Crime and Basic Skills

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Abstract
The crime-reducing impact of education has been widely documented. However, much less is known about the impact of basic cognitive and non-cognitive skills developed in early childhood on youth crime. This paper studies the impact of basic literacy and numeracy skills on education achievement and criminality. It exploits two primary school programmes introduced into English schools, the literacy hour and the numeracy hour programmes, to study whether changing the structure and content of teaching can enhance literacy and numeracy skills in childhood, and if these in turn can act as tools to reduce youth crime. Our results show a significant impact of the literacy hour for males and the numeracy hour for females, as males exposed to the former initiative and females exposed to the latter appear more likely to achieve a high-stake certificate at the end of secondary school and less likely to commit youth crime. This suggests that public policy aimed at changing the content and structure of teaching and boosting relatively poor skills can raise pupil achievement and life chances in a lasting manner.

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1. Introduction

Education is an important means of crime prevention. Construction of human capital, improved labour market prospects and reduced day-to-day possibility to commit crime during adolescence are some of the channels behind the crime-reducing effect of education. Increased school attendance can reduce crime, particularly for males, both in the short run (Jacob and Lefgren, 2003; Luallen, 2006), and in the medium and long run (Lochner and Moretti 2004; Machin et al., 2011; Anderson, 2014; Gilpin and Pennig, 2015; Hjalmarsson et al., 2015; Bell et al., 2022).

Despite the large existing literature that documents the crime-reducing role of education, much less is known about the crime-reducing impact of the set of basic cognitive and non-cognitive skills developed in early years. Cognitive and non-cognitive skills developed in early years can determine student achievement and other outcomes in adolescence (see, e.g., Cunha et al., 2006, Almond and Currie, 2011; and Heckman et al., 2013). Even in OECD countries, where a growing fraction of population holds a university degree, basic skills in literacy and numeracy are essential for success in the labour market and the wage return for basic skills appears sufficiently large to indicate that basic skills are relatively scarce and in high demand (Cherry and Vignoles, 2020). In all OECD countries, individuals with lower literacy skills are much more likely than those with better skills to report poor health, to view themselves as objects and not actors in the political process, and to have less trust in others (OECD, 2016).

While basic skills have a pervasive effect on many aspects of people's lives, much less is understood about the potential link between basic skills and crime. Relatively little evidence exists on the impact of basic skills on crime and very few studies assess the link between early years interventions and juvenile crime. This appears especially relevant in contexts where the lower tail of the adult literacy and numeracy skills distribution is particularly pronounced, such as in the UK and the US, and where victims and perpetrators concentrate heavily in youth - as is the case for violent crime in the UK.

This paper evaluates the crime-reducing effects of the Literacy and Numeracy Hour programmes, which were highly structured literacy and numeracy hours, respectively, introduced to English primary schools in the 1990s. These policies aimed to raise the poor standards of English teaching and to improve the literacy and numeracy standards of primary school children. The Literacy Hour was first introduced in 268 inner-city primary schools (ending at age 11) in two waves, beginning in September 1996 and September 1997 in the context of the National Literacy Project (NLP). Most Local Education Authorities (LEAs), though not all, were selected to participate in the NLP where perceived pupil performance was generally low, and then schools were selected within them.[1]

Similarly, the Numeracy Hour was introduced in three waves from September 1996 to September 1999 into 468 inner-city primary schools, through an initiative known as the National Numeracy Project (NNP). Subsequently, the Literacy and Numeracy Hour programmes were rolled-out nationally to all English schools, through the National Literacy and Numeracy Strategies (NLS and NNS). Although the common background to these initiatives was concerns about poor standards of literacy and numeracy in English schools, there was very little geographic overlap regarding where these policies were implemented.

In our analysis, as children in some schools were exposed to the Literacy and Numeracy Hour programmes in years when children in similar schools were not, the spatial variation in the timing of exposure to these programmes is exploited empirically and a set of difference-in-differences specifications is defined to quantify the causal impact of the Literacy and Numeracy hour programmes on the educational and criminal trajectories of juveniles in England. These initiatives placed a much more rigid and structured form on the curriculum for English teaching than what was previously in place.[2] Since the policies occurred in the mid-

[1] There are 150 Local Education Authorities in England. They are responsible for the strategic management of local authority education services including planning the supply of school places, ensuring every child has access to a suitable school place, intervening where a school is failing its pupils and for allocating funding to schools.
[2] See West and Pennell (2003) for a discussion of these low levels of achievement.

