NSW GOVERNMENT

LITERATURE REVIEW

The effectiveness of tutoring interventions in mathematics for disadvantaged students

Centre for Education Statistics and Evaluation

Overview

Disadvantaged students from low socioeconomic status backgrounds often have poorer educational outcomes compared to their more advantaged counterparts. In Australia, this is particularly evident in mathematics achievement at the secondary school level. One commonly used approach to address disparities in student performance is through the implementation of remedial tutoring programs. This review provides a summary of the relevant empirical literature on the effectiveness of tutoring interventions in maths for disadvantaged students.

Overall, the evidence reviewed strongly suggests that tutoring in maths can have significant positive effects on performance among disadvantaged students. While the magnitude of tutoring effects vary markedly across studies (effect sizes range from approximately .04 to 1.17), the majority of the observed effects represent marked improvements in the performance of tutored students. The best-practice elements of tutoring that are often associated with the most significant performance gains include: designing quality instructional materials that closely reflect classroom content; having close co-ordination with classroom teachers; providing extensive initial and on-going training for tutors; having well-structured programs; providing careful monitoring of student performance; providing regular feedback and reinforcement of progress; and, scheduling tutoring sessions on a frequent and regular basis.

Poor educational outcomes among disadvantaged students can have long-term negative impacts

It is widely accepted that disadvantaged students, often defined as those from low socioeconomic status (SES) backgrounds, generally have poorer educational outcomes compared to their more advantaged counterparts. During school years, disadvantaged students show significant deficits in both literacy and numeracy resulting in lower levels of overall school achievement compared to students from more advantaged backgrounds. In Australia this is evident in the 2009 and 2012 Programme for International Student Assessment (PISA) results, which revealed that students in the lowest SES quartile had substantially lower mean scores in reading, mathematical and scientific literacy compared to those in the highest SES quartile and that the score gap was equivalent to more than two full years of schooling (Thomson, De Bortoli & Buckley, 2013; Thomson, De Bortoli, Nicholas, Hillman & Buckley, 2011). Not surprisingly, disadvantaged students from low SES backgrounds also show consistently lower year 12 completion rates (Australian Curriculum Assessment and Reporting Authority, 2009, Table 33) and have a lower likelihood of attending university (Centre for the Study of Higher Education, 2008). These poor educational outcomes can have a marked negative impact on later life employment prospects and can contribute to the perpetuation of disadvantage across generations.

Remedial tutoring programs are widely used interventions for improving student performance

One approach to addressing the disparity in student outcomes is through the implementation of remedial tutoring programs aimed specifically at improving the school performance of disadvantaged students. While tutoring programs can vary on a number of dimensions, tutoring generally consists of one-to-one or small group-based sessions in which students in need of remedial tuition receive some form of individualised instruction focussing on a particular content area, skill, or learning goal (Kohls & Wilson, 2012; Medway, 1995, as cited in Mischo and Haag, 2002; Topping, 2000). Tutoring is widely considered to be an effective method of increasing student achievement and has been used extensively worldwide as an intervention to remediate student performance (e.g. Chappell, Nunnery, Pribesh & Hager, 2011; Gaustad, 1992; Gordon, 2009; Ritter, Barnett, Denny & Albin, 2009; Slavin, 1999). Tutoring is an especially popular intervention for primary and elementary school aged students to address achievement gaps in reading and literacy and the empirical educational literature consists of many studies which demonstrate the effectiveness of tutoring in this domain (Leung, Marsh & Craven, 2005; Ritter et al., 2009; Topping, Thurston, McGavock & Conlin, 2012; Wasik & Slavin, 1993; Won Jun, Ramirez & Cumming, 2010).

However, there has been comparatively less of a focus in the tutoring literature on interventions specifically focussed on mathematical achievement for disadvantaged secondary school-aged students. While the importance of intervening in literacy with younger students should not be underestimated, it is critically important to understand what works in improving maths outcomes for struggling students at the secondary school level. This is particularly timely in the Australian context given the recent declining trend in mathematical literacy observed among 15-year old students across PISA administrations (Thomson, 2011, pp. 3-4). Understanding how best to remediate student performance in maths also has important longer-term implications given the ever-increasing value placed on maths skills in the job market (Bynner & Parsons, 2000; Rose & Betts, 2001; Geary, 2011; Rendall & Rendall, 2014; Tian, 2006). Indeed, recent economic research suggests that wages are more highly correlated with maths ability than measures of verbal or general cognitive ability and that differences in maths skills are a key driver of income inequality (Rendall & Rendall, 2014).

