Teacher Education

Policy, Practice and Research

Anthony Selkirk • Maria Tichenor

Editors

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ISBN-13: 978-1-60692-506-5
ISBN-10: 1-60692-506-7

9 781606 925065

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TEACHER EDUCATION: POLICY, PRACTICE AND RESEARCH

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Nova Science Publishers, Inc.
New York

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Teacher education : policy, practice, and research / editors, Anthony Selkirk and Maria Tichenor.
p. cm.
Includes index.
ISBN 978-1-60692-506-5 (hardcover)
1. Teachers--Training of. I. Selkirk, Anthony. II. Tichenor, Maria.
LB1707.T4225 2009
370.71'1--dc22

2008050271

Published by Nova Science Publishers, Inc. ✝ New York

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In: Teacher Education: Policy, Practice
Editors: Anthony Selkirk and Maria Tichenor

ISBN: 978-1-60692-506-5

Chapter 13

CHOOSING TO TEACH IN THE "STEM" DISCIPLINES: CHARACTERISTICS AND MOTIVATIONS OF SCIENCE, TECHNOLOGY, AND MATHEMATICS TEACHERS FROM AUSTRALIA AND THE UNITED STATES

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ABSTRACT

This study examines prospective "STEM" [Science, Technology, and Mathematics] teachers' motivations for undertaking a teaching career and their perceptions of the teaching profession, for undergraduate and graduate teacher education entrants from three major established urban teacher provider universities in the Australian States of New South Wales and Victoria (N = 245) and two from the United States in Michigan (N = 86). Motivations and perceptions were assessed using the recently developed and validated FIT-Choice [Factors Influencing Teaching Choice] Scale. Differences are highlighted between males and females, and undergraduates and graduates, including switchers from previous careers. Demographic profiles for STEM teacher candidates are also provided. Our findings suggest implications for enhancing the effectiveness of efforts to recruit mathematics, science and technology teachers.

INTRODUCTION

It is now commonplace for governments around the globe to affirm that science, technology, engineering and mathematics ("STEM") disciplines are the drivers of technological advancement, innovation and provide the foundational infrastructure to secure a robust economic future (e.g., National Committee for the Mathematical Sciences of the Australian Academy of Science, 2006). The STEM disciplines are characterised as the engine-room of economic development in a world where the wealthiest nations secure their economic edge through increasingly knowledge-based economies. Advanced and developing economies alike seek to ensure that their education systems provide a sufficient number of tertiary educated people in STEM (Roeser, 2006). In some highly developed countries this avowed aim is not always easily achieved and is increasingly accompanied by tensions and problems when the education system is not able to fulfil the labour force demands for skilled and talented individuals (Jacobs, 2005). Other countries such as India and China are investing heavily to ensure that participation in these disciplines will result in sufficient numbers of people being prepared to pursue higher education and careers in STEM (Roeser, 2006).

The United States secured a leading edge in science, technological and engineering innovation and development in the decades following World War II and through until the 1990s, by welcoming and educating top scientists from around the world. Now they are concerned that trends in educational attainment in secondary schools and universities have undermined that edge (e.g., Jacobs, 2005). Participation in the sciences and mathematics in secondary and tertiary education has exponentially declined in the United States over the last two decades, to the point where there is grave concern about the viability of those disciplines to sustain economic growth and development (Jacobs, 2005).

A similar concern exists in Australia where there is an increasing decline in STEM participation and educational attainment (Dow, 2003b). Not surprisingly, the Australian Government has identified the STEM disciplines as central to the critical infrastructure needed to secure economic success in an increasingly globally competitive and unpredictable world. Australia's future is seen to lie in its potential as a knowledge-based economy and society – one built on the knowledge, intellectual capabilities, and creativity of its people (National Committee for the Mathematical Sciences of the Australian Academy of Science, 2006). To achieve this potential, it will be necessary to raise the scientific, mathematical and technological literacy and the innovative capacity of students; strengthen the education system that provides the platform from which world class scientists and innovators emerge; and support the development of a new generation of excellent teachers of science, technology and mathematics (Dow, 2003a).

Well-educated university graduates in STEM are inexorably linked to the quality of education which children and adolescents receive at school. Clearly, well-educated specialist teachers of those disciplines are a critical to foster the next STEM generation. Without proper planning and careful management to ensure the education system provides a sufficient flow of knowledge workers through the STEM "pipeline", Australia could find itself in a similar situation to Norway where some secondary schools can no longer offer science (Lyng & Blichfeldt, 2003), creating a downward spiral of suitably qualified STEM professionals – including teachers. Even now in Australia, while there are acknowledged and increasingly insistent teacher shortages in rural and remote areas, there is also a specific shortage of STEM qualified teachers (Harris & Jansz, 2006; National Committee for the Mathematical Sciences of the Australian Academy of Science, 2006). Similarly pronounced lack of supply in STEM teachers is evident in a number of OECD countries (Lawrance & Palmer, 2003); a situation that is all the more concerning, given the rapid escalation in the need for STEM-related skills in the modern world, both in careers and everyday life.

Teacher Recruitment

In Australia, recruitment efforts for teachers have included a strong focus on graduate-level teacher preparation. Within this approach, individuals graduating from non-teaching university degrees as well as those working within other professions are eligible and encouraged to undertake a teaching qualification within a reduced timeframe. However, without well-educated teachers capable of drawing children and adolescents into a fascination with STEM fields, there will be little chance of sustaining the numbers who remain in the pipeline. The pipeline metaphor seems especially appropriate to STEM disciplines, in that later knowledge development is highly dependent on earlier knowledge frameworks. If children miss out earlier on, it will be all the more difficult for them to engage effectively with the higher levels of STEM study.

To make teaching more attractive, it has been argued that increasing its salary and improving the working conditions should attract school leavers, university graduates, and people from out of other careers into teaching (Harris & Jansz, 2006). Unfortunately, university graduates from the STEM disciplines are not particularly attracted to teaching as a career; and STEM disciplines are not popular among those already enrolled in teacher education (Lawrance & Palmer, 2003). A national Australian study commissioned by the Deans of Science and published in 2001 found that among science and technology graduates there was very little interest in a teaching career (McInnes, Hartley, & Anderson, 2001). The lack of enthusiasm by STEM graduates for a teaching career may be a direct function of the general shortage of STEM professionals, opening up the number and type of high-status and lucrative career options available to graduates in those fields, thereby exacerbating the difficulties of attracting new graduates and career switchers into a career teaching in STEM (Harris & Jansz, 2006). Parenthetically, few of the science education graduates in the national study held degrees in mathematics (2%), life and physical sciences (4-7%), or computer science (0%; McInnes, Hartley, & Anderson, 2001), signalling a need to examine profiles across the different STEM domains rather than shortages and solutions at an aggregate level. The present study consequently disaggregates and contrasts findings for mathematics, science and technology ("ICT"; Information Communication and Technology) teacher candidates.

The Teacher Shortage

The teaching force is ageing in many of the OECD countries, with half the teaching force aged over 40 in some European countries (European Commission, 2000). In Australia the median age of teachers was 43 in 2001, with 44% older than age 45 (DEST, 2003). Australian mathematics teachers are also older than the national average, signalling a particular imperative to encourage more people into mathematics teaching. Evidence from the Third International Mathematics and Science Study [TIMSS] further suggests that these mathematics and science teachers are not particularly happy with their job. Although the TIMSS study was designed to report on the learning of students aged 9, 13 and at the final year of secondary school from Africa, Asia, Europe, North America, South America, and Oceana (Australia and New Zealand), it also gathered fascinating data on the lives of teachers. Revealingly, it was the Australian and New Zealand teachers who represented the highest proportion who indicated they would "prefer to change to another career" (Lokan, Ford, & Greenwood, 1996, p.197). In mathematics in particular, 39% of teachers in a recent national study were undecided as to whether they would remain in teaching, and 16% actively planned to leave the profession (Harris & Jansz, 2006). The retirement-fuelled exodus of teachers from the "baby boom" generation will quickly escalate shortages in the STEM disciplines, creating more difficulties in already hard-to-staff schools in rural and urban areas. Even if this generation of teachers could be persuaded to stay on until they reached the retirement age of 65, this would only alleviate problems in the shorter term.

A further deeply embedded problem is that males are heavily concentrated into the older age groups of teachers and that a "disproportionate number of male science, mathematics and technology teachers are aged over 45" (Dow, 2003b). Although teaching is increasingly a feminised profession in many OCED countries including Australia, fewer girls and women are retained in the STEM pipeline progressively through senior high school, university studies, and career choices. Women drop out of the STEM disciplines even when their achievement in those disciplines is equal to or higher than that of males (Jacobs, 2005). In both the United States (e.g., Eccles (Parsons), 1984; Eccles, 1985; Jacobs, 2005) and in Australia this has been well documented in the case of mathematics (see Watt 2005, 2006; Watt, Eccles, & Durik, 2006). In a highly competitive job market facing a crisis in the availability of tertiary-trained workers (Birrell & Rapson, 2006), particularly in STEM, the women who *do* persist or excel in those domains can earn a higher salary and occupational status in careers other than teaching. The trend towards increasing numbers of women entering teaching, together with lower female participation in STEM disciplines, is likely to intensify the short-fall in STEM teachers.

The Present Study

We need to first be concerned about whether the shortage of STEM teachers can be met in the short and longer term; and secondly, whether those who are attracted into teaching in those disciplines have sufficient ability, personal interest in and enthusiasm for the sciences, mathematics and technology to enliven and sustain the interest of children and adolescents. Given the shortages of tertiary educated people across the labour market more generally, even those with low-level STEM skills may have more attractive and lucrative career options. It is not acceptable that in Australia for instance, 25% of mathematics and science teachers have no higher education in those domains (National Committee for the Mathematical Sciences of the Australian Academy of Science, 2006). To effectively engage children and adolescents in STEM requires teachers with content as well as pedagogical expertise.

Given the detractors we have outlined from teaching STEM and STEM-trained individuals' potential for finding other more lucrative work, we ask the question: Why do people still choose a teaching career in STEM? The purpose of our paper is to enquire into the profiles of characteristics, motivations, and perceptions of those who choose to pursue STEM qualifications with the intention of becoming teachers, including those who following a period of employment in another career have made the decision to become teachers. Participants are entire cohorts of those beginning STEM teacher education from 3 Australian and 2 United States universities.