1990s, they were very early policy interventions in the UK education system that has been characterized by a whole host of education reforms in later years (see Machin and Vignoles, 2005). Their early introduction is important since our estimates are not therefore contaminated by other policy interventions that may have occurred at the same time.

Looking at whether the content of teaching (i.e. what is taught) and the pedagogy of teaching (how it is taught) matter for student achievement and criminality is an important, policy relevant question. For a policymaker interested in devising interventions that genuinely improve basic skills, the parameters estimated here are of direct interest. To this end, this study uses individual-level administrative data matching education and criminal records from the UK Department for Education (DfE) and the UK Ministry of Justice (MoJ) from 2002-18 for the entire population of students sitting end-of-primary-school exams in England in the school years 1996/7 to 1998/9. Long-run consequences of the literacy and numeracy hour can be studied because the DfE-MoJ data follow children who were exposed to these initiatives until young adulthood and it tracks their entire educational and criminal trajectories until then.

In the empirical analysis, a set of difference-in-differences (DiD) specifications is defined to estimate the causal impact of the literacy and numeracy hour programmes, respectively, on reading and English achievement and math achievement of pupils in schools affected by the policy relative to that in an unaffected, observationally similar control group of schools. Our DiD specifications exploit the fact that some children were first exposed to the literacy and numeracy hour for one or two school-years in 1997/8 and 1998/9 while other children were not. Our data enable us to conduct placebo tests in the pre-policy period to ensure that pupils in schools affected by the policy were not exhibiting different trends in student performance before the policy was implemented.

Our results indicate that the literacy hour programme improved reading test scores at the end of primary school by 7.8% of a standard deviation for all pupils and by 10.2% of a

standard deviation for males. In contrast, the numeracy hour programme improved math test scores at the end of primary school by 6.5% of a standard deviation for the first cohort of treated pupils and by 9.8% for the second cohort of treated pupils. Separate analysis by gender reveals that achievement gains were concentrated among females in this case, since the numeracy hour programme improved math test scores at the end of primary school by 8.5% of a standard deviation for the first cohort of treated females and by 13.7% for the second cohort of treated females. Some evidence of achievement gains in math exams from the numeracy hour appears also for the second cohort of treated males, but these gains do not appear as clear as those arising from the literacy hour for reading test scores, where males notoriously lag behind females.

Analysis of student performance in the General Certificate of Secondary Education (GCSE) Exams, i.e., high-stakes end-of-secondary-school exams, reveals that the literacy hour programme reduced by 12.1% the likelihood of males leaving secondary school without a certificate and it increased their GCSE test scores by 3.7% of a standard deviation. The numeracy hour, instead, reduced by 16% the likelihood of females leaving secondary school without a certificate and it increased their GCSE test scores by 4.3% to 8.2% of a standard deviation (depending on which cohort is studied). As a result of the numeracy hour programme, females were also 6.3% to 8.9% more likely to leave secondary school with at least 5 A*-C grades in GCSE exams. This is a key target for GCSE takers in England and it is widely regarded by employers and educators.[3]

Analysis of post-16 educational and criminal outcomes of individuals reveals that both the literacy hour and the numeracy hour increased the likelihood of enrolment in Advanced level qualifications (known as A-levels), which are post-16 non-compulsory subject-based qualifications that generally lead to university. Overall, pupils exposed to the literacy hour

[3] Machin, McNally and Ruiz-Valenzuela (2020) show the effect of marginally missing a C grade in GCSE exams.

programme were 5.2% more likely to enrol in A-levels while pupils exposed to the numeracy hour programme were 7.7% more likely to enrol in A-levels. When looking at males only, for whom effects appear larger, pupils exposed to the literacy hour were 13.2% more likely to enrol in A-levels while those exposed to the numeracy hour were 8.8% more likely to enrol in A-levels. This conclusion echoes some of the findings in Aucejo and James (2021) that also shows literacy skills to play a critical role in determining access to college in the US.