The aim of the following review is to summarise the relevant empirical literature outlining the effectiveness of tutoring and to focus on interventions in maths that target disadvantaged, or otherwise at-risk, secondary school students. Where possible, the review focusses on studies which have adopted the most robust methodologies, including meta-analyses and randomised controlled trials (RCTs).

The effectiveness of tutoring in mathematics: An overview of the literature

As noted above, tutoring is not a uniform intervention with a single prescribed approach. Tutoring interventions can vary across a number of dimensions and this heterogeneity is reflected across the empirical literature. For example, the content and delivery of tutoring programs varies depending on the age and skill level of the tutee, the age or type of tutor employed (same-age or older peers, community volunteers, paid private tutors, teachers), the format of tutoring (one-to-one, small group), the frequency and duration of tutoring sessions, the instructional approach used, and perhaps most importantly, the subject, content or skill-set being tutored (Center for Prevention Research and Development, 2009). Despite this variability, tutoring programs typically share the common core goal of providing students with individualised instruction focusing on a particular subject area or goal. Gaustad (1992) has suggested that it is this individualised instruction that is responsive to students' needs and the emotional and motivational benefits of this type of interaction that account for much of the improvement associated with tutoring (pp. 7-8). In addition, tutoring allows students to derive academic benefits from spending more time-on-task as well as having more opportunities to receive performance feedback and individualised monitoring (Bowman-Perrott et al., 2013; Ginsburg-Block & Fantuzzo, 1998; Greenwood, Carta & Hall, 1988; Topping, 2005).

While the inherent variability in how tutoring programs are implemented can present some challenges to distilling an overall picture of tutoring effectiveness (Center for Prevention Research and Development, 2009, p. 2), a vast amount of research has been conducted worldwide examining the effects of tutoring on student achievement. An often-cited early meta-analysis of tutoring conducted by Cohen, Kulik and Kulik (1982) synthesized the results from 65 independent evaluations of school-based tutoring programs. This analysis included studies with tutees of varying ages (class levels one-three, four-six and seven-nine) and focused predominately on outcomes in reading and maths. Results showed that tutoring programs had a significant positive effect on student academic performance with an overall effect size of 0.40[1]. This equates to an increase in performance among tutored students of two-fifths of a standard deviation unit compared to non-tutored students (Cohen et al., 1982). While the evaluations analysed included a greater focus on interventions in reading compared to maths (30 studies versus 18 studies), when effects were examined separately by subject, results showed markedly larger impacts of maths tutoring on student achievement (0.60) than interventions focussing on reading instruction (0.29). There were no significant differences for tutees of different ages. The efficacy of maths tutoring specifically for disadvantaged students was further supported by a 1989 narrative review which concluded that peer tutoring was an effective method of improving maths outcomes for low achieving students, including those from socially disadvantaged backgrounds, and for students with mild disabilities (Britz, Dixon & McLaughlin, 1989). However, this study failed to report measures of effect size, making it difficult to estimate the magnitude of the reported effects.

A later meta-analysis examining the impact of school-based peer tutoring programs on the maths achievement of low-achieving students from kindergarten through year 12 revealed a moderately high mean effect size of 0.62 (Baker, Gersten & Lee, 2002). However, a literature review conducted by Robinson, Schofield and Steers-Wentzell (2005) focusing on the impact of peer and cross-age tutoring on maths achievement among minority students showed that while the effects of tutoring are mostly positive, the magnitude of the observed effects varies markedly from study to study (effect sizes from 0.30 to 1.17). The authors note that much of the variance across studies is likely associated with the types of tutors employed, the age of tutees and tutors, whether tutors received training, the length of the tutoring program, and the measures used to assess achievement (Robinson et al., 2005, p. 334). More recently, Bowman-Perrott et al. (2013) conducted a meta-analytic review of peer tutoring interventions for students in both elementary and secondary school, focussing largely on studies of poor performing students and those with disabilities, or at-risk for disabilities. The results from this analysis revealed a significant positive overall effect of peer tutoring on student performance (0.75), with slightly larger effects observed for secondary (0.74) compared to elementary students (0.69). When outcomes were analysed by content area, results showed relatively large effects for studies focusing on maths (0.86), and for those examining vocabulary based interventions (0.92). However, the authors note that these subject level effects should be interpreted with caution as the content area analysis was based on a relatively small number of studies in each discipline (Bowman-Perrott et al., 2013, p. 51).

