Passing it on: Linking Adult Innumeracy to Mathematics Attitudes, Low Self-Efficacy Beliefs, and Math-Anxiety in Student Primary Teachers

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The connection between adult innumeracy and mathematics-anxiety is examined, and a particular focus is identified for the role of primary teachers. The results of an Inventory of Mathematics Attitude, Experience, and Self-awareness (IMAES) survey of students undertaking Bachelor of Education (Junior Primary and Primary) degree studies reveal that they tend to have pervasive negative attitudes, low mathematics self-efficacy beliefs, and anxiety of mathematics that are more extreme than those found in other undergraduates. The findings affirm the strong influence of early mathematics learning experiences. Since student teachers will ultimately carry their mathematics-attitudes and perceptions into primary school classrooms, it is argued that there are profound implications for the perpetuation of poor early mathematics learning experiences and hence, ultimately, for adult numeracy concerns.

Introduction

In 2006, a Confederation of British Industry (CBI) report implied that some 15 million people aged 16 to 65 years in England had numeracy levels that were at or below the standard expected of children finishing primary (elementary) school (CBI, 2006). A 2001 UK-commissioned brief reviewed research on adult basic skills and reported that ‘about 20 percent [of the British adult population], or some 7 million adults, have poor numeracy’ (Brooks et al., 2001). While the latter is a substantially more conservative assessment than that of the CBI, one has to carefully regard how numeracy is defined and measured: “… ‘numeracy’ does not have a universally accepted definition, nor agreement about how it differs from ‘mathematics’.” (Gal, van Groenestijn, Manly, Schmitt, & Tout, 2005, p. 7). Innumeracy rates amongst adults in Australia are similar, though thought to be less severe (Gal et al., 2007). Indeed, there are commonalities among many Western countries. The question is not so much whether adults lack adequate numeracy skills but why so many adults are thus affected. Some may have experienced educational disadvantage as children, denying them the opportunity to acquire skills. While unfortunate, in modern societies with compulsory schooling this could only account for a fraction of innumerate adults. Typically, the mathematics procedures that most adults learned at school find little use in ‘real world’ contexts (Hogan, 2000; Wedege, 1999). Instead, the majority have either forgotten childhood lessons, dismissed their mathematics schooling as largely irrelevant, or failed to gain significant and lasting benefit from early mathematics education, which must, then, be regarded as sub-optimal. Moreover, as Rooney (1998, p. 12) noted, “So many people, both pupils and adults, appear frightened of mathematics or maintain that they hate it.”

It is postulated here that endemic adult innumeracy is deeply embedded in modern Western societies, inextricably linked with various levels of mathematics-anxiety, negative mathematics attitudes, and an often profound aversion to the learning of mathematics. This has many of the hallmarks of a ‘bootstrap’ problem, lacking a clear starting point from which to seek a solution. However, by examining the connection between adult innumeracy and mathematics-anxiety, the
origin of both will be shown to be located in the area of primary education, with a particular focus identified for the role of primary teachers, particularly in the middle to late years of primary education as pupils struggle with the transition from the concrete to increasingly sophisticated abstractions.

In addition, the attitudes, self-efficacy beliefs, and mathematics-anxiety of students undertaking Bachelor of Education (Junior Primary and Primary) degree studies were surveyed to identify their perceptions of mathematics, including their own capabilities. It will be shown from the results that student primary teachers tend to have pervasive negative attitudes, low mathematics self-efficacy beliefs, and anxiety about mathematics that are more extreme than those found in other undergraduates. Consistent with earlier reports, this affirms the notion that perceptions of mathematics and the capacity to engage with mathematical content are strongly influenced by early mathematics learning experiences. Since these disproportionately mathematics-averse and possibly covertly innumerate (in an integrative sense) student teachers will ultimately carry their attitudes and perceptions into primary school classrooms, it will be argued that there are profound implications in these findings for the perpetuation of poor early mathematics learning experiences and hence, ultimately, for adult numeracy concerns.