Our study makes three particularly important contributions to the existing literature. First, studies which have previously focused on teacher characteristics for specific discipline areas have tended to closely examine particular groups in isolation, with the consequence that it has not been possible to discover factors peculiar to those groups. A strength of our study is that the STEM teacher sample forms a subset of our larger sample of 1,653 Australian and 552 United States beginning secondary, primary/elementary, and early childhood teachers from across 5 major universities. It is therefore possible to contrast characteristics and motivations for each of the mathematics, science and ICT subsamples, against the aggregate profiles we have described previously (see Richardson & Watt, 2006). Second, while a recent influential Australian national study focused on practising mathematics teachers (Harris & Jansz, 2006) has provided detailed statistics on their background characteristics and career intentions, we include additional information such as ethnic and socioeconomic backgrounds, and a stronger focus on motivations and perceptions. Third, teaching motivations were less rigorously investigated in that national study (via six "check-boxes" with an "other" option), and we have elsewhere argued the need for drawing upon established motivational frameworks and utilising rigorous measures in assessing motivations (Watt & Richardson, 2007).

The FIT-Choice scale (Factors Influencing Teaching Choice Scale; Watt & Richardson, 2007) is grounded in the Eccles et al. Expectancy-Value model (1983), which conceptualises and organises classes of motives to rigorously and comprehensively approach the question of what motivates people to choose a teaching career. Within the Expectancy-Value model, success expectancies and subjective task valuation are the major influences on participation choices. Developed to explain gendered senior high mathematics enrolments, it has since been applied to other school domains, and to mathematics-related career choices.

Previously, research into teachers' motivations has not drawn upon the extant motivation literature, but tended to examine variously operationalised listings of motives, not integrated within a solid theoretical framework. A comprehensive review of teacher motivations highlighted intrinsic, extrinsic and altruistic motivations as the most important (Brookhart & Freeman 1992). However definitional imprecision and overlapping categorisations are evident from one study to another; for example, the desire to work with children sometimes as an intrinsic but sometimes as an altruistic motivation.

The Expectancy-Value model provides a comprehensive framework into which we have incorporated previously identified motives from the teacher education literature. It additionally suggests the inclusion of expectancy motives, also emphasised within from the career choice literature which highlights related efficacy beliefs (e.g., Lent, Lopez, & Bieschke, 1993). Previously identified teaching motives fitted under Expectancy-Value "values", which further divide into intrinsic, utility, attainment, and cost values. The theorisation and psychometric validation of the FIT-Choice Scale had been previously detailed by Watt and Richardson (2007). The resultant theoretically robust FIT-Choice measure was validated across two cohorts of Australian preservice teachers (*N*s = 488, 652; Watt & Richardson, 2007).

The present study consequently implements a comprehensive, validated, reliable measure for teaching motivations and perceptions, and explores differences between mathematics, science, and ICT prospective teachers within two different yet culturally similar country settings – both of which face similar difficulties in attracting STEM teachers.

METHOD

Sample and Setting

Participants ($N = 331$) were beginning teacher education candidates in STEM programs at three Australian ($N = 245$) and two United States ($N = 86$) universities who each comprise a subsample of total beginning teacher cohorts in the three Australian (total $N = 1653$; see Richardson & Watt, 2006) and the two United States universities (total $N = 552$). Response rates were high in the full samples, ranging upwards from 75%, implying our findings represent the population characteristics for each of the five universities.

Measures

Teacher education candidate characteristics. Participants stated their age in years, and checked boxes to indicate their gender, undergraduate or graduate enrolment, and secondary teaching strand/s. Strands were grouped into science, ICT, mathematics, humanities, visual and performing arts, social studies, TESOL [Teaching English as a Second Language], and LOTE [Languages Other Than English]. Graduate entrants who indicated that they had previously pursued another career were asked to list details of that career, which were then classified as STEM-related or not.

Family background. Participants indicated their parents' combined income from when they were in high school as an indicative measure for background socioeconomic status (SES). Income categories were \$0-30,000, \$30,001-60,000, \$60,001-90,000, \$90,001-120,000, \$120,001-150,000, \$150,001-180,000, \$180,001-210,000, \$210,001-240,000, and \$240,000 or above. They also nominated their parents' occupations, which were subsequently coded as "STEM-related" or not, and as "teachers" or not. Participants nominated the language mainly spoken at home, coded as ESB [English speaking background] and NESB [non-English speaking background].

Motivations for teaching. Participants' motivations for choosing teaching as a career were assessed using the FIT-Choice scale (for full details about the scale development and validation see Watt & Richardson, 2007). These motivations are presented as part of Figure I and include intrinsic values, personal utility values (job security, time for family, job transferability), social utility values (shape future of children/adolescents, enhance social equity, make social contribution, work with children/adolescents), self perceptions of individuals' own teaching abilities, the extent to which teaching had been a "fallback" career choice, social influences, and prior positive teaching and learning experiences. Each factor was measured by multiple item indicators whose response options ranged from 1 (not at all important) through 7 (extremely important). A preface to all motivation items in the scale was "I chose to become a teacher because…", which was typed in large bold-faced font at the top of each page.

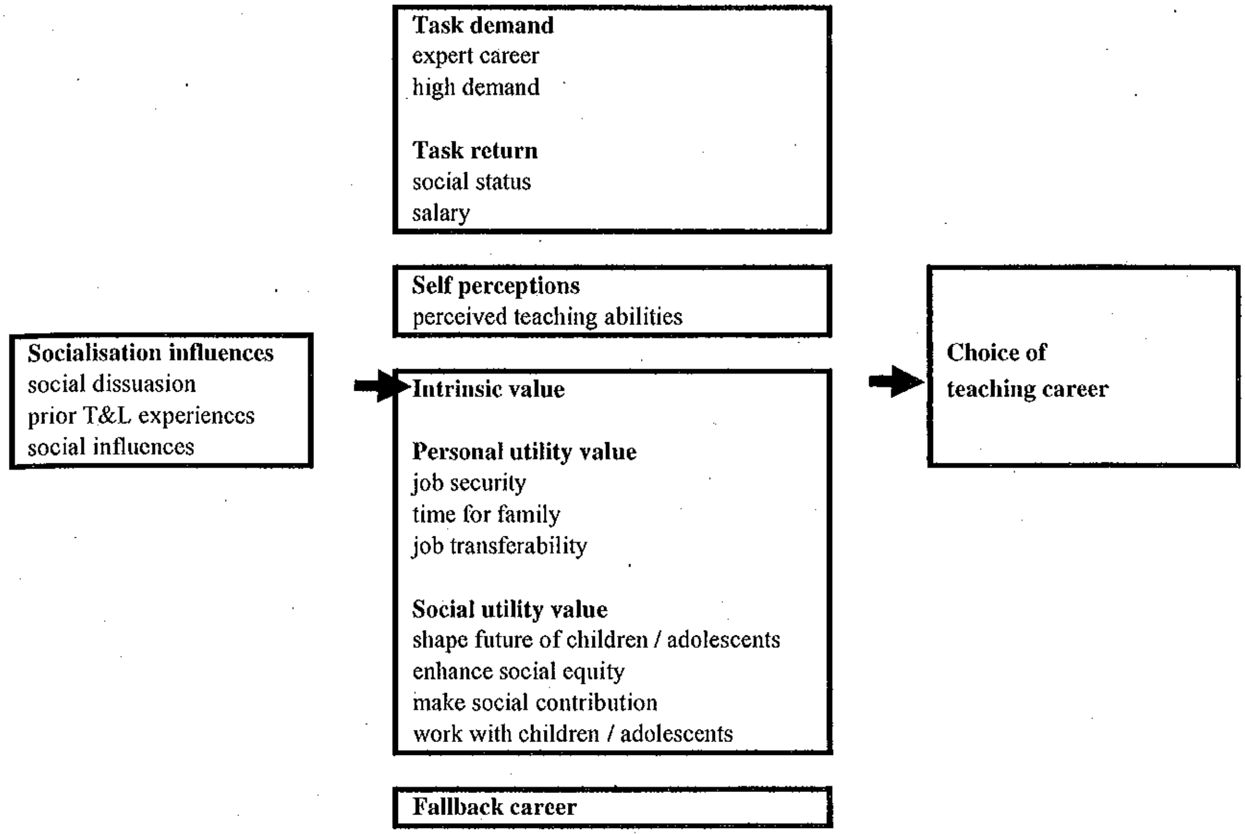

Figure I. The FIT-Choice framework: Motivations for choosing a teaching career.

Perceptions about the profession. Participants also rated the extent of their agreement with a number of propositions about the teaching profession, with response options ranging from 1 (not at all) through 7 (extremely). Multiple propositions together comprised factors relating to the extent to which respondents perceived teaching as high in task demand (expert career, high demand), and as high in task return (social status, salary).

Career choice satisfaction. Participants' career choice satisfaction was measured by three items with response options again ranging from 1 (not at all) through 7 (extremely). As part of this section, participants also rated the extent to which they had experienced social dissuasion from teaching as a career choice.

Procedure

Surveys were conducted early in the academic year 2002/2003. They were administered in tutorial class groups to enhance data integrity and allow for clarification of respondent queries. Administration was by the researchers and two trained assistants, with University ethics approval, consent of program coordinators, and informed consent of all participants. It took approximately 20 minutes for participants to complete the survey.

RESULTS

Who Chooses Teaching?

Initial background profiles for each university summarised degree enrolments, proportions of females and males, and English Speaking Background [ESB] vs. NESB, within each enrolment strand. Tabulated frequencies describe enrolments within each of undergraduate and graduate science, ICT, mathematics, and other teacher education strands (Table 2), and percentages summarise the proportion of females and ESB home language within each strand. Age profiles were developed within each STEM strand, represented using line-graphs. Indicative SES profiles were created based on participant-reported combined parental income, again using line-graphs within each STEM strand. Proportions of participants who had parents from STEM-related and teaching careers were presented by bar charts. For the subset of graduate participants who indicated they had pursued a previous career, bar charts displayed percentages whose prior career was in STEM.