1 Effect size is a measure of the difference in performance of two groups. In the context of the current review, effect size refers to the difference in performance between tutored and non-tutored students. As a guide for interpretation, Cohen (1988) suggests that an effect size of 0.20 reflects a 'small' effect, 0.50 reflects a 'medium' effect and 0.80 reflects a 'large' effect.

Evidence from the American context: An overview of Out-of-School-Time tutoring initiatives and Supplemental Educational Services

In the United States, studies of Out-of-School-Time (OST) programs provide additional evidence pointing towards the effectiveness of tutoring on maths outcomes. OST programs generally refer to a broad range of interventions that are delivered to low achieving or otherwise at-risk[2] students from elementary and secondary schools outside of the regular school day (i.e. before or after school, during summer breaks) (Lauer et al., 2006). While OST programs vary in terms of their characteristics and can include both social and academic components, many programs include either one-to-one or small group tutoring to assist at-risk students in reading and/or maths (Lauer et al., 2006). Meta-analytic reviews of the effectiveness of OST programs at improving student outcomes have generally shown that participation in OST can result in significant increases in both maths and reading achievement compared to students who do not participate in OST (Lauer et al., 2004; 2006). For example, in Lauer et al.'s 2004 meta-analysis the overall effect size observed for reading achievement ranged from .06 to 0.13, while moderately higher outcomes were observed for maths achievement .09 to 0.17. Notably, results also showed that student grade level was a significant moderator of achievement effects, with the largest effects on reading achievement observed for younger primary students (0.26), while the largest effects for maths achievement were observed for high school students (0.44) (Lauer et al. 2004). Overall, while these outcomes provide some support for the effectiveness of tutoring in maths, particularly for at-risk secondary school students, the observed effects are small in magnitude. In addition, these outcomes should be interpreted with some degree of caution since OST programs were often not well described and likely included a broad range of "academic" and "social" activities (Lauer et al., 2004, p. 78). Therefore, the impact of tutoring, if or when provided, cannot be reliably isolated from other program activities.

A great deal of the American educational literature on the impact of tutoring has also focussed on the Supplemental Educational Services (SES) initiative. SES is a free tutoring initiative that was developed under the *No Child Left Behind Act* (2002) whereby schools that have not made adequate yearly progress on standardized test scores for two consecutive years must offer students from low-income families the opportunity to participate in free tutoring outside of regular school hours (Heinrich & Burch, 2012, p. 1). The SES initiative is implemented at the school district level, and within each district, school administrators can engage a range of diverse providers to offer SES-funded tutoring services (Heinrich & Burch, 2012, p. 1). While this arrangement allows students some degree of choice in selecting a tutoring provider, the implication is that tutoring provided under SES often varies markedly across programs in terms of the frequency, duration, and cost of tutoring as well as the content covered, the instructional approach used and the qualifications held by tutors (Heinrich & Burch, 2012; Heinrich et al., 2014; Munoz, Chang & Ross, 2012).

Since its inception, a number of evaluations often localised to particular states or school districts have sought, with varying degrees of methodological rigour, to examine the effectiveness of tutoring provided under SES on academic achievement among disadvantaged students (Heinrich & Burch, 2012; Springer, Pepper & Ghosh-Dastidar, 2009; Munoz et al. 2012). In 2011, a meta-analysis was conducted that sought to synthesize the results from all previous evaluations to provide an estimate of the overall impact of SES on academic outcomes (Chappell et al., 2011). SES effects were assessed independently for reading and maths achievement, with results showing small, but significant positive effects of SES tutoring in both domains, with marginally greater effects observed for maths achievement (mean weighted effect size = .043) than for reading achievement (mean weighted effect size = .017) (Chappell et al., 2011).

