

Australian Journal of Educational & Developmental Psychology. Vol 5, 2005, pp107-116

Exploring Adolescent Motivations for Pursuing Maths-Related Careers

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ABSTRACT

Adolescents from grade 9 in Sydney Australia ($N=60$) were interviewed regarding why they would or would not consider pursuing maths-related careers. Open-ended interview data explored the comprehensiveness of explanations within the Expectancy-Value framework. The Expectancy-Value model is the major motivational framework for explaining students' maths participation choices in senior high and college enrolments, and the present study extended participation choices to maths-related career plans. Findings provided support for Expectancy-Value factors as sources of adolescents' intentions to pursue (or not pursue) maths-related careers, and suggest extensions to the model.

Keywords: adolescence, motivations, mathematics, career choice

INTRODUCTION

The purpose of this study was to explore adolescents' motivations and perceived influences on their plans to either pursue, or not pursue, maths-related careers – a timely topic given the current critical shortage of people entering maths-related careers (Herzig, 2004; Stage & Maple, 1996). The most prominent current motivational theory developed to explain students' maths participation is the *Expectancy-Value* theory of Eccles and colleagues (Eccles (Parsons), Adler, Futterman, Goff, Kaczala, Meece, & Midgley, 1983; Wigfield & Eccles, 2000). This theoretical framework represents students' expectancies for success and subjective valuation of maths as the major influences on their choices for maths participation, drawing on the theoretical and empirical work of decision-making, achievement and attribution theorists (Meece, Eccles (Parsons), Kaczala, Goff, & Futterman, 1982). More distal influences are students' perceptions about the difficulty of maths. Eccles and her colleagues developed the Expectancy-Value model primarily to investigate enrolment patterns in mathematics, contending that existing research into academic choices was limited by the lack of an integrative theoretical framework. Their model was developed with the aim of providing such a framework having more precise conceptualization of the components, linking the various pieces together, suggesting causal sequences, and outlining the relations between beliefs and behaviors (Eccles et al., 1983).

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Eccles and her colleagues have widely demonstrated the influences of maths expectancies and values on students' choices to participate in maths in senior high and college enrolments (e.g., Eccles (Parsons) et al., 1983; Eccles (Parsons), 1984; Eccles, 1985; Eccles, Adler, & Meece, 1984; Meece et al., 1982; Meece, Wigfield, & Eccles, 1990; Wigfield, 1994; Wigfield & Eccles, 1992; see also Watt, in press a). The Expectancy-Value model has guided extensive quantitative and longitudinal research. However, it is also important to explore whether adolescents express additional important factors for their maths-related choices, that have not been focused on within this approach. That is the impetus for the present study, which explores the exhaustiveness and processes underlying key elements of the model using an open-ended interview procedure. The study also extends examination of the influences on choices for maths participation to adolescents' *career plans*, forming an important contribution to extending our understanding of maths-related choices beyond the high-school years.

Within the Expectancy-Value framework of Eccles and colleagues, *expectancies for success* are empirically similar to ability beliefs, defined as perceptions of one's current competence at a given activity (Eccles & Wigfield, 1995). *Values* have been defined as containing four components (Eccles (Parsons) et al., 1983; Wigfield & Eccles, 1992): 'intrinsic value' refers to the enjoyment one gets from carrying out a given task; 'utility value' to how a task will be useful to an individual in the future; 'attainment value' to the importance of doing well on the task; and 'cost' to what the individual has to sacrifice doing to carry out the task, as well as the effort required to complete it. Most of the empirical work conducted by Eccles and her colleagues has been carried out with the first three of these values (Wigfield & Eccles, 2000).