Cultural background. Within each of the Australian universities there was a high proportion of STEM teacher education students from English speaking backgrounds (see Table 1) although this proportion was slightly lower than across the full Australian sample (85%; see Richardson & Watt, 2006). In the United States sample, all but one of the students from each of the two universities came from an English speaking background (Table 1).

Table 1. STEM Representation Across University, Gender and ESB Groups

		math n's UG / grad	ICT n's UG / grad	science n's UG / grad	Totals † UG / grad
Australia	Univ. 1	12 / 13	2 / 2	23 / 20	29 / 26
	Univ. 2	13 / 30	6 / 20	16 / 54	24 / 78
	Univ. 3	11 / 33	3 / 17	14 / 38	20 / 68
	Totals	36 / 76	11 / 39	53 / 112	73 / 172
	% Female	42.9	44.0	55.2	52.7
	% ESB	70.5	70.0	85.5	78.0
United States	Univ. 4	8 / 4	2 / 2	24 / 4	31 / 7
	Univ. 5	22 / 11	2 / 1	8 / 17	28 / 20
	Totals	30 / 15	4 / 3	32 / 21	59 / 27
	% Female	53.3	57.1	67.9	61.6
	% ESB	100.0	100.0	96.2	97.7
Combined sample	**Grand totals**	**66 / 91**	**15 / 42**	**85 / 133**	**132 / 199**
	% Female	**45.9**	**45.6**	**58.3**	**55.0**
	% ESB	**79.0**	**73.7**	**88.1**	**83.1**

† *Note.* Totals for numbers of undergraduates and graduates within each university are not summed totals for mathematics, ICT, and science, because 102 individuals studied more than one STEM domain (82 in Australian and 20 in U.S. sample): 23 individuals are represented in each of mathematics and ICT (19 Australian and 4 U.S.), 77 in each of mathematics and science (62 Australian and 15 U.S.), and 2 in each of science and ICT (1 Australian and 1 U.S.).

Gender representation. While just over half the STEM teacher education students were female (Table 1), this proportion was considerably lower than the representation of females across the full cohort. The proportion of females was somewhat lower in the Australian sample (52.7%) compared with the U.S. (61.6%; Table 1), however, in general, the samples from both settings appeared rather similar. Enrolments within each STEM strand were slightly more male dominated for mathematics and ICT, and slightly more female dominated for science (see Table 1). The mathematics statistics reflect the similar proportions which have been documented for male and female practising teachers (Harris & Jansz, 2006).

Table 2. Teaching Specialisms

	Combined sample			Australian			United States		
	math (*N* = 157)	ICT (*N* = 57)	science (*N* = 218)	math (*N* = 112)	ICT (*N* = 50)	science (*N* = 165)	math (*N* = 45)	ICT (*N* = 7)	science (*N* = 53)
Mathematics	24†	23	77	23†	19	62	1†	4	15
ICT	23	14†	2	19	14†	1	4	0†	1
Science	77	2	115†	62	1	86†	15	1	29†
Humanities	15	5	8	3	5	5	12	0	3
Visual and performing arts	1	2	0	1	2	0	0	0	0
Social Studies	12	9	15	5	5	12	7	4	3
TESOL	0	4	0	0	4	0	0	0	0
LOTE	10	2	1	3	2	0	7	0	1
Sport	2	0	2	0	0	0	2	0	2

Note: † indicates number of students whose only method of study was either mathematics, ICT or science.

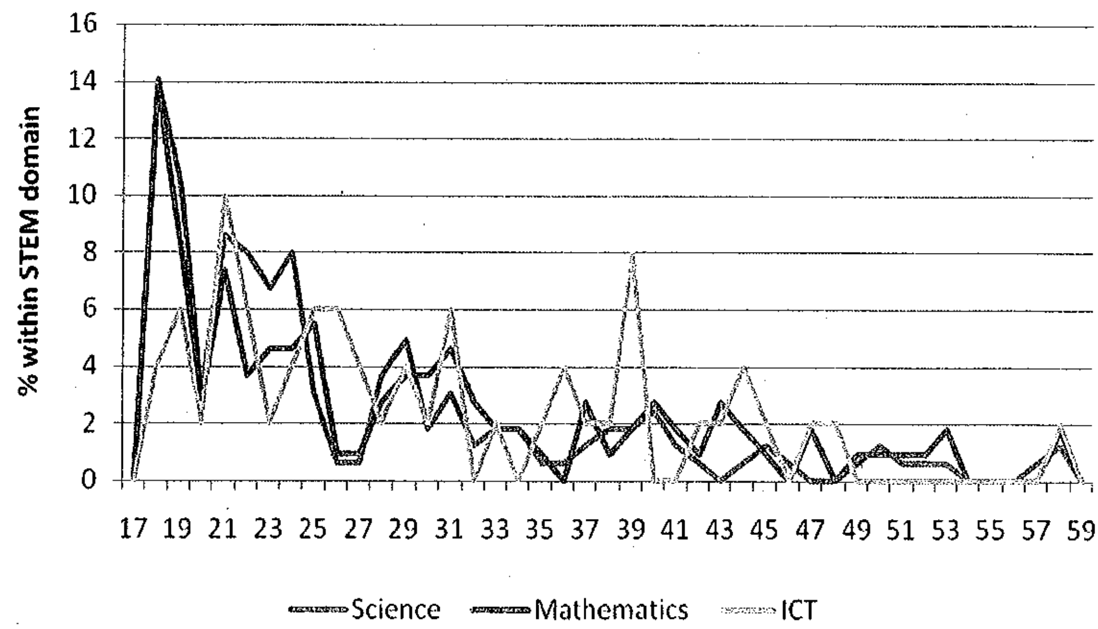

Figure IIA. Age profiles for beginning teacher education candidates in STEM disciplines in Australian sample. Note. Summary statistics for science: M = 26.92, SD=9.55; ICT: M = 30.26, SD = 9.57; mathematics: M = 29.23, SD = 10.62.

Age profiles. Age tended to be slightly higher for ICT, followed by mathematics, and then by science (see Figures IIA and IIB). Summary statistics for science reflected typical ages of graduates in our full sample, while ICT and mathematics teacher candidates were on average 4-5 years older.

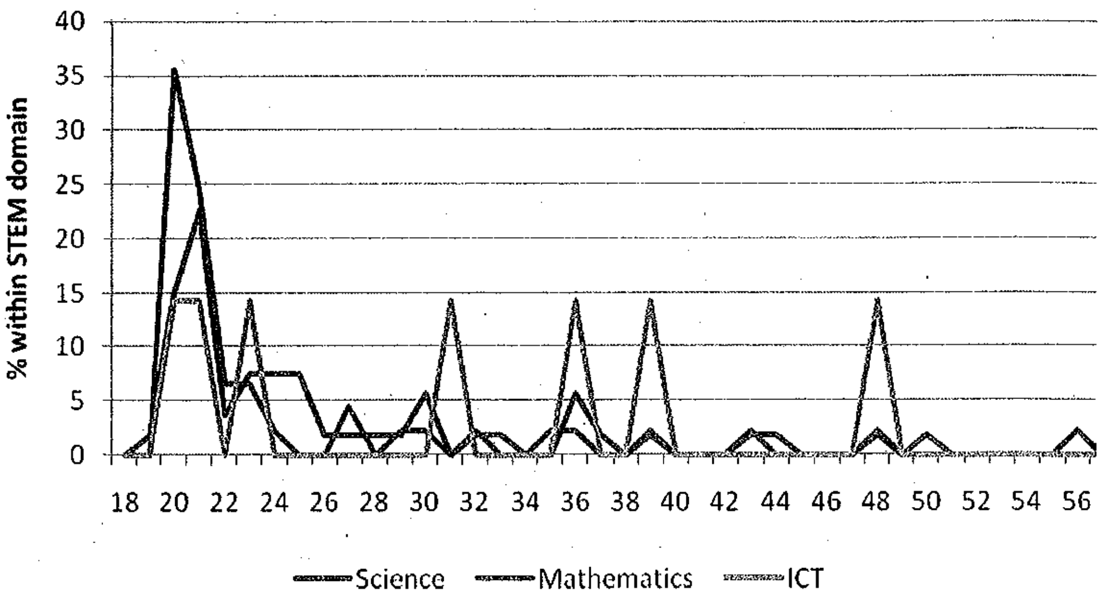

Figure IIB. Age profiles for beginning teacher education candidates in STEM disciplines in U.S. sample. Note. Summary statistics for science: M = 26.36, SD = 7.76; ICT: M = 31.14, SD = 10.51; mathematics: M = 24.71, SD = 8.18.

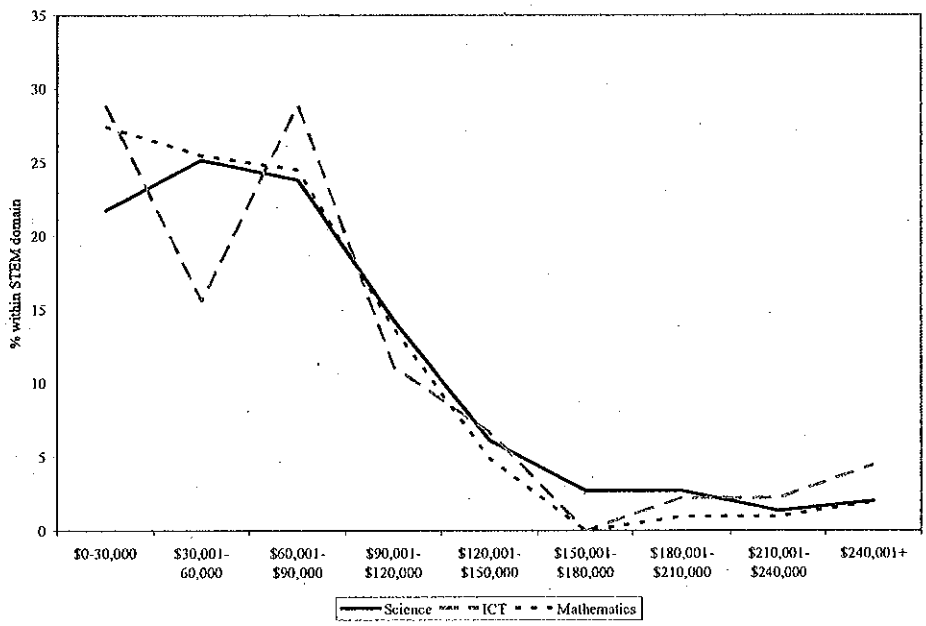

Figure IIIA. Combined parent income for beginning teacher education candidates in each STEM discipline (indicative SES) in Australian sample. Note. Summary statistics for science: M = 2.96, SD = 1.81; ICT: M = 2.98, SD = 2.07; mathematics: M = 2.64, SD = 1.64 (Income values: 1: $0-30,000, 2: $30,001-60,000, 3: $60,001-90,000, 4: $90,001-120,000, 5: $120,001-150,000, 6: $150,001-180,000, 7: $180,001-210,000, 8: $210,001-240,000, 9: $240,000 +).