Given the broad variability of tutoring programs offered through the SES initiative, further analysis was conducted to identify to the program features that were most likely to yield the largest impact on student achievement in each subject area. For maths achievement, programs that used high quality instructional materials, employed qualified tutors, and provided both initial and on-going training for tutors were likely to yield the greatest effects (Chappell et al., 2011, pp. 14-15). While the results from this analysis were statistically significant, the magnitude of the effects were again, quite small and underscore the need for further research to establish whether or not this program is a successful and cost-effective intervention to improve student performance (Chappell et al., 2011). Also, since outcomes were not differentiated by grade level, it is difficult

2 At-risk is defined as: (i) low performance on standardized tests or classroom assessments; and (ii) having characteristics typically associated with low achievement including, low SES, racial or ethnic minority background, a single-parent family, a parent with low education, or limited proficiency in English (Lauer et al., 2006, p. 281).

to discern any specific impact for disadvantaged secondary school students. However, there is evidence that uptake of SES tutoring services among secondary school students is relatively low compared to younger students (Heinrich & Burch, 2012). Consequently, much of the existing research on the effectiveness of the SES tutoring initiative is primarily applicable to younger students (e.g., Deke, Dragoset, Bogen & Gill, 2012; Munoz et al., 2012; Springer et al., 2009).

Taking a two-pronged approach: The efficacy of a combined tutoring plus behavioural intervention for disadvantaged students

More recently, significant positive outcomes have been reported for the efficacy of a highly structured tutoring intervention focussing on maths for disadvantaged secondary school students from low income families in Chicago. This RCT, conducted with 106 highly disadvantaged male students in Years 9 and 10, examined the effectiveness of a two-pronged intervention consisting of a high-dose maths tutoring program alongside a cognitive behavioural therapy (CBT) intervention on improving students' academic outcomes and engagement in school (Cook et al., 2014). This study was motivated primarily by the view that many previous interventions for highly disadvantaged students have failed to yield impressive academic gains because there is a 'mismatch' between what's typically provided to students in the classroom and in remedial programs and what disadvantaged students actually need to succeed in school (Cook et al., 2014, p. 4). Specifically, the authors argue that by adolescence, disadvantaged students may be significantly, and in some cases, many years behind in school and may also have entrenched social-cognitive skill deficits brought upon by an impoverished upbringing and that it is critical to address students' needs in both of these domains in order to improve academic performance (Cook et al., 2014).

The tutoring program implemented in this study was an intensive intervention based on the model developed by Match Education[3] that was delivered by trained paid tutors for one hour each day over approximately eight months of the U.S. academic year. As part of this program, each tutor worked with two students at a time providing individualised instruction and on-going tailoring of the material to students' needs in order to allow students to progress at their own pace (Cook et al., 2014). Tutoring sessions were curriculum based, with half of each session devoted to content that reflected classroom learning and the other half devoted to remedial skill development. An important benefit of this intervention was that it specifically addressed the 'mismatch' between a student's grade level and the actual skill level of each student (Cook et al., 2014). The non-academic CBT-based intervention was delivered in small groups (10-15 students) once per week throughout the school year. This intervention focussed mainly on assisting students to develop effective social-cognitive skills and to learn more pro-social decision-making skills (Cook et al., 2014).

In this study, students were randomly allocated to receive the CBT-based intervention plus tutoring, the CBT-based intervention alone, or a control group that received no additional intervention. However, due to some spill over between the CBT alone and CBT + tutoring groups, data for these groups was pooled as one treatment group and compared to students in the control group. Results showed that students who received the intervention showed significant and substantial improvements in their maths achievement (Cook et al., 2014). Taking an intention-to-treat (ITT) approach, whereby data from all students offered the intervention are analysed regardless of actual program participation, results showed that students exposed to the intervention achieved increases in standardised maths scores that were 0.51 standard deviations higher than the control group, and maths Grade Point Average (GPA) scores (scored on a 4-point scale) that were 0.43 points higher. Intervention students also failed significantly fewer maths courses, had fewer absences from school and were significantly more likely to be considered 'on-track' for graduation (Cook et al., 2014). In addition, the outcomes of a cost-effectiveness analysis showed that the cost of the intervention was between $3,000 and $6,000 per student, which the authors contend measures favourably with other educational interventions in terms of test score gains per dollar spent (Cook et al., 2014, pp. 31-32).

