeracy performance in undergraduate psychology, nursing and medical students

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ABSTRACT

Psychology, nursing and medicine are undergraduate degrees that require students to attain a level of numerical competence for graduation. Yet, the numeracy aspect of these courses is often actively disliked and poorly performed. This study's aim was to identify what factors most strongly predict performance in such courses. Three hundred and twenty-five undergraduate students from these three disciplines were given measures of numeracy performance, maths anxiety, maths attitudes and various demographic and educational variables. From these data three separate path analysis models were formed, showing the predictive effects of affective, demographic and educational variables on numeracy performance. Maths anxiety was the strongest affective predictor for psychology and nursing students, with motivation being more important for medical students. Across participant groups, pre-university maths qualifications were the strongest demographic/educational predictor of performance. The results can be used to suggest ways to improve performance in students having difficulty with numeracy-based modules.

1. Introduction

Numeracy is commonly defined as the ability to understand and use numbers in everyday life (e.g. Rothman et al., 2006). It is strongly context dependent (FitzSimons, 2002), meaning that what is classed as numeracy might be different for, as an example, a bank clerk compared to a statistician. Many academic degrees contain a substantial numeracy component, even if they themselves are not mathematically-focused. Worryingly, many students strongly dislike this numeracy component, these negative experiences potentially leading on to poor numeracy performance (Phoenix, 1999). Such difficulties with numeracy have been evidenced in a range of academic pathways (e.g. Mulhern & Wylie, 2004; Tariq, 2003).

Psychology, nursing and medicine, in particular, are subjects that require students to be numerate for their degrees. For psychologists, numeracy is necessary for a competent understanding of statistics. The Quality Assurance Agency for Higher Education (QAA) states, as a benchmark, that psychology students in the UK need to have, "A systematic knowledge of a range of research paradigms, research methods and measurement techniques, including statistical analysis," (Quality Assurance Agency for Higher Education, 2007). For nurses and medics numeracy is related to tasks that are essential in their future occupational life, such as calculating drug dosages. Again, UK nursing and medical qualifying bodies view numerical ability as a pre-requisite for course completion (e.g. Higher Education Occupational Physicians/Practitioners, 2010; Nursing and Midwifery Council, 2008). The aim of this study was to create statistical models, specific to these three disciplines, that would help to illustrate and explain, at least in part, the combinations of variables (including affective, demographic and educational factors) responsible for causing poor numeracy performance in undergraduate students.

1.1. Mathematics anxiety

Maths anxiety is generally defined in the literature as a feeling of tension, dread or fear that appears when a person is required to undertake some kind of task involving maths performance (Ashcraft, 2002). At university level, it can lead to students purposely avoiding subjects or modules that have a high maths content (e.g. Durrani & Tariq, 2009) and, post-university, taking a less than optimum career path (Durrani & Tariq, 2012). Previous research has suggested that females suffer from maths anxiety more than males (e.g. Maloney, Waechter, Risko, & Fugelsang, 2012) although there is no consensus regarding this (e.g. Scafidi & Bui, 2010). Likewise, age appears to impact maths anxiety to some degree (e.g. Baloğlu & Koçak, 2006), with older university students having stronger levels of anxiety about exams and their numeracy-based course than younger students, but having less anxiety regarding the numerical tasks themselves.

A number of studies have illustrated the existence of a relationship between mathematics anxiety and numeracy performance in undergraduate students. Miller and Bichsel (2004) found that maths anxiety significantly predicted performance in both basic and applied maths tests. Literature reviews (e.g. Ashcraft & Moore, 2009) and additional

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research on different student populations (e.g. Loong, 2012; Núñez-Peña, Suárez-Pellicioni, & Bono, 2013) have supported this relationship. In all of these cases, this relationship was a negative one, with anxiety reducing performance. However, it should be noted that some studies (e.g. Macher, Paechter, Papousek, & Ruggeri, 2012) do show that aspects of anxiety can lead to improvements in numeracy performance.

While this research suggests the existence of a significant relationship between maths anxiety and maths performance, it is currently difficult to empirically infer a causal direction from most of these sources, with many studies basing their conclusions on bivariate correlations (e.g. Bull, 2009). Many researchers argue that fear and anxiety result in poor performance, while others suggest that poor performance leads to an increase in anxiety. Previous literature suggests that the former of the two arguments is the more likely. Hembree (1990), in a meta-analysis of the literature concludes that reductions in maths anxiety result in higher achievement, with treatment raising the performance of individuals with formerly high anxiety to performance levels associated with low maths anxiety. Hembree also points to a lack of relationship between maths anxiety, IQ and general ability, with initiatives designed specifically to improve student maths ability not resulting in any change in maths anxiety levels. Likewise, Ashcraft and Moore (2009) state that maths anxiety results in a level of working memory suppression, which inhibits numeracy performance, thus providing a clear, causal link. However, other research (e.g. Ma & Xu, 2004) suggests that this relationship is inverted (with performance predicting attitudes) or that it is non-existent (e.g. Eldersveld & Baughman, 1986).