SES income backgrounds. Participant-reported combined parent income categories were somewhat lower on average for mathematics vs. science and ICT teacher candidates (see

Figures IIIA and IIIB). All distributions were positively skewed, indicating that a greater concentration of participants came from the lower parent income categories provided for in the survey. For all three STEM domains, SES backgrounds were below those from the full sample, in which the median and modal category was $60,001-$90,000.

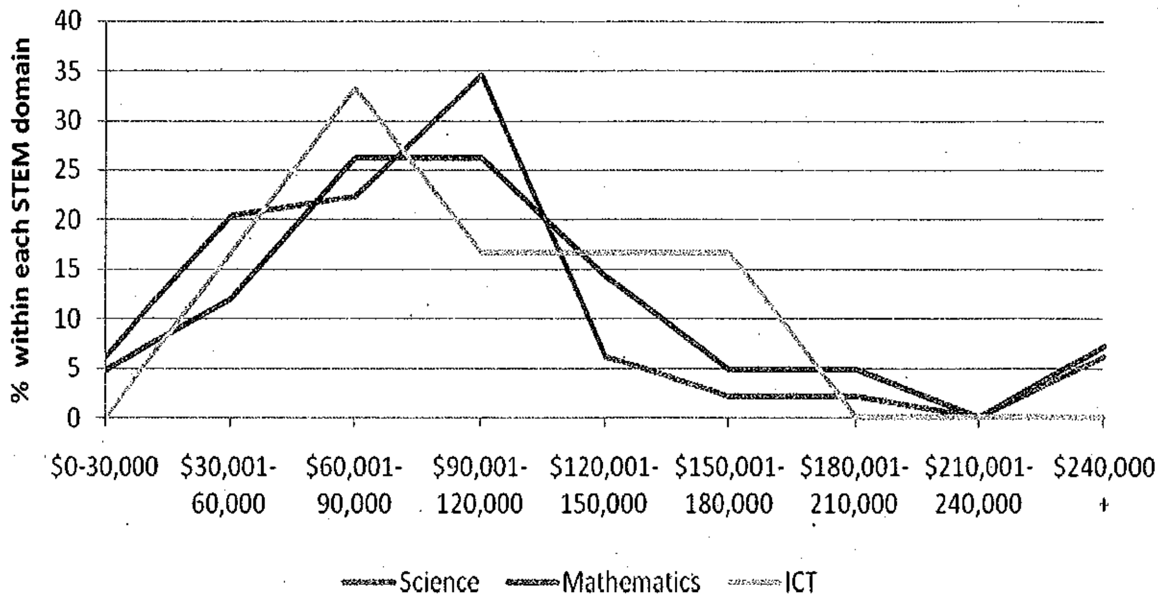

Figure IIIB. Combined parent income for beginning teacher education candidates in each STEM discipline (indicative SES) in U.S. sample. Note. Summary statistics for science: M = 3.65, SD=1.84; ICT: M = 3.83, SD = 1.47; mathematics: M = 4.10, SD = 1.95.

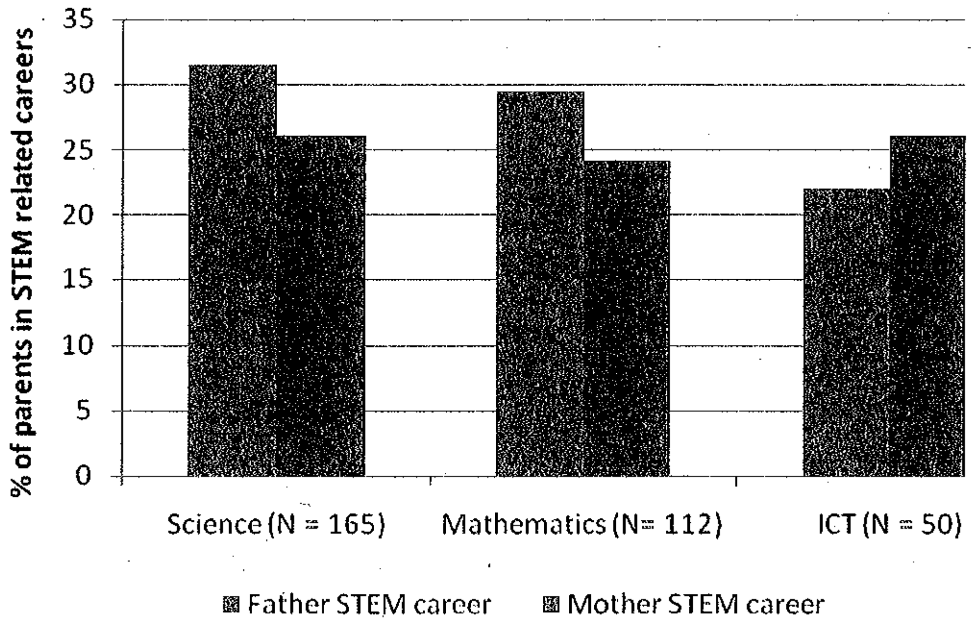

Figure IVA. Proportions of parents of Australian teacher education students from STEM-related careers.

Parental background. A considerable number of preservice STEM teachers had parents who worked in STEM-related areas. 97 participants (29%) reported their fathers worked in a STEM-related area (29%), and 72 (22%) of mothers. 34 (10%) had both parents working in STEM-related areas (see Figures IVA and IVB for a breakdown by speciality and location). Smaller proportions of candidates reported that their parents were teachers. 45 (14%) reported their mother was a teacher and 16 (5%) had fathers who were teachers. 8 (2%) reported both their parents were teachers (see Figure IVC and IVD).

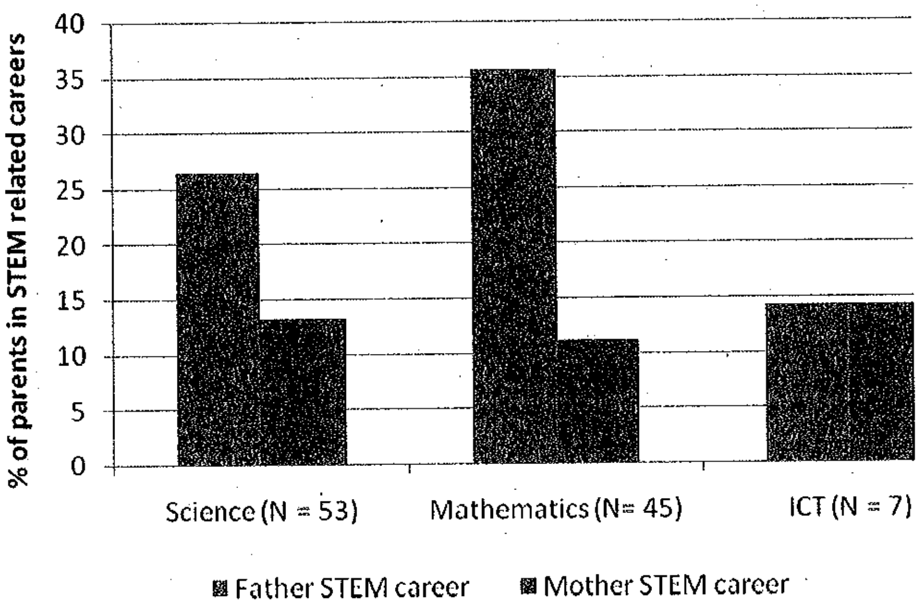

Figure IVB. Proportions of parents of U.S. teacher education students from STEM-related careers.

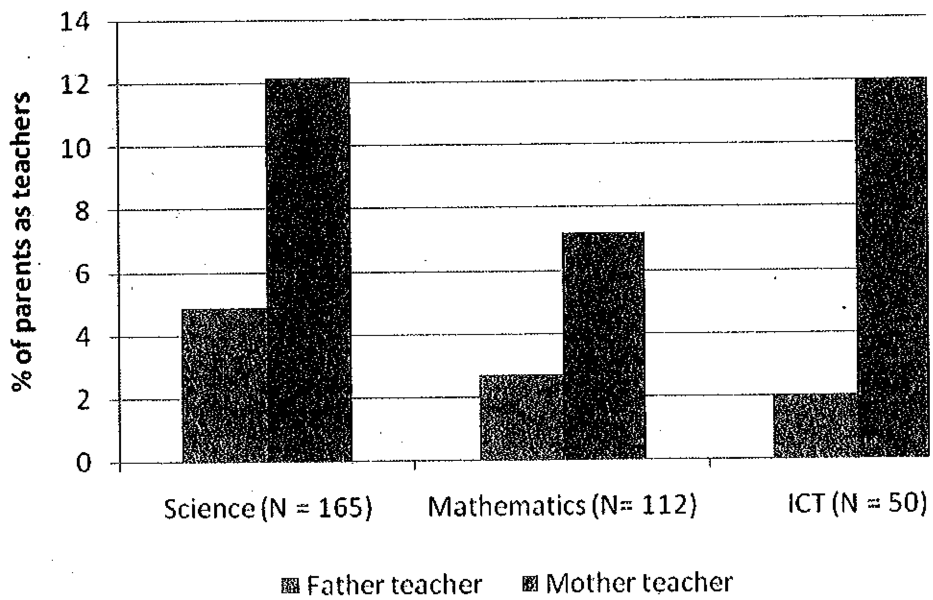

Figure IVC. Proportions of parents of Australian teacher education students in teaching careers.