Innumeryacy

Innumeryacy, in itself, is a passive state, representing an absence of knowledge, practiced skills, or patterns of cognition. It can be covert—far more so than illiteracy, where those unable to read must face a barrage of demands; rather, beyond an inability to do arithmetic, the innumerate may have lack awareness of their deficit cognitive skills. That is, in terms of Maguire and O’Donoghue’s (2002) organizing framework, while adults may be aware of their limitations in the formative phase of numeracy, the increasing sophistication of the mathematical and integrative phases can render such attributes invisible to those who do not possess them. Most studies of adult numeracy predominantly focus on the ‘functional’ numeracy associated with Maguire and O’Donoghue’s formative phase, perhaps broaching the mathematical phase for everyday contexts. This is also true of most mainstream practice, despite the dominance in contemporary theorizing of the integrative conceptions of adult numeracy (Condelli, 2006). Independent of level, any knowledge or ability deficit, once identified, ought in principle to be amenable to correction through education so that, ordinarily, adults might thus choose to undertake remedial study. In practice, though, there are obstacles.

Concerning adult mathematics learning, practitioners and researchers alike have observed that possibly a majority of adults lack confidence in their own mathematical abilities. They experience anxiety when confronted with overtly mathematical tasks and fail to appreciate the extent to which many of their ‘common sense’ daily practices are essentially mathematical in nature. Their mathematics learning is affected by the attitudes, beliefs, and feelings they harbour towards the subject (Coben, 2003), as is their inclination to engage in the study of mathematics, with many adults who are capable of learning being inhibited by their fear from doing so (Biller, 1996). Extensive literature demonstrates that in most modern cultures people exhibit signs of anxiety, stress, lack of confidence, and phobic reactions when faced with mathematical problems (Macrae, 2003). Such mathematics-aversion must surely be linked inextricably with adult innumeracy and it is here that innumeracy can manifest as an active state, with adults choosing to remain innumerate. This is not to say that they come to an informed and rational decision in this regard: where the choice is conscious, it likely derives primarily from emotional states rather than reason (though perhaps rationalized, nonetheless); where the choice is unconscious—as in avoidance behaviour—it is likely a reaction to anxiety, akin to a phobic response.
The mathematics-anxious are a diverse group scattered throughout the community, including many with high mathematics qualifications (Sewell, 1981), and the sources of their negative beliefs and mathematics-anxiety are just as varied (Uusimaki & Nason, 2004). This is not innate human behaviour but a learned response from prior life experiences. Stuart (2000) notes that poor teaching, humiliation, and belittlement are factors for some people or that the anxiety is acquired through association with influential mathematics-anxious individuals such as teachers and parents. Early learning experiences as contributing factors to mathematics-anxiety, negative mathematics-attitudes, and poor mathematics self-efficacy beliefs have featured strongly in previous companion studies (Klinger, 2006, 2008a, 2008b) and numerous others, such as Raymond (1997) and Cornell (1999) have similarly reported that such negative positions originate in the classroom through bad experiences, the influence of unsympathetic teachers, or as a consequence of poor teacher preparation programs.

Uusimaki and Nason (2004, p. 374), citing both Brown, McNamara, Hanley, and Jones (1999) and Nicol, Gooya and Martin (2002) as examples, observe that some researchers suggest that poor attitudes towards mathematics originate mostly in secondary school. However, that is a very weak inference as neither of those works explicitly expresses such a view. Rather, the contrary position put by Uusimaki and Nason and endorsed with conviction by this author, based on empirical evidence from more than a decade of professional practice with mathematics-anxious university students (Klinger, 2004a), is that there is strong evidence that mathematics-anxiety in fact has its roots firmly in the elementary years.