The present open-ended interview investigation explored whether other important influences were operative in students' plans regarding participation – or non-participation – in maths-related careers, thereby investigating the comprehensiveness of the Expectancy-Value framework in explaining those choices, and probing the processes underlying their explanations. From this theoretical perspective, students planning to pursue maths-related careers were expected to cite reasons relating to: 1) their expectations of being successful in maths, 2) their high mathematical ability, 3) their interest in maths, 4) perceptions of maths as useful, 5) regarding maths as important to do, and/or 6) not having competing interests or costs. Students planning *not* to pursue maths-related careers were anticipated to give explanations relating to 1) expectations of not succeeding in maths, 2) their low mathematical ability, 3) being uninterested in maths, 4) not perceiving maths as useful, 5) not needing maths or regarding maths as unimportant, and/or 6) having competing interests or costs. Additional reasons outside these key Expectancy-Value factors were of particular interest in terms of exploring the model's comprehensiveness for understanding students' perceived influences on their maths-related career plans.

METHOD

Participants

Participants ($N=60$) were selected from a larger cohort of 459 grade 9 students from three coeducational government schools in an upper-middle class area of metropolitan Sydney (see Watt, 2002), of comparable socioeconomic status (based on socioeconomic index for areas, ABS, 1991). Grade 9 adolescents were selected for the study, since around this age (14.5 years) students are beginning to explore their career choices, and previous research has empirically demonstrated considerable consistency in the maths-relatedness of adolescents' career aspirations from grade 9 through senior high school (Watt, in press b).

Interviewees were selected from the larger-scale survey study according to their gender, high and low perceived mathematical talent self-ratings, and high and low measured mathematical performance on standardized tests (Progressive Achievement Test Form 2B, ACER, 1984, alpha=.80). This resulted in a mix of similar numbers of males and females

having high and low perceptions about their mathematical talents (see Watt, 2002, 2004), and high and low maths achievement, since adolescents' perceptions of their mathematical talents have been found to influence their maths-related educational and occupational aspirations over and above their actual achievement (Watt, in press a, b; for ability self-concepts see also: Simpkins, Davis-Kean, & Eccles, in press). Triad splits were used to determine 'high' and 'low' groups in each case², with 10 interviewees randomly selected within each condition as illustrated in Table 1.

Table 1: Interviewee Group Composition

	high maths talent perceptions	low maths talent perceptions
high maths performance	10 boys (group 1) 10 girls (group 2)	10 boys (group 5) 10 girls (group 6)
low maths performance	10 boys (group 3) 10 girls (group 4)	

Procedure

Intentions whether or not to pursue a mathematics-related career were assessed via an open-ended question in which students were asked whether they would consider pursuing a maths-related career. They were then asked why or why not. Individual interviews were conducted mid-year following informed consent of interviewees and parents, and were carried out by the researcher and a trained male research assistant. To control for the gender interface, the male interviewer interviewed all the boys, and I interviewed all the girls. Interviewees were assured of the confidentiality of their responses, invited to select an alias name, and told that the purpose of the interview was to find out more about their perceptions related to maths, from the surveys earlier that year.

Analyses

Interviews were initially transcribed and copies were sent to interviewees for comment³. Responses to each question were collated within each of the six interview groups, and analyzed using constant comparative analytic procedures (Glasser & Strauss, 1967) to derive sets of concepts, that were then grouped into categories, and delineated in terms of properties and dimensions related to key explanatory factors in the Expectancy-Value model. Example passages from transcripts were selected for illustrative purposes as typifying certain themes, and exceptions to themes were identified to describe divergent processes. The interview excerpts provided for the expression of participants' voices (Geertz, 1993).

Confidence in inference is enhanced within the present study, by the use of random sampling techniques to select interviewees within each of six groupings. It is unlikely, therefore, that emergent patterns for each group would be absent in the general population represented by each. Following Merriam (1988), I report interpretations and inferences in detail, to allow the reader to determine the relevance and transferability of these findings and conclusions to other contexts. The typicality of cases in the present study is clearly established through definitive and replicable interviewee selection criteria, so that readers

² Cut-offs for boys and girls using 33rd and 67th percentiles on the 28-item mathematics test were 20 and 24 for boys, 21 and 24 for girls. For perceived mathematics talent cut-offs on the 7-point Likert-type scales were 4.24 and 5.28 for boys, 4.00 and 4.80 for girls.

³ Only one participant made changes to her transcript, all of which were typographical.

have a strong foundation for comparison, based on the similarity with other contexts to which they may wish to apply the findings.