Results also show that males exposed to the literacy hour programme committed 19.6% fewer crimes at age 16-25, while females exposed to the numeracy hour programme committed 25% to 30.8% fewer crimes at age 16-25. Separate analysis at age 16-20 and 21-25 reveals that a significant reduction in the count of crimes both at age 16-20 by 20% and at age 21-25 by 18% appears for males, whereas the reduction in the count of crimes for females appears concentrated at age 16-20 by 34.4% to 40.7%. While percent estimates for females appears larger than those for males, these are calculated from a much smaller average count of crimes in 1996/7, i.e., prior to these initiatives, reflecting the fact that crime is predominantly a male phenomenon.

Since crime is predominantly a male phenomenon and a sizeable crime-reducing effect appears from exposure to the literacy hour programme for males, the rest of the analysis focuses on the literacy hour. To test robustness of our estimates, the Callaway and Sant'Anna (2021) estimator is used in a DiD framework to check robustness of our estimates for reading and English achievement at the end of primary school, for student performance in high-stakes exams at the end of secondary school, access to Post-16 further education and criminality.

Our estimates show that students exposed to the literacy hour in primary school ranked 3.3 percentile points higher in Key-Stage 2 exams, i.e., in high-stakes exams that pupils sit at the end of primary school in England. Exposure to the literacy hour in primary school also appears associated with a 6.2% of a standard deviation increase in the Key-Stage 2 test score.

Both effects appear driven by the test score in reading and by male students, thus proving very consistent with our main estimates.

Placebo estimates in the 1996-97 period, i.e., prior to the introduction of the literacy hour in the schools that are studied here, show there to be no significant discrepancies in the trends from 1996-97 between pupils in schools that introduced the literacy hour in 1998 and other pupils. This suggests that the causal interpretation of our DiD estimates is indeed warranted and it confirms that the literacy hour boosted literacy skills in early childhood.

Estimates using the Callaway and Sant'Anna (2021) estimator also show that individuals exposed to the literacy hour in primary school were 15% less likely to leave school without any GCSE record, i.e., without any end-of-secondary-school certificate. Individuals exposed to the literacy hour were 5% more likely to obtain at least five A*-C Grades in high-stakes GCSE exams at the end of secondary school. The same individuals also appear 7.5% more likely to enrol in A-level qualifications. Individuals exposed to the literacy hour also committed 17% fewer offences from the age of 16 to 25, with the gap ranging from 15% at age 16-20 to 19% at age 21-25. Analysis by gender shows again that males exposed to the literacy hour committed 20% fewer offences from the age of 16 to 25, while no effect appears again for females. Additional analysis by crime category reveals that the crime-reduction brought about by the literacy hour involved especially violent crime, as the policy reduced the likelihood of violent offences at age 16-25 by 16% for all individuals and by 18% for males.

Further analysis shows little support to the notion that the lasting effects of the literacy hour may stem from a compositional change of students in the schools that implemented this initiative. To our knowledge, this is among the first studies of whether a policy of this type actually works in tackling youth violence. In previous work, Machin and McNally (2008) documented the short run impact of the literacy hour initiative on student test scores in Key-Stage 2 exams at the end of primary school. This study confirms their findings for Key-Stage

2 exams and it expands the analysis to the numeracy hour programme and the long-run effects of both the literacy hour and the numeracy hour programmes.

Finally, the policy seems to be successful in that it was not expensive to implement and thus highly cost effective. Hence, when one considers this kind of policy against other, much more expensive, alternatives – like class size reductions and raising teacher salaries – one sees that the literacy hour fares extremely well. Of course, one should realise that its success rests on improving literacy skills at the lower end of the achievement distribution and getting children to basic levels. On this basis, it seems to be a highly successful and desirable education policy.

The rest of the paper is structured as follows. Section 2 reviews the existing literature of relevance, seeking to highlight that the link between basic skills and criminality is remarkably understudied. Section 3 discusses the introduction of the literacy hour and the numeracy hour, as well as the way in which schools were selected. Section 4 describes the nature of testing in English schools, our data, some statistics at baseline and our research design. Section 5 provides causal estimates of the effects of the literacy and numeracy hour programmes on student performance at the end of primary school, as well as on test scores at the end of secondary school, access to Post-16 education and crime. Section 6 tests robustness of our estimates for the numeracy hour to the use of alternative difference-in-differences estimators. Section 7 tests the cost effectiveness of the policy. Section 8 concludes.