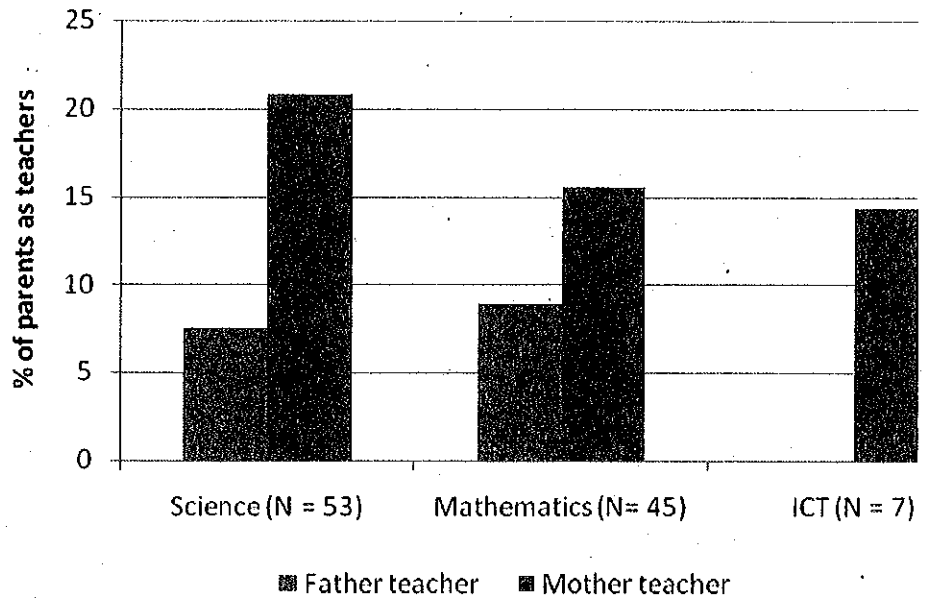

Figure IVD. Proportions of parents of U.S. teacher education students in teaching careers.

"Career switcher" backgrounds. A large number of graduate-entry teacher candidates in each STEM discipline reported having previously pursued another career (see Note to Figure V). These proportions were considerably higher than those aggregated across the full samples, where the proportion was approximately one-third (Richardson & Watt, 2006). Of these, most had come from prior STEM careers (Figure V).

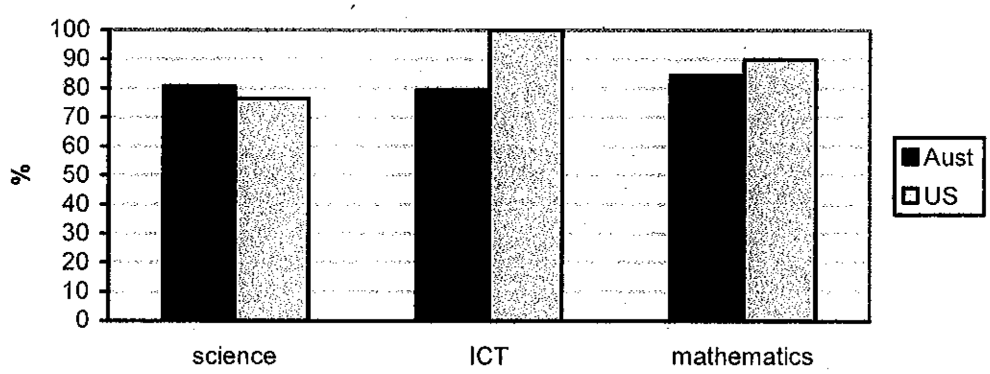

Figure V. Proportions of graduate entry career switchers coming from STEM-related previous careers. Note. Numbers of graduate entry career switchers in Australian sample: science n = 52, ICT n = 24, mathematics n = 39; in United States sample: science n = 17, ICT n = 3, mathematics n = 10.

Why Choose Teaching?

Motivations for choosing teaching as a career, perceptions about the teaching profession, and career choice satisfaction were summarised by mean factor scores for participants within each STEM strand, displayed using histograms. Multivariate analyses of variance (MANOVAs) subsequently tested for statistically significant differences within each STEM strand between undergraduates and graduates, males and females, and interaction effects. Alpha was set at 0.05 in view of the sample size. Australian and United States samples were also compared within STEM strands for any significant differences in motivations for choosing teaching and perceptions of teaching as a career.

Motivations for teaching. Within each STEM discipline the highest rated motivations for choosing teaching were perceived teaching abilities, the desire to make a social contribution, to shape the future of students, the intrinsic value of teaching as a career, and the desire to work with children or adolescents. The lowest rated motivation was choosing teaching as a "fallback" career, followed by the social influences of others encouraging them to undertake a teaching career. These patterns of motivations are consistent with the patterns previously documented for teachers across different domains and areas of teaching (see Richardson & Watt, 2006).

Few systematic differences were evident between the teaching motivations for undergraduates and graduates within the different STEM domains in the combined sample. Prior teaching and learning experiences were more important to undergraduates than graduates training to be science teachers (Pillai's trace = 0.108, $F(1, 196) = 13.028, p < 0.001$, partial $\eta^2 = 0.062$, *M*s 5.54 and 4.73). There were no other significant differences between undergraduates and graduates in their motivations for pursuing teaching. Differences between males and females were also rare: Females in science rated working with children / adolescents as a more important motivation than males (Pillai's trace = 0.112, $F(1, 196) = 6.811$, $p = 0.010$, $\eta^2 = 0.034$, *M*s 5.23 and 4.87), and there was also a significant interaction between gender and degree (Pillai's trace = 0.053, $F(1,196) = 5.321$, $p = 0.022$, $\eta^2 = 0.026$). While undergraduate females in science were more motivated than undergraduate males by their desire to work with children / adolescents ($M = 5.5$ for females and $M = 4.6$ for males), this gender difference was not evident among the graduate-entry candidates ($M = 5.00$ for females and $M = 4.99$ for males).

Males and females training to be mathematics or ICT teachers also reported different levels of motivation in terms of their desire to work with children / adolescents. Females were more motivated by this factor than males both in mathematics (Pillai's trace = 0.211, $F(1,148) = 4.749$, $p = 0.031$, $\eta^2 = 0.031$, *M*s 5.47 and 5.02), and in ICT (Pillai's trace = 0.212, $F(1,52) = 6.125$, $p = 0.017$, $\eta^2 = 0.105$, *M*s 5.75 and 4.74). Conversely, males in mathematics rated job transferability (Pillai's trace = 0.211, $F(1, 148) = 9.790$, $p = 0.002$, $\eta^2 = 0.063$, *M*s 4.26 and 3.60) and choosing teaching as a fallback career (Pillai's trace = 0.211, $F(1, 148) = 8.703$, $p = 0.004$, $\eta^2 = 0.057$, *M*s 2.51 and 1.94) significantly higher than females.

Between the Australian and United States samples, a number of significant differences were evident in teaching motivations, for those training to be science teachers (Pillai's trace = 0.149, $F(12, 187) = 2.725$, $p = 0.002$, $\eta^2 = 0.149$) and mathematics teachers (Pillai's trace = 0.195, $F(12, 136) = 2.744$, $p = 0.002$, $\eta^2 = 0.195$) (see Figures VIA, VIB and VIC). No significant differences were found for ICT teachers, however, this was most likely due to the very small number of students training to be ICT teachers in the United States sample.

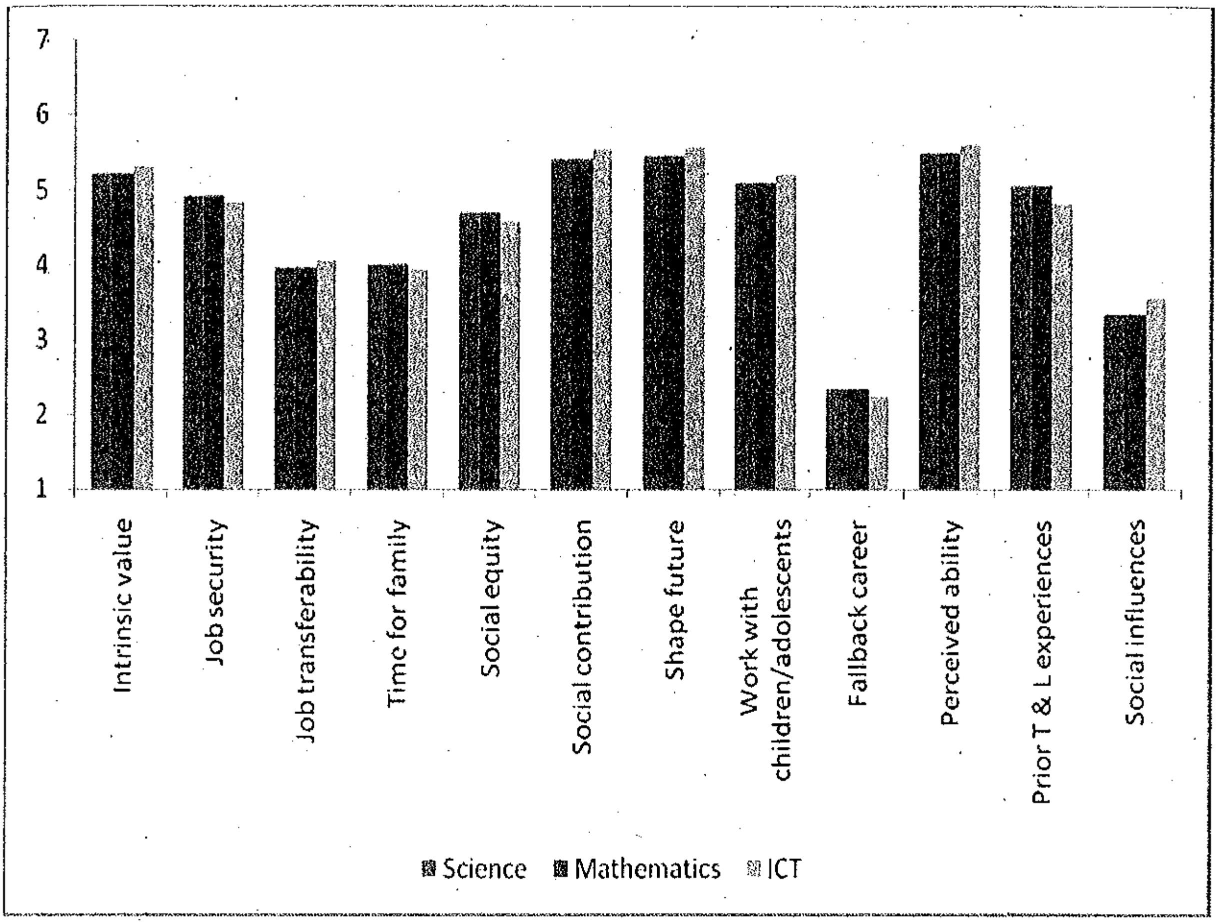

Figure VI. Factors influencing teaching choice for teacher education candidates within each STEM discipline.