While later mathematics learning experiences in secondary, and to a lesser extent post-secondary, school can certainly cause or exacerbate negative perceptions, overwhelmingly (as Uusimaki & Nason, 2004, also identified) the reasons are first attributed to primary school teachers and, to a lesser extent, parents. It is a scenario with intuitive appeal, particularly for parents, or any keen observer of small children. These young individuals do not typically exhibit aversion to early mathematics learning experiences—a pre-schooler eagerly taught the counting words delights its parents by parroting numbers well before connections are made between the words and the abstract notion of quantity. The child mimics parental behaviour and simulates the counting of anything and everything in its environment, frequently with almost obsessive zeal. Early primary school mathematics lessons are met with as much enthusiasm as any other activity. As the child progresses through school, hands-on, concrete mathematics learning activities are gradually overtaken by increasingly abstract representations and formalized procedures. The arithmetic of counting by manipulating blocks, for instance, is replaced by ‘doing sums’ on paper, the introduction of multiplication and division algorithms, and rote memory drills. While most other learning activities continue to connect closely with things the child can touch, taste, and feel, the mathematics lessons tend to become increasingly separated from experiential reality. In the latter years of primary education, most pupils are yet to enter Piaget’s formal operational stage of cognitive development where they increase their ability to think abstractly. Rather, it is more likely that most are still in Piaget’s third developmental stage of concrete operations. While cognitive psychologists such as Willingham argue that Piaget’s theory is not right and that development does not, in fact, proceed in stages, it is at least acknowledged that many of his observations are nonetheless sound—for instance, “9-year-olds do have some trouble with highly abstract concepts” (Willingham, 2008, p. 36). Such children are cognitively immature and ill-prepared to deal successfully in abstract manipulation. This is not to say that abstraction should be eliminated from elementary classrooms but, rather, that abstract concepts should be introduced with discretion by proceeding gradually from the concrete to the abstract whilst monitoring how pupils respond.
Children enjoy success and are discomforted when it is not forthcoming; those who struggle with the abstractions or who miss steps for whatever reason are immediately at risk and the chance of developing mathematics-anxiety increases exponentially. The middle to late primary school years are a critical developmental period in mathematics education; if educators get it wrong, there will be few opportunities for redemption.

There is evidence to support this common-sense scenario. Aside from the myriad accounts throughout the literature of poor school mathematics learning experiences, the 2003 IEA’s Trends in International Mathematics and Science Study (TIMMS) report compared qualitative responses from fourth-grade pupils, in the middle of their primary education, and eighth-graders recently transitioned to secondary school. As Mullis, Martin, Gonzalez, and Chrostowski (2003) report (international statistics), in 1995 an average of 46% of fourth-grade pupils agreed a lot that they ‘enjoy learning mathematics’; by 1999 this had dropped to 25% of the (now) eighth-grade pupils. The report continues that in the 2003 data (sampling different cohorts), the proportions were 50% and 29%, respectively. At the other end of the scale, 16% of 1995 fourth-graders disagreed with the statement, compared to 31% of eighth-graders in 1999 (for the different cohorts in the 2003 data, the proportions were 22% and 35% respectively). Similarly, on the Index of Students’ Self-Confidence in Learning Mathematics (SCM) for 2003 (different cohorts), 55% of fourth-grade pupils were assessed with High SCM compared to 40% of eighth-grade pupils. At the other end, 11% of fourth-grade pupils were assessed with Low SCM compared to 22% of eighth-graders.

To summarize, over a critical four year period prior to moving into secondary education, many primary pupils experience a substantial decline in their mathematics enjoyment and confidence levels such that, upon entering secondary education, a high proportion may be well on the way to joining the ranks of innumerate adults. There is a caveat, though—‘enjoyment’ and ‘confidence’ levels are not indicators of ability or skills, although there are numerous indications that the measures are not independent. Contributing or causal factors to explain this phenomenon must include attributes of teachers, those seeking to enter the profession (pre-service teachers) and their training, and the framework of educational systems, schools, and curriculum practices at the primary level.