2. Literature Review

Although many early childhood development programmes have been studied rigorously, there are very few in which the crime dimension has been considered, and are mainly small scaled and/or preschool programmes. Furthermore, behavioural outcomes are usually self-reported. The Perry Preschool Programme, for example, is considered a successful early childhood

intervention targeting disadvantaged, low IQ African-American children aged three to four in the US. Thanks to its long-term follow-up, this programme has been shown to improve wages, education, marriage and health in adulthood. It is also one of the few early childhood interventions in which crime outcomes were explored. The programme reduced crime and social isolation for both adult men and women (Belfield et al., 2006; Heckman et al., 2010; and Conti et al., 2013). Rather than long run gains in IQ, the improvement in non-cognitive skills induced by participation in the programme lies behind this boost to later life outcomes (Heckman et al., 2013).

The Carolina Abecedarian Project (ABC programme) is another well-studied early childhood education programme with long term follow-up. The ABC programme is a social experiment conducted in North Carolina on four cohorts of disadvantaged children born in 1972-77. The ABC programme studied the effect of stimulating early childhood environment for the prevention of the development of mild mental retardation in disadvantaged children. This intervention has improved adult health and other youth outcomes by boosting both cognitive and non-cognitive capacities of participants (Griffin et al., 2013; Campbell et al., 2014; and Conti et al., 2013). However, there are no conclusive estimates of the effect of this programme on crime. Walker et al. (2011) study a psychosocial stimulation programme in Jamaica for growth retarded children aged 9 to 24 months in a 2-year trial (weekly play sessions to improve mother-child interaction). They found reductions in self-reported violent behaviours, criminal participation and carry of weapons at age 22. All these small-scale studies tracked individuals over time.

This study also contributes to the literature that studies how best to raise pupil achievement. Perhaps starting with Card and Krueger (1992), Angrist and Lavy (1999) and Hanushek (1997, 2003), many papers have studied in recent years the impact of changing school resources such as class size, teacher quality and measures of expenditure. Educationalists

address many of the same issues, but also investigate the efficacy of what is taught in particular subjects and how this is put across in the classroom in terms of such issues as time on task, frequency of monitoring pupils' work and grouping arrangements.[4] In contrast, very few papers in economics look at how subjects are taught. Exceptions are Angrist and Lavy (2002) that study the role of Computer Aided Instruction, Glewwe et al. (2000) that study the impact of flip charts in Kenyan classrooms, Angrist and Lavy (2001) that study the effect of in-service teacher training on achievement in Jerusalem elementary schools, and Rouse and Krueger (2004) that show the effect of an instructional computer program designed to improve literacy.

This gap appears especially noticeable given the policy relevance of this question and how research on reading appears to have influenced public policy (see, e.g., how research findings have been used in the US as a rationale for the reading component of the No Child Left Behind Act of 2001). As discussed by Beard (2000), this research, as well as the experience of 'Success for All' in the US (Slavin and Madden, 2000, 2003), has been influential in the development of a national policy on literacy in England (the National Literacy Strategy).

This study also contributes to the large existing literature that shows the importance of early childhood conditions in shaping skills, determining human capital development, and in turn defining later life outcomes of individuals. High-quality early childhood circumstances matter for an array of long-term outcomes (Knudsen et al., 2006; Heckman, 2008; and Heckman et al., 2013), and attributes developed in early years determine a large fraction of the variability in lifetime earnings across individuals (e.g., Cunha et al., 2006). Evidence also exists of discrepancy in cognitive and non-cognitive skills as early as prior to the beginning of school (Carneiro and Heckman, 2003; Cunha et al., 2006; and Cunha and Heckman, 2007). Family

[4] See the reviews by Sammons (1999) or Teddlie and Reynolds (2000) on educational research on school effectiveness, or Stainthorp (1996) for a review of evidence on what children need to learn to become skilled readers, and Scheerens (2000) and Creemers (1994) on classroom instruction.

investment appears crucial for this early divergence, as marked differences in the development of skills appear since early childhood between children from different socio-economic backgrounds (see, e.g., Hart and Risley, 1995; Lareau, 2011; Fernald et al., 2013; Kalil, 2013; and Moon, 2014).