These positive outcomes for Match-style tutoring are consistent with those observed in another recent study in which Fryer (2014) examined the effectiveness of a range of best-practice interventions, including high-dose Match tutoring, in low performing schools in Houston, Texas. In Fryer's (2014) quasi-experimental analysis, when the marginal impact of Match tutoring was assessed, results showed that tutoring yielded significant increases in maths achievement for secondary school students that were 0.40 standard deviations higher compared non-tutored students. While these results are very encouraging, the outcomes reported in the Cook et al. (2014) analysis are limited by the small-scale of the intervention which raises concerns about whether the program would show similar results if implemented more broadly. To address this concern, a multi-school trial is currently underway where the efficacy of the intervention is being tested across 12 public schools and over 1,000 male students in Chicago (University of Chicago, 2013; 2014).

3 Match Education is an educational organisation based in Boston, Massachusetts. The Match Tutoring program was developed at the Match Charter School in Boston in 2004, where tutoring is provided by trained professional tutors to small groups of one to four students as part of the regular school day. This tutoring model has since been implemented in other school districts across the United States (see: http://www.matcheducation.org/match-corps).

Tutoring: Elements of best practice

While the literature reviewed above clearly points to the effectiveness of tutoring interventions in maths to improve the academic performance of disadvantaged students, the heterogeneity in how tutoring is provided makes it important to understand what elements of tutoring constitute best practice. The features of tutoring that tend to be associated with the greatest gains in academic performance include: designing quality instructional materials that closely reflect classroom content; having close co-ordination with classroom teachers; providing extensive initial and on-going training for tutors focussing particularly on effective instructional strategies; having well-structured programs; providing careful monitoring of student performance; providing regular feedback and reinforcement of progress, and scheduling tutoring sessions on a frequent and regular basis (Center for Prevention Research and Development, 2009; Chappell et al., 2011; Gaustad, 1992; Gordon, 2009; Leung et al., 2005; U.S. Department of Education, 2001).

In addition, it has been suggested that students benefit most from tutoring programs that use diagnostic templates and assessments to organise tutoring sessions and to adapt program content as tutoring progresses (Gordon, 2009, p. 440). In relation to program structure, many scholars agree that tutoring programs that are well-structured deliver significantly better outcomes than unstructured programs (Chappell et al., 2011; Cohen et al., 1982; Gordon, 2009; Ritter al., 2009). For example, Cohen et al. (1982) found that structured tutoring programs yielded significantly higher effect sizes (0.51) compared to unstructured programs (0.26). Similar findings were revealed by Ritter et al. (2009) in a meta-analysis of RCTs examining volunteer tutoring programs which showed that highly structured programs resulted in significantly better student outcomes (0.59) than unstructured programs (0.14). Furthermore, as outlined by Cook et al. (2014) tutoring programs that effectively target both students' academic and non-academic needs while accounting for the mismatch between students' current skill level and their classroom requirements show strong potential for producing significant gains in maths achievement among severely disadvantaged students.

Another important element of tutoring that has been the subject of some disagreement in the literature is what dosage of tutoring is likely to maximise achievement gains. Across the empirical tutoring literature, programs typically vary widely in duration (Robinson et al., 2005), with some studies showing greater benefits for shorter programs (e.g. Cohen et al., 1982) while others have shown greater effects for longer durations of tutoring (e.g. Won Jun et al., 2010) or no differences in student achievement as a function of tutoring duration (e.g. Bowman-Perrott et al., 2013). Alternatively, some scholars have suggested that perhaps there is a minimum threshold that must be reached in order to produce significant effects. For example, in the context of SES tutoring services, Heinrich and Burch (2012) suggest 40 hours as a minimum threshold, whereas Lauer et al. (2004; 2006) report higher effect sizes for OST programs that were at least 45 hours in duration. These findings suggest there is unlikely to be a single optimal dosage of tutoring required to produce significant gains in student performance and that program duration will likely vary depending on the features of a particular intervention and on the level of instruction required to address each student's needs.

Conclusion

The evidence summarised in this review strongly suggests that tutoring in maths for disadvantaged students can have significant positive effects on academic performance. While the types of tutoring programs implemented vary across the literature, it is clear that significant gains in academic performance can be made among the most disadvantaged or low achieving secondary school students. However, this evidence is largely drawn from research conducted overseas and although tutoring is a commonly employed method of remediating student performance in Australia, there is currently a dearth of rigorous, independent research examining the effectiveness of tutoring programs that specifically target maths achievement among disadvantaged secondary school students. This underscores the need for future research to examine whether interventions shown to be effective elsewhere can produce similar positive gains for disadvantaged students in an Australian context.

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