RESULTS

Perceived Influences on Planned Participation in Mathematics-Related Careers

Many respondents were unsure what their intended careers might be (represented by the 'maybe' row in Table 2). This is not too surprising, given that in grade 9 students are likely to be beginning to explore their career choices. Table 2 shows the numbers of boys and girls within each of the six groups planning to pursue, or *not* to pursue, maths-related careers.

Overall, twice as many boys as girls stated that they planned to pursue maths-related careers. This was true for students having high maths achievement but low talent perceptions (groups 5 and 6), and students having low maths achievement but high talent perceptions (groups 3 and 4). In contrast, among students who had both high achievement *and* talent perceptions (groups 1 and 2), more girls than boys aspired to maths-related careers.

Greater numbers of girls than boys planned to pursue *non*-maths-related careers across the sample. This was the case for students having low achievement and high talent perceptions (groups 3 and 4), although that pattern was reversed for students with high achievement and low talent perceptions (groups 5 and 6), and equal numbers of boys and girls planned on non-maths-related careers in the high achievement and talent perceptions groups (1 and 2).

Table 2: Numbers of Interviewees Planning to Pursue Maths-Related Careers

	G1 - boys	G2 - girls	G3 - boys	G4 - girls	G5 - boys	G6 - girls	Total boys	Total girls
Yes	1	3	5	1	2	0	8	4
Maybe	6	4	4	2	1	5	11	11
No	3	3	1	7	7	5	11	15

Reasons for Planning to Pursue a Maths-Related Career

In response to the question "Do you think you will pursue a maths-related career?", the most common reason given by the 12 of the 60 students who responded "yes", was that their aspired career entailed maths, with maths therefore being instrumental to them pursuing their career of choice (6 responses). Self-perceptions of being good at maths was the next most frequent response (4 responses), while only one response related to each of interest in maths and task difficulty, and one reference to parental expectations.

Maths Being Instrumental to Career of Choice. Six students stated that the career in which they were interested *happened* to involve maths, although they were interested in those careers for reasons *other* than their mathematical content. These adolescents' plans to pursue maths-related careers were not based on their interest in or evaluations about maths, but instead on their interest in particular occupations which entailed maths. This reason was cited only by adolescents having high mathematical talent perceptions, equally often for those having realistic (groups 1 and 2) and unrealistic high talent perceptions (groups 3 and 4), and equally often by boys and girls.

Fred: Oh, I think because I would like to have a business ... and you need maths.
(group 1)

David: Yes. Flying, you need good maths, like to work things out, like height you need such-and-such a thing ... I do gliding at the moment. I'm pretty serious, I've always wanted to fly and I enjoy it when I do get to.

Int: Is it an interest in maths that makes you want to fly?

David: Not really [laugh], it's just a love of flying itself. (group 3)

Ariel: I was wanting to be a vet and stuff like that so that's sort of maths a bit, like it involves maths, like medicine sort of stuff like that, 'cause I really like animals and stuff like that, so I'd be something like a vet. (group 2)

Laura: Yes... I think it's because... well my dad wants me to study medicine. I never really knew what I wanted to do, but I'd like to study medicine. 'Cause my dad wants me to study medicine 'cause he couldn't do it, 'cause his parents couldn't afford it.

Int: Does medicine interest you personally?

Laura: Yes, I think because I've been sick a lot and I know what it feels like to be sick. (group 2)

Clearly the maths-relatedness of these adolescents' aspired careers was not the reason that they wished to pursue them. Fred recognized the relevance of maths to running a business, David to being a pilot, and Ariel to becoming a vet. David in particular made it clear that the maths was quite incidental to his interest in flying. Laura's response, while reflecting an intrinsic interest in studying medicine, revealed that this interest came from a personal understanding of what it was like to be sick, as well as wanting to fulfil her father's expectations.