For science teachers, students from the United States gave higher ratings for the motivations of intrinsic value of teaching ($F(1, 198) = 9.358$, $p = 0.003$, $\eta^2 = 0.045$, *M*s 5.58 and 5.04), perceived ability ($F(1, 198) = 4.669$, $p = 0.032$, $\eta^2 = 0.023$, *M*s 5.74 and 5.40), desire to work with children / adolescents ($F(1, 198) = 15.071$, $p < 0.001$, $\eta^2 = 0.071$, *M*s 5.73 and 4.86), and prior positive teaching and learning experiences ($F(1, 198) = 15.836$, $p < 0.001$, $\eta^2 = 0.074$, *M*s 5.75 and 4.81). On the other hand, Australian science teaching candidates rated choosing teaching as a fallback career as a stronger motivation than their United States counterparts ($F(1, 198) = 11.898$, $p = 0.001$, $\eta^2 = 0.057$, *M*s 2.56 and 1.83).

Similarly, students training to be mathematics teachers from the United States gave higher ratings for the motivation to work with children / adolescents ($F(1, 147) = 10.717$, $p = 0.001$, $\eta^2 = 0.068$, *M*s 5.73 and 4.98) and prior positive teaching and learning experiences ($F(1, 147) = 10.484$, $p = 0.001$, $\eta^2 = 0.067$, *M*s 5.79 and 5.05). As with the students training to be science teachers, students training to be mathematics teachers in Australia were more likely to choose teaching as a "fallback" career ($F(1, 147) = 5.093$, $p = 0.025$, $\eta^2 = 0.033$, *M*s 2.41 and 1.87). Additionally, they were more motivated by job security ($F(1, 147) = 3.991$, $p = 0.048$, $\eta^2 = 0.026$, *M*s 4.83 and 4.28) and the job transferability afforded by a teaching career ($F(1, 147) = 7.881$, $p = 0.006$, $\eta^2 = 0.051$, *M*s 4.18 and 3.44).

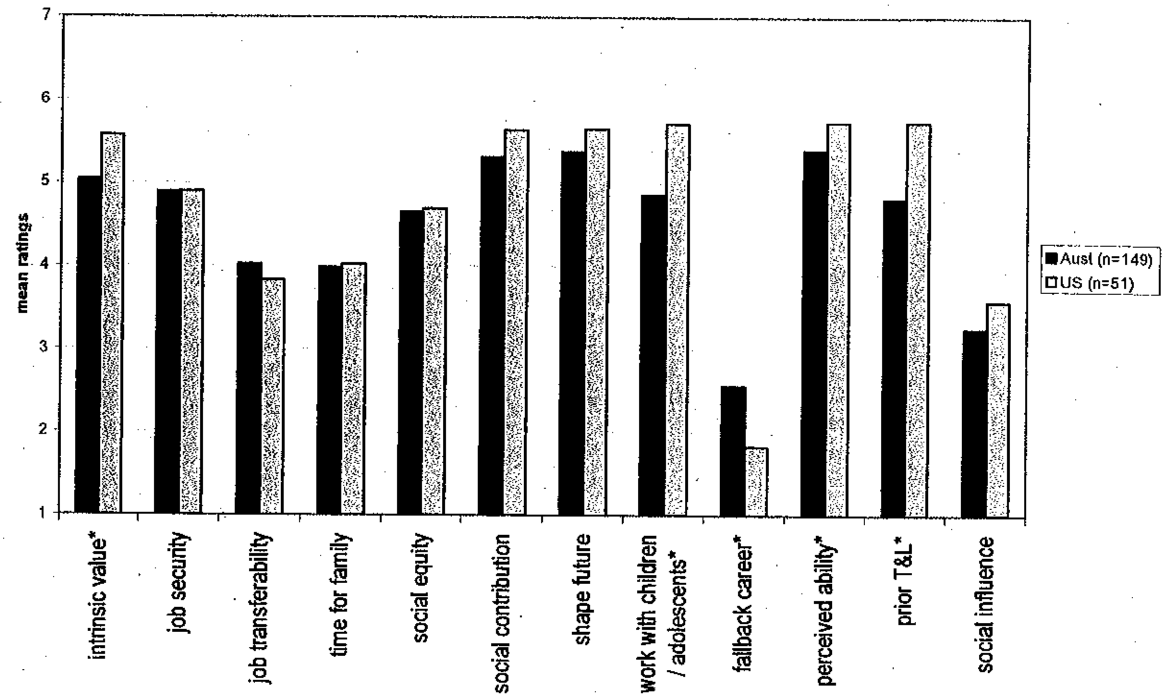

Figure VIA. Factors influencing teaching choice for science teacher education candidates across settings. Note. "*" denotes statistically significant differences between settings (df = 1,198, p < .05).

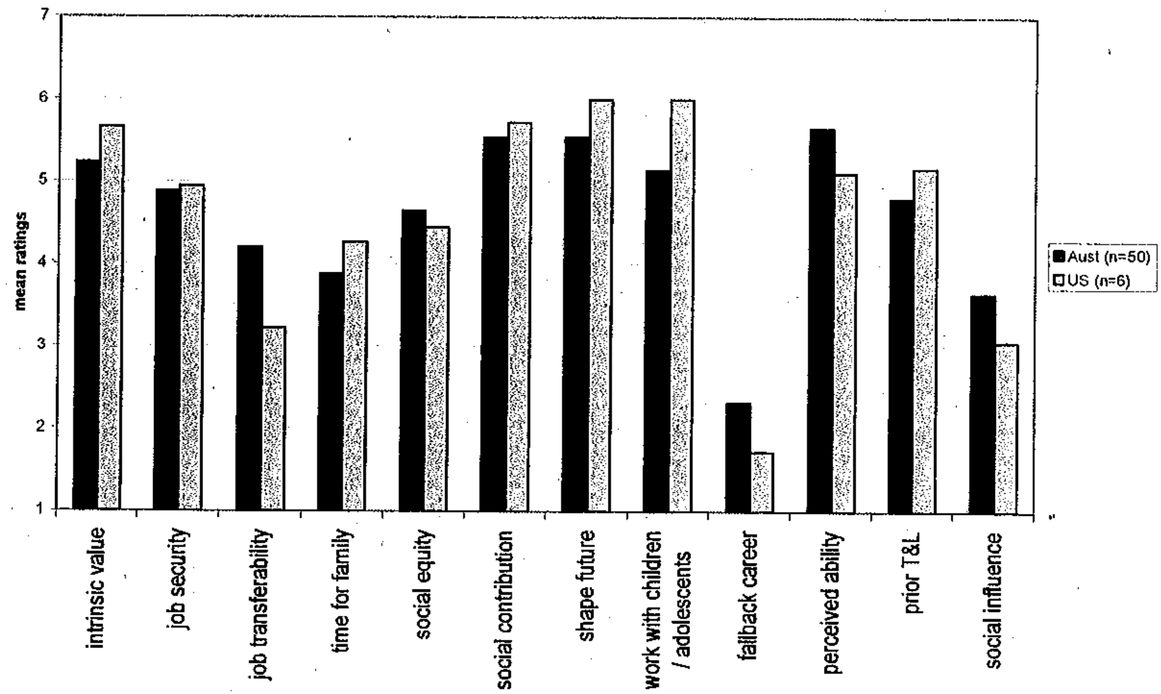

Figure VIB. Factors influencing teaching choice for ICT teacher education candidates across settings. Note. low US numbers imply statistically significant differences are unlikely to be detected, explaining the absence of any significant effects (df = 1,54).

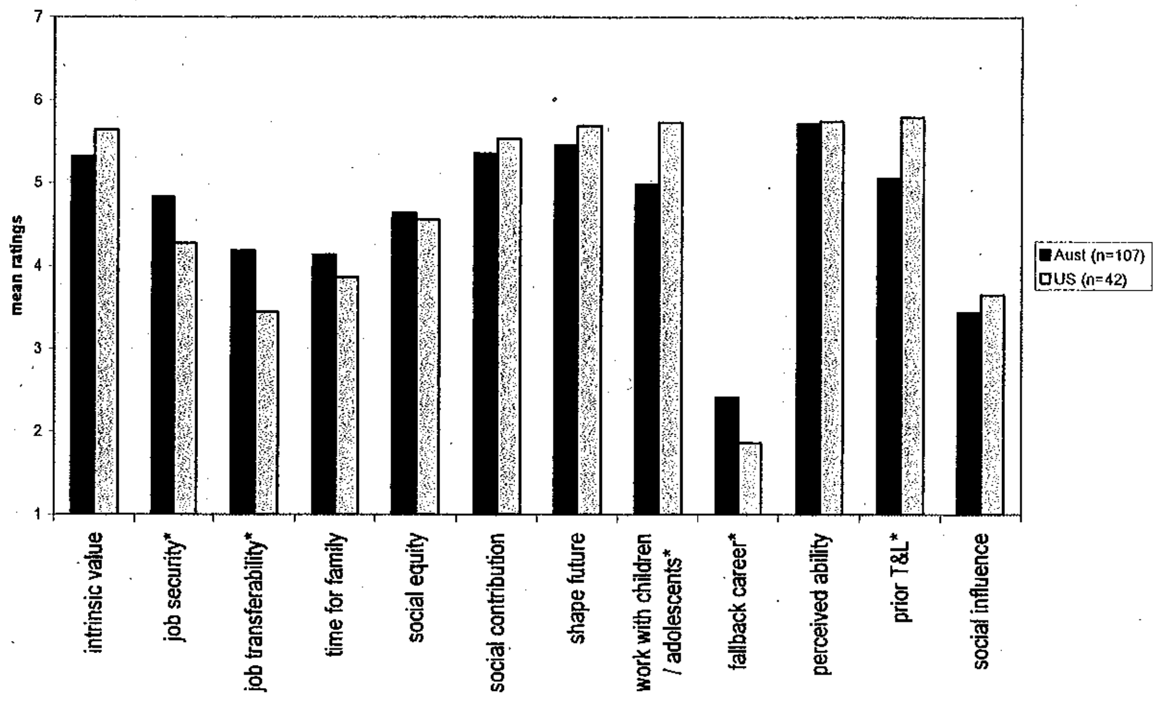

Figure VIC. Factors influencing teaching choice for mathematics teacher education candidates across settings. Note. "*" denotes statistically significant differences between settings (df = 1,147, p < .05).