**Schools and Teachers (In-Service & Pre-Service)**

The South Australian Department of Education and Children’s Services (DECS, 2004) investigated factors that contribute to numeracy performance, finding that many schools were challenged by practices that could lead to improved numeracy and that many teachers experience mathematics-anxiety, have had little relevant professional development, and lack confidence with numeracy teaching. It was particularly noted that there is a need for schools and teachers to commit to improving numeracy, better understanding the relationship between mathematics and numeracy, and allocating adequate teaching time. The latter has figured in several studies. In Australian primary schools, mathematics learning activities, including numeracy, receive less than half the attention given to language: 38% of the teaching time is spent on teaching English while only 18% is devoted to mathematics (Angus, Olney, & Ainley, 2007), consistent with the international average of 16% for fourth-grade pupils (Mullis et al., 2007). The disparate focus is attributed to a lack of resources, a congested curriculum, and that just one in nine primary schools has a specialist numeracy teacher. In contrast, 51% of primary schools have a literacy specialist, 47% have a music specialist, and 46% a physical education specialist (Angus et al., 2007). There is no small irony in a newspaper account of the Angus et al. report, where, under the headline “Time allocated for subjects just doesn’t add up,” the journalist stated that “MATHS is allocated 20 per cent less class time in primary schools than reading and writing, raising concerns over a
drop in numeracy standards” (Hood, 2008, emphasis added). One wonders how many readers recognized the writer’s faux pas.

Internationally, on average about a quarter of those teaching mathematics at fourth-grade level have a post-secondary specialization in the subject—but the statistic is strongly skewed by very high proportions (ranging from 48–62%) in Latvia, Russia, Moldova, Iran, and Singapore; in the UK and the USA only 8% have a mathematics major and in Australia the proportion is reported as 17% (Mullis et al., 2007). Of course, one should not suppose that such figures reflect the number of primary teachers who could properly be regarded as numeracy specialists; as Angus et al. (2007) point out, most often primary teachers are trained as general educators who are expected to teach competently across all subject areas. Of these, typically 80% are female, with the majority aged between 30 and 50 years; they have an average of 16 years teaching experience and more than 90% of fourth-graders participating in the TIMMS study were taught by teachers “who felt ready to teach the topics in number, algebra, measurement, and data” (Mullis et al., 2007, p. 255). One cannot escape the observation that, given the mathematics-anxiety noted above and the substantial decline in their pupils’ confidence and enjoyment of mathematics learning, the teachers’ perceptions of their readiness are incongruent with actual practice and the classroom experience. Perhaps they really mean that they feel prepared to deliver the curriculum. Perhaps their uncertainties and anxieties cloud an appreciation of the distinction between teaching procedures and promoting an understanding of the language and process of mathematics. In that sense, many of them could be regarded as being covertly innumerate at the level of Maguire and O’Donoghue’s (2002) integrative phases.

To further understand practicing (in-service) primary teachers, it is useful to consider the characteristics of those drawn to the profession. Some twenty years ago (that is, in the era when the average primary teacher (above) was in training), the report known as the Speedy Report (Speedy, Annice, Fensham, & West, 1989) produced for Australia’s Department of Education, Employment and Training, stressed the importance of high-order mathematical knowledge and competency, while noting serious concerns that many student primary teachers were entering their teaching courses with a very poor knowledge of mathematics. Similar concerns for the mathematical competency of their American counterparts were reported by Rech, Hartzell, and Stephens (1993), who found that the teaching students rated significantly below the established norms for the general population.