This 'instrumentality' of maths to students' chosen career was the most frequent reason given by respondents planning to pursue maths-related careers. They were not interested in maths *per se*, but were interested for other reasons in careers which happened to involve maths. This relates somewhat to Eccles et al.'s 'utility value' construct (Eccles (Parsons) et al., 1983; Wigfield & Eccles, 2000), concerning the extent to which individuals choose to participate in maths tasks because they regard maths as useful to them. However, their operationalisation of utility value does not capture this 'incidental' aspect of maths *happening* to be involved in adolescents' aspired careers, on which respondents planned for reasons independent of their maths-relatedness. Utility value taps the 'instrumental' aspect, but less so the 'incidental' aspect, or non-centrality of maths-related features in attracting adolescents to those careers.

Being Good at Maths. "Being good at maths" was the second most common reason given for intending to pursue a maths-related career, and related directly to 'perceived maths ability' in the Expectancy-Value framework. These responses came mostly from boys' with unrealistic high talent perceptions (group 3: 3 responses), and also from Tamara, who had high talent perceptions *and* performance (group 2). The boys' responses tended to simply reflect positive self-perceptions of mathematical ability, as illustrated by Stefan: "Um... I like engineering stuff. My brother's friends said that if you are good at maths and science you could do engineering". Tamara's response, "Because I'm better at maths than any other subjects", showed that she perceived herself as being good at maths relative to her other school subjects. This was illustrative of some tendency for girls' maths-related perceptions to be contextualized against their other academic subjects.

Maths Interest. Expressed interest in maths was mentioned only by Steve as the reason for him planning to pursue a maths-related career. Steve had low talent perceptions and high performance (group 5) and planned to participate in a maths-related career because he found maths intrinsically interesting:

Steve: Um... maybe engineering.

Int: Yeah? Why's that?

Steve: Um... it's interesting.

Int: Okay. Is it interesting because there's maths involved?

Steve: Yes. Maths is fun.

Int: You like maths do you?

Steve: Yes.

Int: Why is that, why do you find it fun?

Steve: It's pretty amazing.

Int: Is it? Just answers you can come up with, and ways of working things out?

Steve: Yes.

It is intriguing that Steve held such strong interest in maths at the same time as having low perceptions about his mathematical talent, and despite his high performance. Maths interest mapped to the 'intrinsic values' component of the Expectancy-Value framework, posited to directly impact on maths participation choices, independently of individuals' ability-related beliefs.

Low Perceptions of Task Difficulty. William also held low talent perceptions and had high mathematical performance (group 5), similar to Steve. William planned to be an accountant, because "... probably should be an easy job". This reason maps to the Expectancy-Value 'task difficulty' factor, which Eccles, Wigfield *et al.* believe does not directly impact on maths choices. In support of this, William was the only person to mention task difficulty features as his reason for pursuing a maths-related career, although there may be features about accountancy other than its maths-relatedness that led him to this conclusion. Eccles and her colleagues posit that task difficulty perceptions shape individuals' expectations of success, which then in turn impact on choice-making (Eccles *et al.*, 1983), and recent Australian research also provides empirical evidence for this indirect influence of task difficulty perceptions (Watt, in press b).

Perceived Influences on Plans to Not Pursue a Maths-Related Career

Of the 26 adolescents who indicated that they would *not* pursue a maths-related career, overwhelmingly, the most common response from 17 respondents was that they had interests other than maths. Although related to lack of interest in maths, this response is qualitatively different, in that it reflects lack of interest in maths relative to other subjects, and so does not preclude liking maths. Low self-perceptions of mathematical ability and disliking maths were the next most common responses (5 each), with only one reference to maths being too hard. These reasons again reflected the three key Expectancy-Value constructs of self-, task- and values perceptions.

Having Interests Other than Maths. Two-thirds of the students raised having interests in areas other than maths as their reason for not wishing to pursue a maths-related career. This response was given more than twice as often by girls (12 responses) than by boys (5 responses), and similarly frequently across the realistic high talent perceptions (groups 1 and 2: 5 responses), unrealistic high talent perceptions (groups 3 and 4: 6 responses), and unrealistic low talent perceptions groups (groups 5 and 6: 6 responses). Interests other than maths that were cited by boys showed no particular pattern, being journalism, music and business. In contrast, the alternative interests raised by girls related mostly to the arts (music, fashion (n=2), 'something creative', acting, and dance), with marine biology, sport and medicine also mentioned.