Finally, this study contributes to the literature that evaluates the effectiveness of several early childhood interventions designed to bridge these gaps and the resulting discrepancies in early skills development. These include programmes focused on children in their early years and aimed to reduce violent and anti-social behaviours, as well as early family and parenting programmes seeking to provide families and parents with training and skills that help them better attend to the physical, mental, and social skills of their children. These types of programmes often focus on methods of instruction to strengthen the parent's competencies in monitoring and disciplining their child's behaviour and promoting the child's social and emotional competence. Programmes also include parental trainings to use positive and nonviolent techniques to handle children's behaviour (Piquero et al., 2016). The lessons from these studies are that early childhood programmes can boost cognitive development in lasting ways, they are more effective than interventions during adolescence, and they are most effective when mentoring and scaffolding are involved (Heckman and Mosso, 2014).

3. English Primary Schools, the Literacy Hour and the Numeracy Hour

3.1. The Literacy Hour

Following much discussion about poor standards of English teaching, the literacy hour was introduced into all English primary schools during the school year 1998/99 in the context of the National Literacy Strategy. The national policy was based on the perceived success of the National Literacy Project (NLP), which was introduced to a sub-set of schools in certain Local Education Authorities (LEAs) in September 1996. The NLP policy was not envisaged as a pilot

at the time, and indeed was introduced by a different political administration to that which launched the national strategy.

The policy was introduced in a context in which there was considerable pressure on all schools to improve due to monitoring and accountability measures introduced in the early 1990s. For example, from 1995/96 onwards, primary school examination results were published in School Performance Tables. From 1993/94 a system of school inspections was implemented, whereby the regulatory body (OfSTED, the Office for Standards in Education) would inspect each school at four-year intervals and make reports publicly available. If OfSTED gave a very poor evaluation of school performance, the school could be put on 'special measures' and ultimately shut down.[5]

The literacy hour is firmly based upon criteria aimed at improving standards of literacy highlighted in the National Curriculum that was introduced to schools in 1988. This sets out details of what must be taught, the standards that should be achieved at different stages of the education sequence and recommends a minimum teaching time for core subjects. The National Literacy Strategy, and the National Literacy Project before it, was aimed at raising standards of literacy in primary schools by improving the quality of teaching through more focused literacy instruction and effective classroom management. It can also be seen as an attempt to improve school management of literacy through target-setting linked to systematic planning and monitoring and evaluation.

Key components of the policy are a framework for teaching, which sets out termly teaching objectives for the 5–11 age range and provides a practical structure of time and class management for a daily literacy hour.[6] With regard to the former, a range of texts are specified

[5] Parents could also act on a poor OfSTED inspection or a low ranking in the School Performance Tables by applying to admit their child to another school (and there are no restrictions on state schools to which they can apply, although criteria such as proximity to school are applied if there is over-subscription). Such 'voting with feet' materially affects schools since funding is tied closely to pupil numbers.

[6] In this paper, we refer to this set of measures as 'the literacy hour'.

and teaching objectives are set out at three levels (text, sentence and word) to match the text types studied. The daily literacy hour is divided between 10–15 minutes of whole-class reading or writing; 10–15 minutes whole-class session on word work (phonics, spelling and vocabulary) and sentence work (grammar and punctuation); 25–30 minutes of directed group activities (on aspects of writing or reading); and a plenary session at the end for pupils to revisit the objectives of the lesson, reflect on what they have learnt and on what they need to do next.

Beard (2000) discusses how the literacy hour relates to findings from educational research. Of particular relevance are 'structured teaching' (e.g. making clear what has to be learnt; dividing material into manageable units; teaching in a well-considered sequence) and 'effective learning time' (e.g. as reported by Scheerens (1992) in his meta-analysis). Beard (2000) also notes that the literacy hour has been influenced by literacy schemes in the US and in Australia. Stannard and Huxford (2007) discuss the background to the 'literacy hour' and its content at length.

3.2. Did the Literacy Hour Change Teaching Practices?

Whilst the literacy hour introduction constituted a discrete, well-defined and systematic change in the teaching of literacy in primary schools, one might plausibly ask to what extent the quality of English teaching was sub-standard prior to its introduction. It is evident that the general standard of reading and writing was a serious concern, particularly in some LEAs.[7] For example, an OfSTED report about the teaching of reading in Inner London primary schools included criticism of the following practices: free reading with little or no intervention by the teacher; too much time spent hearing individual pupils read; insufficient attention to the systematic teaching of an effective programme of phonic knowledge and skills (OfSTED, 1996).

[7] Indeed, John Stannard, the Director of the National Literacy Project, told us that 'in some LEAs teaching of literacy had fallen apart'. The person in charge of introducing NLP in Tower Hamlets LEA in East London was equally downbeat saying, prior to NLP, teachers used to 'hear' reading rather than 'teach' it and noted that there was a lot of 'quiet reading time'.