Perceptions about the profession. Participants generally perceived teaching to be a career which is high in demand – and low in return. Figure VII summarises the mean ratings for candidates studying to become teachers within each STEM discipline. Participants rated teaching as a highly demanding career with a heavy workload that makes high emotional demands and requires considerable hard work. Candidates in each of the STEM disciplines also rated teaching as a highly expert career requiring specialised knowledge and abilities. At the same time, teaching as a career was perceived to be relatively low in terms of salary and social status. Again, there were very few differences between undergraduates and graduates within each of the disciplines. For both science (Pillai's trace = 0.098, $F(1,204) = 17.543$, $p < 0.001$, $\eta^2 = 0.079$, *M*s 6.23 and 5.81) and mathematics teacher candidates (Pillai's trace = 0.063, $F(1,148) = 8.994$, $p = 0.003$, $\eta^2 = 0.057$, *M*s 6.09 and 5.66), graduates rated teaching higher in demand than undergraduates. A significant interaction between gender and degree occurred for students training to be science teachers on the "expertise" factor (Pillai's trace = 0.032, $F(1,204) = 5.856$, $p = 0.016$, $\eta^2 = 0.028$). For males in science, graduates perceived teaching to require a higher level of expertise ($M = 5.53$ for graduates and $M = 4.98$ for undergraduates); while for females in science, undergraduates rated the required expertise of teaching higher ($M = 5.22$ for graduates and $M = 5.45$ for undergraduates).

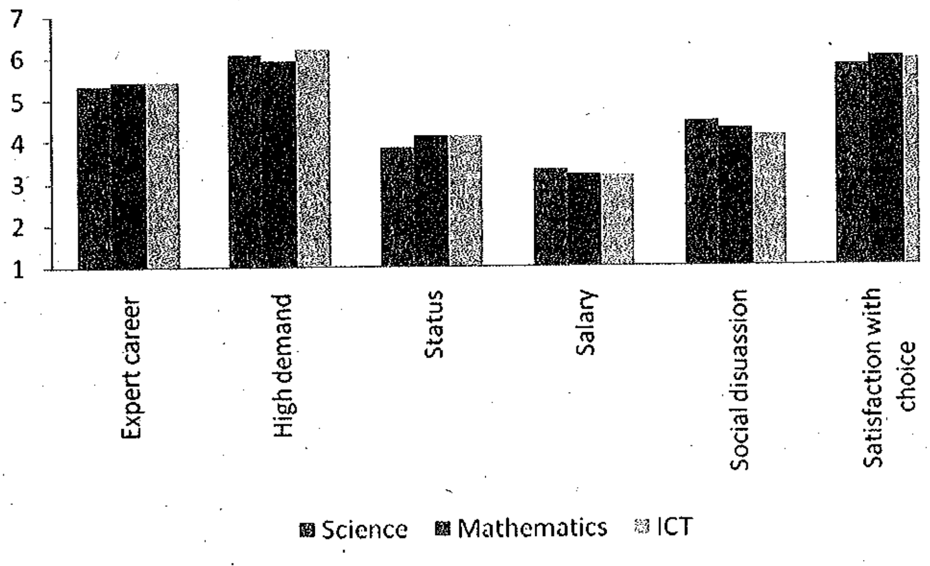

Figure VII. Perceptions about teaching for teacher education candidates within each STEM discipline.

There were few gender differences for perceptions of teaching. Females in ICT rated the demands of teaching higher than males (Pillai's trace = 0.115, $F(1,52) = 4.20$, $p = 0.046$, $\eta^2 = 0.075$, *Ms* 6.45 and 5.97). This was also the case for females vs. males in mathematics (Pillai's trace = 0.211, $F(1,148) = 5.41$, $p = 0.02$, $\eta^2 = 0.035$, *Ms* 6.08 and 5.77). Males in science rated teaching salaries significantly lower than females (Pillai's trace = 0.069, $F(1,204) = 4.749$, $p = 0.005$, $\eta^2 = 0.037$, *Ms* 2.96 and 3.52); while females in science rated the demands of teaching significantly higher than males (Pillai's trace = 0.069, $F(1,204) = 5.71$, $p = 0.018$, $\eta^2 = 0.027$, *Ms* 6.16 and 5.94).

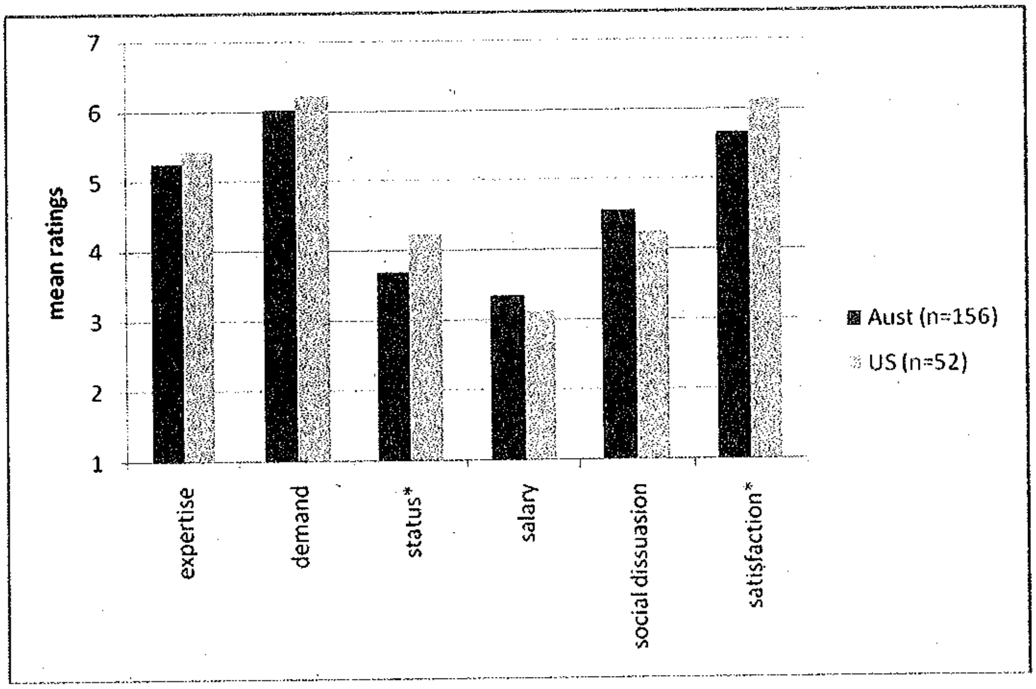

Figure VIIA. Perceptions about teaching for science teacher education candidates across settings. Note. "*" denotes statistically significant differences between settings (df = 1,206, p < .05).

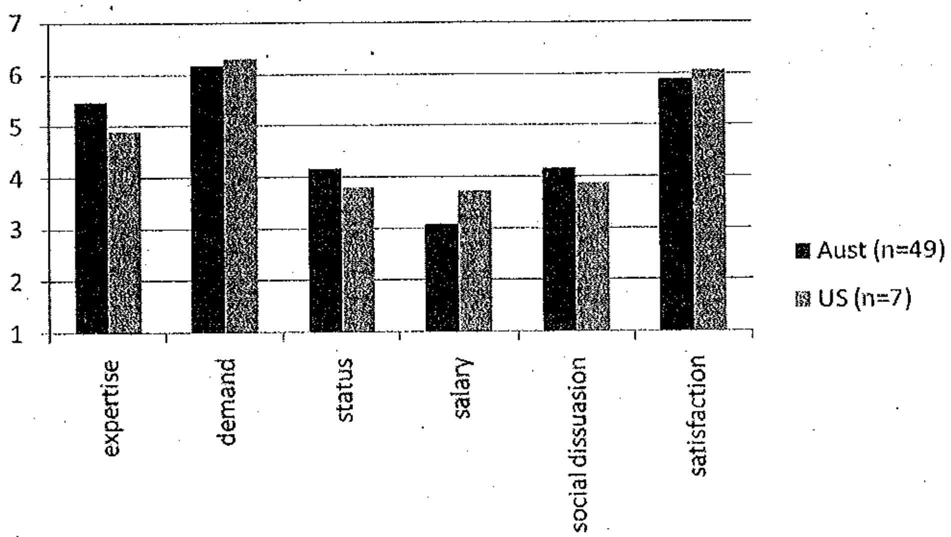

Figure VIIB. Perceptions about teaching for ICT teacher education candidates across settings (df = 1,54).