1.2. Motivation, usefulness and confidence

Less research has been undertaken on additional mathematics-based affective variables, and how they might relate to numeracy performance. Fennema and Sherman (1976) suggested that, along with maths anxiety, confidence, motivation and perceptions on the usefulness of maths were important variables in the construct of maths attitudes. Confidence, in particular, has been linked to numeracy performance (e.g. Hoffman, 2010; Pajares & Miller, 1994). Confidence and self-concept in maths are also related to maths anxiety (Tariq & Durrani, 2012) and seem to be predicted by gender, with males showing stronger levels of confidence than females (Pajares & Miller, 1994) and by age, with mature students being less confident about their maths ability than traditionally-aged students (i.e. students between the ages of 18 and 21) (Tariq & Durrani, 2012).

Motivation towards doing well in maths has been less thoroughly researched than confidence, but has still been linked to maths-based achievement (e.g. Núñez-Peña et al., 2013). Few empirical studies, however, have looked at whether perceptions on the usefulness of maths can predict performance, despite the fact that it is a common factor in numerous measures of maths attitudes and attitudes towards maths-related variables (e.g. Tapia & Marsh, 2004). Armstrong (1985) found there to be a relationship between perceptions of utility and performance, but no causal direction could be ascertained. Conversely, additional research (e.g. Pyzdrowski et al., 2013) found no links between usefulness (termed 'subject value') and numeracy performance.

1.3. Demographics

Many studies support the existence of a causal link between gender and numeracy performance, with females performing significantly worse than males (e.g. Martens, Hurks, Meijs, Wassenberg, & Jolles, 2011; Mulhern & Wylie, 2005). However, such views are not unanimously shared, with other research demonstrating no differences (e.g. Lindberg, Hyde, Linn, & Petersen, 2010; Scafidi & Bui, 2010) or, occasionally, stronger numeracy performance in female students (Elmore & Vasu, 1986). Research (e.g. Durrani & Tariq, 2009; Kargar, Tarmizi, & Bayat, 2010) also shows that gender has a significant effect on maths-based, affective variables that predict numeracy, particularly anxiety and confidence, with females demonstrating much stronger negative affect compared to males. This suggests the possibility of both direct links between gender and performance, and indirect links via the affective variables.

Only a small number of studies have explored whether student age is a significant predictor of numeracy performance. Durrani and Tariq (2009) found that younger students expressed more confidence and competence in regard to maths than older students. In contrast, Payne and Israel (2010) found exactly the opposite – that older students did significantly better at a statistics course than younger students. Furthermore, a considerable number of studies show that student age has no significant main effect on performance in numeracy-based tasks at all (e.g. Roberts & Saxe, 1982; Zeidner, 1991).

1.4. Educational and family background

Considerable previous literature (e.g. Joyce, Hassall, Montaño, & Anes, 2006; Tariq & Durrani, 2012) posits that previous mathematics educational background (i.e. highest previous mathematics qualification) has some significant effect on both numeracy-based attitudinal and performance-related variables. Núñez-Peña et al. (2013) demonstrated that psychology students with a background in humanities were more likely to do worse on the numeracy-based component of their course, compared to those students with more quantitative backgrounds. Huws, Reddy, and Talcott (2005) found that GCSE maths grades significantly predicted university grades; A-Level grades, however, did not (GCSEs are compulsory exams undertaken by UK students at age 16 while A-Levels are non-compulsory exams taken by UK students at age 18, generally used as university admissions criteria.). Grandell-Niemi, Hupli, Puukka, and Leino-Kulpi (2006) and Hilton (1999), studying nursing students, found that those students with higher levels of previous education were more competent with numeracy than those with lower levels. Such findings, however, are not universal with Woodward and Galagedera (2006), for example, uncovering no significant relationship between course performance and previous maths qualification.

A number of studies have looked at factors related to family background (e.g. Ferry, Fouad, & Smith, 2000) but never explicitly in the same way as it is defined in the current study. It is possible that a family background in maths could have a positive impact on performance if the student has a parent or sibling who requires some level of numeracy as part of their job, as the student might view numeracy as being more useful and less intimidatingly abstract. The student may, therefore, have more motivation to work harder at maths, as they would see numerical knowledge as being more beneficial and less challenging. It is hoped that the study reported in this article will provide support for this hypothesis.

In conclusion, the relationships between the factors that predict numeracy performance are complex and have not always been the subject of rigorous empirical research. Maths anxiety appears to predict numeracy performance while additional maths affective factors also predict performance directly, as well as indirectly through anxiety. Numeracy and the affective variables are themselves predicted, again both directly and indirectly, by demographic and educational variables. Many of these variables are, however, under-researched and no study has attempted to integrate all of these variables into a single model.

1.5. This study

This was an exploratory study with the aim of predicting numeracy performance in a sample of undergraduate psychology, medical and nursing students, as well as determining the relationships between the demographic, educational and affective predictor variables. In particular, anxiety was expected to predict performance, based on the considerable amount of previous research that has suggested this (e.g.