It was thought that standards in the teaching of reading varied widely from school to school, with many primary teachers not having had the opportunity to update their skills to take account of evidence about effective methods of teaching reading and how to apply them (Literacy Task Force, 1997a).[8] Stannard and Huxford (2007) provide similar insights into the nature of teaching before the 'literacy hour', and particularly stress the lack of whole-class teaching. They also note evidence from the School Curriculum and Assessment Authority and the Schools Inspectorate (OfSTED) estimating that schools allocated between 22 and 25% of their time to the teaching of English; but in a class of 30, this might only amount to direct teaching time (per pupil) of 3–5 minutes per week.

A daily hour of continuous teaching time devoted to literacy with carefully planned content and a clear structure was a radical departure from what went before. It represents a change in how literacy skills are taught rather than an increase in the time devoted to English.[9] Stannard and Huxford (2007) argue that a revolutionary feature of the NLP was its focus on intervening at the level of classroom instruction because prior to that, English policy makers had stressed that teachers should always take the lead on this.

In schools that were selected for the NLP, the programme was introduced to school staff through attendance at an induction day on Management of Literacy by the Headmaster and Chair of Governors, and a training week for designated key teachers, including English coordinators. There was also one school inset day devoted to NLP issues. There were conferences in each LEA for head teachers and a representative of the governing body. Thus, the NLP was a fairly low-cost policy to implement.

The Schools Inspectorate (OfSTED, 1998) evaluated the NLP by visiting 20% of the schools involved. Three visiting were made: two in 1997 during the spring and the autumn

[8] These concerns about reading in particular prompt us to consider the impact of the NLP on reading in specifically, as well as on overall performance in English.
[9] Also, according to Stannard and Huxford (2007), the decision to recommend 1 hour per day was based on the working assumptions underpinning the balance of time for English in the National Curriculum.

terms and the final one in the summer term of 1998. Over 300 literacy hours were observed and discussions were held with head teachers and staff, including the key teachers. The report says that the impact of the literacy hour on the quality of teaching, and on pupils' attitudes and interest in reading and writing was very positive. It says that the NLP brought about significant improvements in the quality of teaching and has been the important catalyst in raising standards of literacy in the large majority of schools.

3.3. The National Literacy Project

The National Literacy Project (NLP) was introduced in about 400 schools during the school years 1996/97 and 1997/98.[10] The Office for Standards in Education (which published the above cited report about the teaching of literacy in inner city London) approached the then Secretary of State for Education to adopt the policy within Local Education Authorities (LEAs) where educational standards were low. However, not all such LEAs were selected into the NLP. From a research design perspective, the NLP gives a setting where some children were exposed to the literacy hour for one school-year when children in similar schools were not, allowing us to define a set of difference-in-differences (DiD) specifications and retrieve the causal impact of its introduction on the educational and criminal trajectories of children exposed to it.

The selection of NLP schools occurred via a two-stage process. First, some LEAs were selected to participate, and second some schools within LEAs were chosen. At the first stage, the LEAs chosen were, in the main part, those perceived to have lowest pupil performance. In reality, this turns out to be somewhat mixed, with a range of LEAs being chosen. Most, but clearly not all, are from the lower end of the national achievement distribution, and some LEAs

[10] The NLP was also launched in an additional 112 ‘first’ or infant schools, which we do not consider here because the treatment group in this case does not correspond to the same birth cohort. These schools cater for children up to between the age of 7 and 10 (depending on the school). The majority of children in England (over 80%) attend primary schools that cater for children up to and including the Key Stage 2 assessment at age 11.

with below average levels were not included. According to the Director of the National Literacy Project, the LEAs chosen for the NLP were selected (fairly arbitrarily) from a longer list.