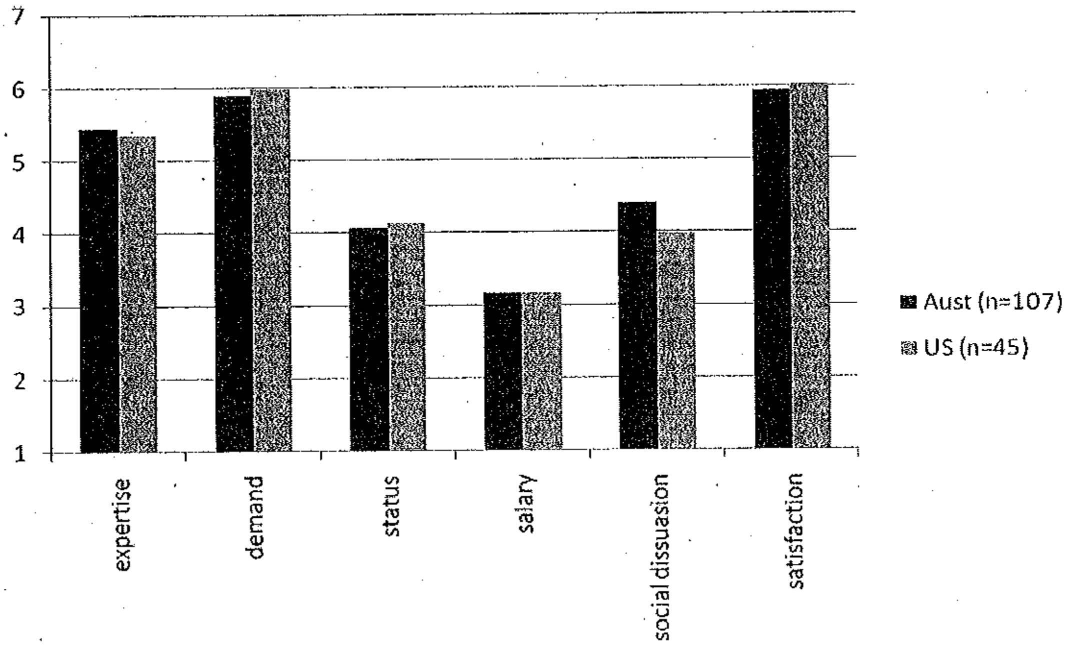

Figure VIIC. Perceptions about teaching for mathematics teacher education candidates across settings (df = 1,150).

Between the Australian and United States samples there were very few differences in perceptions of teaching as a career. The two significant differences were both for science teacher candidates: United States candidates rated the status of teaching higher (Pillai's trace = 0.104, $F(1,206) = 8.808$, $p = 0.003$, $\eta^2 = 0.041$, *M*s 4.23 and 3.68), and reported higher levels of satisfaction with their choice of a teaching career (Pillai's trace = 0.104, $F(1,206) = 8.009$, $p = 0.005$, $\eta^2 = 0.037$, *M*s 6.14 and 5.67) (see Figures VIIA, VIIB and VIIC).

Career choice satisfaction. Teacher education entrants reported moderate experiences of social dissuasion from teaching as a career (Figure VII). These experiences appeared similar for individuals undertaking each of science, ICT and mathematics teacher education. Despite this, and despite perceptions of teaching as a career high in demand and low in return, mean *satisfaction* ratings for teaching as a career choice were uniformly high (Figure VII).

CONCLUSION

Our discussion is organised around several issues that persist with regard to teaching motivations and more particularly as these relate to STEM teachers: who chooses teaching?; why do these people choose teaching?; and what might keep these people in a teaching career? We conclude with a discussion of the policy implications of our study.

Who Chooses Teaching?

This study of prospective STEM teachers is a subset of a much larger sample of teacher education candidates from three Australian and two United States universities. As such, we are able to compare the characteristics of the STEM sub-sample with those in the full sample, allowing us to distinguish what is similar or different for the STEM teacher education candidates.

STEM teacher candidates mostly undertook specialisms within STEM domains (e.g., chemistry, biology, physics, mathematics, ICT), although some undertook combinations with social studies and to a lesser extent humanities. High proportions came from English speaking backgrounds, although this percentage was slightly lower than in the full sample, accounted for by greater NESB proportions in mathematics and ICT specialisms.

Given that teaching as a profession is increasingly feminised (OECD, 2005), it was not surprising to find that more than half the sample was female, with the balance in science tilted slightly toward females, and in mathematics and ICT toward males. However, the proportion of females in the STEM disciplines was lower than for the full sample of all teacher education candidates, and lower than in the teaching profession generally. Currently in the Australian context there is a higher proportion of males in mathematics and science teaching; and in physics and chemistry they outnumber women more than 2:1. Males in these fields are also considerably older and closer to retirement (Dow, 2003c). Such a situation signals further shortages and an urgent need to attract new people into teaching in the STEM disciplines.

STEM participants came from the lower parent income categories – lower than in the full sample, and roughly half had parents who worked in STEM-related careers. While anecdotally it has been thought that teachers breed teachers, few had both or either parent as teachers. Higher proportions of STEM teacher candidates had pursued a prior career when compared with the full samples, primarily in STEM domains, and were typically 4-5 years older than in the full sample within the ICT and mathematics domains.

Why Do These People Choose Teaching?

While STEM teacher candidates perceived teaching as highly demanding, low in salary and social status returns, and had experienced relatively moderate levels of social dissuasion away from teaching as a career, they nonetheless reported high levels of satisfaction with their choice. Those patterns of motivations previously documented in the full samples (e.g. Richardson & Watt, 2006) were found to be similarly influential among STEM candidates, with few and small systematic differences between graduates and undergraduates, males and females, or Australian and United States participants.

Motivations registering well above the mid-point on the scale were those focused on social utility values (a desire to shape the future, enhance social equity, make a social contribution, and work with children / adolescents), as well as intrinsic value, perceived ability and positive prior teaching and learning. Such motivations are those one might hope for in teachers whose job it is to help develop and shape the next generation. More personal motivations such as job security, time for family and job transferability figured as important, although less so than the others we have outlined.

It would perhaps be surprising to find people being attracted into teaching who either did not want to work with children or adolescents, or who were indifferent to their needs. That said, females in mathematics and science were more motivated to work with children / adolescents than males, and across the STEM disciplines females rated the demands of teaching higher than males. Further, that these participants held positive prior teaching and learning experiences and saw themselves as having the ability to do a job they intrinsically valued, would suggest that they were not taking up teaching because they had no other options. Indeed, teaching as a "fallback" career – something they chose because their career options were limited – was rated lowest.

What Helps To Retain STEM Teachers?

There is increasing concern across many countries about short-falls in the number of STEM teachers and the impact this has on student learning in these disciplines. In the PISA 2000 survey (OECD, 2000) school principals were asked about their perceptions of the adequacy of teacher supply and the impact of teacher shortages on student outcomes in relation to mathematics, science and English (or the language of instruction in other countries; the areas measured by the PISA 2000 study). Principals from both Australia and the United States, together with their counterparts in other OECD countries, reported problems in both attracting and retaining suitably qualified STEM teachers (OECD, 2005). People may be attracted into teacher education with highly positive attitudes, expectancies, beliefs and values, and employed in the secondary school system – but then the issue becomes, as Ingersoll (2001) has observed in the United States, a matter of making sure these people are retained. It would appear that this is a significantly complex task.

The very motivations that draw people into teaching may, if they are not able to be realised in their particular school contexts, act as a catalyst to lever them out of teaching. We know from the TIMSS study (Lokan, Ford, & Greenwood, 1996) that a high proportion of Australian mathematics and science teachers would prefer to change to another career; and that in the United States, teachers of these disciplines are more likely to leave the profession than teachers in other disciplines (Guarino, Santibanez, Daley, & Brewer, 2004). When STEM teachers are dissatisfied with their job, the most common reasons offered for their departure are: low salaries, lack of support from school leadership and administration, student discipline problems, low student motivation, and a lack of influence over school decision-making (Ingersoll, 2001).

Over the last five years or so as the short-fall in STEM teachers has worsened, teacher recruitment agencies and politicians have turned their attention to programs designed to attract people out of industry, business and other careers. Intuitively, this seemed like a way of solving what has been characterised as a problem of supply. A study in the United States of such "non-traditional" recruits to mathematics and science teaching indicated that retention is of critical importance when it found that those who left teaching did so because they were dissatisfied with working conditions: large class sizes, heavy workload, courses at a low level of instruction, low salary, and an emphasis on paperwork and non-teaching activities (Kirby, Darling-Hammond, & Hudson, 1989). These findings and those of Ingersoll (2001) have been largely confirmed by recent studies in Australia (Harris & Jensz, 2006; Harris, Jensz, & Baldwin, 2005) and across the OECD countries (OECD, 2005). When there are shortages of tertiary educated people available to the labour market as we are currently experiencing in Australia, it would not be surprising to find that individuals with good STEM qualifications could well earn higher salaries in more agreeable workplaces than teaching. Attracting people into STEM teaching from other careers may address the supply issues in the short term, but without concurrent enhanced pay and working conditions in schools, their retention is not guaranteed.

Policy Implications

Our study has shown that similar teaching motivations are robust across Australian and United States samples, and we have a clearer understanding of the complexities of the motivations that have drawn people into teaching in the STEM disciplines: a desire to shape the future, enhance social equity, make a social contribution, work with children / adolescents, together with intrinsic value, perceived ability and positive prior teaching and learning experiences.

STEM teacher candidates tended to be older, from lower socioeconomic backgrounds, with a higher percentage from prior careers, mostly in STEM domains. In future research it will be important to further investigate the reasons career switchers have for coming into teaching, and whether these might impact on their time in the profession. If, for instance, they came from lower paying jobs, they may be more inclined to remain. On the other hand, those who have come into teaching as a result of a down-turn in industry where they had higher paying positions may only persist until they can secure better salaries and career opportunities elsewhere. If their experiences in teaching are in workplaces that are disagreeable, poorly resourced and disorganised, with conditions that do not allow them to teach effectively, then the push out of teaching should be strong. However, these people may make a positive contribution to the education of children and adolescents for the time they remain.

The collective implications of our study are that recruitment campaigns could target these motivations we have identified to effectively attract STEM teachers, and that older graduates working in STEM-related careers could provide a fruitful pool from which to attract qualified people with diverse experiences into a teaching career, to address the existing shortages of STEM teachers.

Future directions in our ongoing longitudinal program of research will be to examine how teaching motivations subsequently play out in the context of schools as workplaces. If teaching is to be an attractive career to well-qualified graduates, then teacher education and employing authorities will need to take into account those motivations that have attracted people into teaching, and seriously address issues and practices in schools that sap teacher motivation and undermine commitment. If teachers were relieved of the burden of non-teaching activities, earned better salaries, had better career structures, and improved working conditions in schools with fewer disruptive and unmotivated students, would these have an impact on the recruitment and retention of STEM teachers? The answer is probably in the affirmative, but we will need to examine these questions in another study.

ACKNOWLEDGMENTS

This research has been funded by Australian Research Council Discovery grant DP0666253 awarded to Richardson, Watt (co-Chief Investigators), and Jacquelynne S. Eccles (Partner Investigator); and a Monash University Faculty of Education Small Grant awarded to Watt and Richardson. Watt, Richardson and Pietsch contributed equally to this chapter.

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