Frank did not consider the possibility of a maths-related career, because he already knew that he wanted to be a sportsman and play baseball. Interestingly, Frank did not consider he lacked ability in maths (consistent with his membership of group 1: high talent perceptions and high performance), he observed that "Just a lack of interest" was the reason he did not plan to pursue a maths-related career.

Similarly, Agatha (group 2, high talent perceptions and high performance), although less decisive about what she wanted to do, knew she wanted to do something related to sport:

Agatha: I want to do something to do with sports because I like sports, like I want to do sports medicine or something...

Int: So what you decide will be because you're interested in it?

Agatha: Yeah... you'd have to like it otherwise it gets boring.

Sarah, who had high talent perceptions and low performance (group 4), illustrated the pattern for female interest in the arts, having interests apart from maths that she wished to pursue:

Sarah: I like fashion and art and all that.

Int: So basically you're more interested in other things than maths?

Sarah: Yes.

These students did not wish to pursue maths-related careers at this point in time in their schooling, not because they were *not* interested in maths necessarily, but because they had *competing* interests that they wished to pursue. For girls, these competing interests were typically of a creative nature. This explanation relates to the 'cost' values component of the Eccles, Wigfield and colleagues' Expectancy-Value framework, which refers to what the individual has to give up in order to participate in maths. Students' other interests can be considered competing options within this perspective.

Not Being Good at Maths. The next most frequent reason given for not planning to have a maths-related career was not being good at maths (5 responses). This was given as a reason most frequently by students with unrealistic low talent perceptions (3 responses from group 5, 1 response from group 6), as well as by Jane from group 4 (girls with high talent perceptions and low performance). An example from group 5 was Tony, who despite quite liking maths did not consider himself good at it: "I think maths is okay but I'm not really that good at it".

Jane (group 4) had no intention of pursuing a maths-related career because she did not consider herself good at maths relative to her other school subjects. This was another example of girls' maths-related self-perceptions being contextualized against their self-perceptions in other academic domains: "Because it's not my best subject and I don't know what I'm going to do but I don't think it would be maths". Holly (group 6) neither enjoyed maths nor perceived herself as good at it. Her career plans were related to the arts, as was typical for the girls having interests apart from maths that they wished to pursue.

Holly: Because I'm not very good at it and I don't enjoy it at all, it's not what I want to spend my life doing.

Int: Do you know what you want to do yet?

Holly: Yep, I want to be an actress.

Disliking Maths. Disliking maths was a response given equally as often as not being good at maths (5 responses) for planning not to have a maths-related career. Similarly, this reason was given most often by adolescents having unrealistic low talent perceptions (groups 5 and 6: 4 responses), as well as by Joe who had unrealistic high talent perceptions (group 3). Joe was not interested in maths because he did not find it exciting: "I don't find it very interesting [laugh]... It's not a very exciting subject". Paul was an example from group 5 who stated that he hated maths because he perceived it to be factual, uncreative and not useful:

Paul: I just hate it because I'm more into – maths is like all facts, I'm more into like an ability to speak. I like arguments, trying to get yourself out of things. I don't like maths, I don't see a real point in maths. They say it's exercise, gymnastics for the mind. Like we are doing surds now and I asked the teacher 'where in my life am I going to use surds?' and she said 'never'. Then I don't see why I am actually doing it.

Jessica (group 6) was not interested in maths by comparison with other school subjects she enjoyed:

Jessica: Because I don't take that much interest in maths, it's not my favourite subject.

Int: What is? What is your favourite subject?

Jessica: I like doing art, music and history.

It appears that these boys did not find maths interesting in and of itself. Jessica's lack of interest in maths was relative to her greater interest in other creative subjects that she enjoyed, again reflective of a trend for girls to contextualize their maths-related perceptions against other academic domains.