It turns out that about 80% of NLP schools were located in LEAs in inner city, urban areas.[11] This is where the most disadvantaged and poorly performing schools in England are concentrated (West and Pennell, 2003). Collectively, about 40% of primary schools within these LEAs were involved in the NLP. The remaining NLP schools were in eight LEAs in three counties.[12] Only about 7% of primary schools in these counties were involved in the NLP. Since the policy was more actively promoted in the former areas (and partly for methodological reasons)[13], we focus our analysis on the effect of the NLP in urban schools. In the context of debate about poorly performing inner city schools in the UK, it is entirely appropriate to focus on schools in these areas.[14]

In terms of which schools were selected within LEAs, advice was given to choose schools most in need of the programme, but to achieve some balance between schools that were perceived to be low achieving and those with ongoing problems (e.g. poor leadership) and low achieving schools showing some signs of improvement.[15] However, since the NLP was planned to last 5 years, a rolling programme was envisaged wherein schools would enter the programme in different waves. The planned cost of the NLP was £12.5 million over five years.

3.4 The Numeracy Hour

After nearly ten years of discussion about what mathematics should be taught, in the late 1990s a public belief spread in England that the math skills too of English children were unsatisfactory and so was, therefore, the way mathematics was being taught in primary schools.

[11] Specifically, these inner city schools are located within several LEAs in London and also Sandwell, Liverpool, Manchester, Sheffield, Newcastle and Bristol

[12] The three counties are Hampshire, Essex and Norfolk. The precise LEAs are as follows: Hampshire, Portsmouth, Southampton, Essex, Southend-on-Sea, Thurrock, Isle of Wight, Norfolk.

[13] It is easier to define a suitable control group for schools in urban areas (as discussed below).

[14] However, we note that the intervention seems to have been ineffective for the small number of treatment schools located in these rural areas. This could be as a result of genuine heterogeneity in the effect of the policy or (in our view more plausibly) because the implementation might have been weaker in these areas.

[15] John Stannard, Director of the National Literacy Project 1996-98, personal communication.

Teaching methods started to be progressively questioned and the content of mathematics teaching started to receive public attention. In particular, OFSTED started to raise concerns over the excessive reliance on individualization and the insufficient dosage of whole-class teaching (Jones, 2002). The relatively poor achievement of English pupils in international studies of mathematical attainment (Keys, Harris and Fernandes, 1996; Reynolds and Farrell, 1996) also spurred the common belief that the mathematics of English children was not good enough and that some teaching approaches were not appropriate.

In 1996, the then Secretary of State for Education, Gillian Shephard, announced parallel national literacy and numeracy projects which would involve poorly performing LEAs in England. The National Numeracy Project (NNP) started in the autumn of 1996. By the end of 1998 'there were approximately 750 schools, 7000 teachers and 180,000 children taking part' (Straker, 1999: 39). The heart of this programme was a daily 'numeracy hour' to be taught in primary schools. As part of this initiative, head-teachers, mathematics co-ordinators and classroom teachers received a highly structured training that provided familiarization with the Framework for Teaching Mathematics from Reception to Year 6 (DfEE,1999), a detailed planning document that set out what mathematics should be taught on a termly basis from Reception to Year 6 (and that then became the key planning document for mathematics in most English primary schools).

Like the literacy hour, the numeracy hour programme was intended to improve the quality of teaching through greater focus in instruction and greater effectiveness in classroom management. It was supported by a framework for teaching, which defines termly objectives for the 5-11 age range and sets out a practical structure of time and class management. The framework document for the 'numeracy hour' included a booklet of exemplar lessons and training on strategies to teach mental calculation. Mental calculation was in fact a key ingredient of the numeracy programme and was deemed to lie at the heart of the programme,

while the use of calculators in school was significantly restricted. To this end, the numeracy hour itself included a three-part template for daily mathematics lessons, starting with 10-15 minutes of oral/mental arithmetic practice, then direct interactive teaching of entire classes and groups, and in the end 10 minutes of plenary review. Thus, the numeracy hour did not constitute an increase in the overall time devoted to teaching numeracy subjects, but rather a significant change in how these subjects were taught.

The goal of the numeracy hour programme was to increase the share of pupils who met the standard expected at age 11 in mathematics from 55% to 75% from 1996 to 2002. These targets were stressed in the government's Green Paper, Excellent in Schools (DfEE, 1997) which also indicated that all schools needed to introduce a numeracy hour from September 1999. Teacher training began in 1998–9, with the numeracy hour starting officially in all primary schools in September 1999. By September 1999, most English primary teachers had received at least some training targeted at implementing the numeracy hour programme. Key features of this initiative included a systematic and standardized national training programme; detailed planning using a week-by-week schedule (DfEE,1999); an emphasis on calculation, especially mental calculation; and a three-part template for a daily maths lesson (Brown et al., 2000).