Several studies since have educed consistent findings, reporting not only concerns over competency and a lack of conceptual understanding of the mathematics content that primary education students will be expected to teach (Perry, Way, Southwell, White, & Pattison, 2005) but also the common occurrence among them of negative attitudes towards mathematics and science, including many who are overtly mathematics-anxious and even mathematics-phobic as a result of their past mathematics learning experiences (see, for instance, Hawera, 2004; Schuck, 1999; Taplin, 1998; Trujillo & Hadfield, 1999). In one study of pre-service teachers, 72% of the subjects perceived their own negativity to be particularly attributable to the primary teachers who taught them (Uusimaki & Nason, 2004). Much more has been written about the consequences that this can have in the primary classroom and it is clear that those new to teaching are particularly swayed by their past learning experiences (Stables, Martin, & Arnhold, 2004). Schuck and Grootenboer (cited in Perry et al., 2005, p. 626) put it succinctly, stating that the negative beliefs about mathematics generally held by student primary teachers “prevent them from teaching mathematics that empower children.” While this has long been acknowledged, much of the literature uses qualitative and descriptive methodologies to report the attributes of pre-service teachers (particularly those training for primary education) and there is a shortage of consistent quantitative research. To seek a better understanding of the nature of the mathematics-anxiety,
negative attitudes, and mathematics self-efficacy beliefs of student teachers, and to establish a profile that permits comparison with other groups, the *Inventory of Mathematics Attitude, Experience, and Self-awareness* (IMAES) instrument developed by the author and introduced in Klinger (2006) was again employed.

**Student Primary Teachers and the IMAES Instrument**

Details of the IMAES instrument are well documented (in particular, Klinger, 2006). It is a multi-part questionnaire that uses (mostly) 5-point Likert scales for responses to 95 statements about mathematics-attitude, mathematics-anxiety, mathematics self-efficacy beliefs, and past/early mathematics learning experiences, with attitudinal statements involving the affective, behavioural, and cognitive domains. The questionnaire also provides for the collection of demographic information, including the last year of completed mathematics education. The survey data are partitioned into domains, which are further segregated into sets of positive and negative statements. Aggregate scores for the primary constructs are calculated and further aggregation joins negative and positive subsets on single scales, providing primary construct measures for mathematics attitude, mathematics anxiety, and mathematics self-efficacy. Sub-aggregate results also provide partitioning of attitude into affective, cognitive, and behavioural domains, yielding separate positive and negative scales for each construct. For the present study, there were 26 participants, all undergraduate students commencing four-year double degree teaching programs comprising a Bachelor of Education (Junior Primary and Primary) typically coupled with a Bachelor of Arts or Bachelor of Science. Major sequences within the second degree were not recorded.

Of the 26 participants: 21 (or 81%) were female; just over half had not undertaken mathematics classes beyond secondary Year 11; 19.4% had only studied secondary mathematics to Year 10; and eight (31%) had chosen a science as their second degree. In all of the aggregated and sub-aggregated scales, compared to their male peers, females were shown to have greater mathematics-anxiety, more negative and fewer positive mathematics-attitudes, and lower mathematics self-efficacy beliefs. This was consistent with previous findings using IMAES and with the literature—despite the trend over recent years towards a levelling of the historical gender differences in mathematics performance, females continue to suffer psychological disadvantage. Rather than present a more detailed analysis of differences within this study, the results for this group were compared with previous results obtained for commencing undergraduate students as a whole (Klinger, 2008b) to determine whether the IMAES profile of pre-service teachers differs significantly from that of other tertiary students.

While the pre-service teachers reported, on average, more negative early mathematics learning experiences and fewer positives than their non-teaching peers, neither of the differences were statistically significant. On the other hand, Figure 1 demonstrates very clearly that the student teachers scored lower than other students in the three primary constructs of mathematics-anxiety, mathematics-attitude, and mathematics self-efficacy beliefs. Zero on each scale indicates neutrality.
In the sub-aggregated measures for each of these domains, the student teachers scored higher on the negative scales and lower on the positive scales—that is, compared to all other students, they had stronger responses to negative statements on the questionnaire and weaker responses to the positive statements. Figure 1 merely reveals differences, giving no indication as to their statistical significance, and so two-tailed \( t \)-tests were conducted to reveal very low \( p \)-values (0.026, 0.018, & 0.020, respectively for the attitude, anxiety, and self-efficacy scales) that provide strong (\( \alpha = 5\% \)) evidence to infer that the observed differences are indeed real effects with some systematic cause.