Finding Maths Too Hard. Finding maths too hard was distinct from not being good at maths, since the former relates to 'task' and the latter to 'self' features. This response was given by Amy in group 4, who also made reference to being more interested in things other than maths:

Amy: As a job for me I don't think I can do it, like it's a bit hard for me...

Int: Okay. All right. Would you be interested in it though or would you be interested in other things?

Amy: More interested in other things.

DISCUSSION

Of the students who stated that they either planned to, or planned not to, pursue a maths-related career, responses all reflected key elements of the Expectancy-Value framework, with one addition relating to father expectations. Self-perceptions of ability, task difficulty and values were all reasons raised by respondents. The most common reason for planning to pursue a maths-related career was that the careers in which adolescents were interested *happened* to involve maths. Here, features of the intended careers that attracted adolescents were independent of their maths-relatedness. This relates to Eccles et al.'s 'utility value' construct which assesses the extent to which maths will be useful in students' planned careers (Wigfield & Eccles, 1992), although that construct does not really capture this 'incidental' aspect of student-described maths instrumentality. Self-perceptions of mathematical ability were the next most common reason for plans to pursue maths-related careers, with single responses reflecting intrinsic value and task difficulty. Values emerged as the most frequent determinant of maths-related career plans, followed by ability perceptions, with task difficulty perceptions infrequently mentioned. This pattern maps directly to propositions within the Expectancy-Value theoretical framework.

The most common reason for planning *not* to pursue a maths-related career was that students were interested in areas other than maths. Although related, this is distinct from lack of interest in maths, since having interests other than maths does not preclude also being interested in maths. These competing interests therefore relate to the 'cost' component of values as conceptualized by Eccles, Wigfield and colleagues (Eccles (Parsons) et al., 1983; Wigfield & Eccles, 1992, 2000), which refers to what the individual has to give up in order to participate in maths. Lack of interest in maths, the 'intrinsic values' component of the Expectancy-Value framework, was the next most frequent explanation, along with low self-perceptions of mathematical ability. Again, there was only one reference to maths being too hard, the 'task difficulty' component of the model.

Importantly, students' explanations for why they planned to pursue (or not pursue) maths-related careers corroborated major predictive factors in the Expectancy-Value model of Eccles, Wigfield and colleagues (Eccles (Parsons) et al., 1983; Wigfield & Eccles, 2000). Self- and values perceptions are posited to be the most immediate influences on students' plans for mathematics coursework participation in that model, and the present analysis has also extended this proposition to maths-related career participation, which has clear social relevance. Task difficulty features merited only a single mention, supporting notions that difficulty perceptions do not directly impact on academic choice outcomes (Eccles (Parsons) et al., 1983).

Through eliciting spontaneous student explanations regarding why they planned to either pursue, or not pursue, maths-related careers, this exploratory study supports the comprehensiveness of Expectancy-Value theorisation of self- and value perceptions being key

predictors of academic choice outcomes (Eccles (Parsons) et al., 1983; Wigfield & Eccles, 2000). In fostering students' plans for participation in maths-related careers, maths values, and to a lesser extent self-perceptions, are therefore of most concern. As in the Expectancy-Value model, values were found to be the strongest influence, followed by self-perceptions of mathematical ability. Value perceptions are proposed to be the most indicative of choice outcomes, particularly intrinsic value (Eccles (Parsons) et al., 1983; Eccles (Parsons), 1984), with the extent to which students are interested in and enjoy a subject being the primary influence on whether they elect to participate in it at its higher levels, both in senior high and planned careers. It is worth noting that for planned careers, intrinsic value was mentioned only once as a determinant of maths-related career plans; while the identified 'maths being instrumental to career of choice' theme was by far the most common response. Further work on notions of maths being instrumental, yet incidental, may be a fruitful area of expansion for that 'values' factor. Further research is also needed with older adolescents for whom career choice is more proximal, and young adults for whom this is an actuality.

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Acknowledgments:

Thank you to Steve Quodling for his invaluable assistance with interviewing. My thanks to Assoc. Prof. Ray Debus and Prof. Robert Young from the University of Sydney, and Dr Paul Richardson from Monash University, for their critical feedback on earlier versions of this manuscript.

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