Further \( t \)-tests on the sub-aggregated scales showed that differences observed in the positive measures also are significant, with \( p \)-values of 0.044 (attitude), 0.007 (anxiety), and 0.034 (self-efficacy). The corresponding measures on the negative scales were similar for attitude (\( p = 0.034 \)) and self-efficacy (\( p = 0.025 \)) but the difference on the negative anxiety scale is significant only at the 10% confidence level, having a \( p \)-value of 0.078. Disaggregated scores for affective, cognitive and behavioural domains within the attitude scales reveal that the significant differences for attitude on both the positive and negative scales are attributed overwhelmingly (but not entirely) to the influence of the affective domain, with \( p \)-values below the 1% confidence level. ‘Drilling down’ to the level of individual questionnaire statements shows where the differences originate: out of the 95 items, just twelve differ with overwhelming (\( \alpha = 1\% \)) statistical significance and a further eleven are significant at the 5% confidence level. These responses are internally consistent and identify strong apprehension of the mathematics classroom experience (whether reflective or anticipatory), fearful perceptions of mathematics itself and the challenges it presents, disinterest in mathematics as an occupation or intrinsically enjoyable activity, and lack of problem solving confidence. The sole exception to these negative constructs was unexpected: on average, student teachers agreed more strongly with the statement, ‘A person who is good in maths has a great chance to succeed in many fields of endeavour’, indicating that their overall negative views of mathematics in terms of personal engagement serve to elevate its status in a
more abstract sense. This, together with the pattern of negative responses, also suggests that on
the whole their disaffection with mathematics is more a reaction to mathematics learning than to
mathematics itself.

Discussion and Conclusion

In seeking to better understand the innumeracy problem, four principal dimensions have been
identified. There is the matter of curriculum content and the question of whether the aim of
attempting to school young pupils in abstract concepts is an appropriate and productive
endeavour. There is the matter of the time allocated to mathematics teaching and learning
activities compared to that allocated to other curriculum areas—not only in the sense of
classroom and curriculum priorities but also what this says about the value that society affords
numeralcy. There is the matter of teachers’ expertise and preparedness to teach mathematics
effectively—not merely drilling pupils in procedures but fostering an understanding of process so
as to give meaning to the mathematics. More than subject expertise, this requires a vastly greater
understanding, which many generalist teachers lack, and, in Australia at least, the proportion of
specialist primary mathematics teachers is abysmal compared to the availability of other specialist
teachers; again, this speaks to the value that society affords numeracy. Finally, there is the matter
of the attitudes and anxieties of teachers and prospective teachers. This received particular
attention here and the empirical IMAES results add new, quantitative evidence to reinforce the
existing literature. The attitudes, anxieties, and self-efficacy beliefs that pre-service primary
teachers typically hold towards mathematics have been shown to be profoundly unfavourable and
surely must be detrimental to many of their future responsibilities. Just as those who suffer abuse
often become abusers in turn, in a cycle that is inordinately intractable, so too might mathematics
anxiety and innumeracy be ‘passed on’ by many of the next generation of primary teachers.

The implications for teacher education should be clear and, while it is laudable that many training
institutions are responding to the literature, care is needed to ensure that sufficient and
appropriate resources are allocated. There are strong implications for education authorities in
their management and direction of schools and curricula: every primary school should have at
least one specialist mathematics teacher if all children are have an opportunity to break the cycle;
curriculum content needs review to ensure that appropriate learning objectives are set and
attained; and substantially more teaching time needs to be allocated to mathematics learning
activities. This could be approached by mandating a cross-curriculum approach to mathematics
teaching—thus providing more opportunities for learning concrete mathematics and numeracy
operations, promoting relevance and a problem-solving/inquiry-based approach that could deliver
greater opportunities to foster by example conceptual thinking and abstraction.

References

Kaleen, ACT: Australian Primary Principals Association.


Conference on Liberal Arts and Education of Artists, New York, NY, October 16–18.

A review of research on adult basic skills. London: Department for Education and Employment
Research Report No. 220.