4. The English School System, Data and Econometric Approach

4.1. Testing in English primary schools and Outcomes of Interest

Following the introduction of the National Curriculum in 1988, testing throughout the school years has been an important feature of the English school system. Children are administered tests at ages 7, 11, 14 and 16, in what is known as Key Stages 1, 2, 3 and 4. Key Stages 1 and 2 take place in primary school and Key Stages 3 and 4 in secondary school. These national

tests are externally set and marked.[16] Key Stages 2 and 4 are particularly 'high stake' tests for schools as results are published in national school Performance Tables.

Since the literacy and numeracy hour programmes were introduced in primary schools, the empirical analysis assesses their impact on the Key Stage 2 tests that children take at the end of their time in primary school; on the Key Stage 4 tests (i.e., GCSE tests) that youth take at the end of secondary schooling when they are aged 16; on enrolment into A-levels, which is a non-compulsory qualification-based phase of education where youth enrol to prepare for university; and on criminality at age 16-25, when the risk of committing crime is highest on average (Quetelet, 1831).

4.2. Data

The empirical analysis is based on individual-level administrative data matching education and criminal records from the UK Department for Education (DfE) and the UK Ministry of Justice (MoJ) from 2002-18 for the entire population of students sitting end-of-primary-school exams in England in the school years 1996/7 to 1998/9. The DfE data extract contains administrative records of pupil-level achievement and pupil characteristics. The former consists of detailed test score records of students at the end of Key Stage 2 and Key Stage 4. The first available year of national Key Stage 2 data at pupil level is in 1995/96, which corresponds to the school year before the National Literacy Project and the National Numeracy Project were introduced, while the first available year of national Key Stage 4 data at pupil level is in 2001/02. Since pupils sit Key Stage 4 exams five years after sitting Key Stage 2 exams, this implies that Key Stage 4 data are not actually available for the 1995/96 cohort of Key Stage 2 takers (i.e., who took Key Stage 4 exams in 2000/01).

The literacy hour was first introduced in 268 inner-city primary schools (ending at age 11) in two waves, beginning in September 1996 and September 1997. Similarly, the numeracy

[16] Key Stage 4 exams are also known as the General Certificate of Secondary Education (GCSE) exams.

hour was introduced in three waves from September 1996 to September 1999 into 468 inner-city primary schools. Although the common background to these initiatives was concerns about poor standards of literacy and numeracy in English schools, there was very little geographic overlap regarding where these policies were implemented. Consequently, both programmes were rolled-out nationally to all English schools.

The main analysis therefore focuses on schools that implemented the literacy and numeracy hour programmes for the first time in the school year of 1997/8. In the case of the literacy hour, the outcomes of pupils enrolled in these primary schools are compared with those of pupils in schools that did not implement the literacy hour until the school year of 1998/9, when the National Literacy Strategy was introduced nationwide. In the case of the numeracy hour, the outcomes of pupils enrolled in primary schools that adopted the numeracy hour for the first time in the school years of 1997/8 and 1998/9 are compared with those of pupils enrolled in schools that did not implement the numeracy hour until the school year of 1999/2000, when the National Numeracy Strategy was introduced nationwide. To this end, the main analysis uses, for the same pupils, the Key Stage 2 data in the school years of 1996/7 to 1998/9, the Key Stage 4 data in the school years of 2001/2 to 2003/4 and the A-level data in the school years of 2002/3 and 2004/5. In contrast, the first available year of national Key Stage 2 data at pupil level in 1995/96 is only used in the placebo analysis that uses data until the school year of 1996/97 to compare the evolution of outcomes from 1995/96 to 1996/97 (i.e., in the year prior to the policy) for pupils in schools that implemented the literacy hour in the school year of 1997/98 vis-à-vis pupils in control schools.

Several pupil characteristics are included in the DfE data extract and our analysis uses information on gender of the student, socio-economic deprivation, proxied by Free School Meal eligibility, ethnicity and native language. Information on the precise school of enrolment at all stages of education is also included in the dataset and is used in our analysis.

With regard to outcome measures, the analysis of the short run impact of the literacy and numeracy hour programmes concentrates on two measures at the end of primary school: the standardised reading and math score and the percentile ranking in Key Stage 2 exams. Since the marking scheme can change over time, we convert raw scores to percentile scores and standardisation is done within school-year. The analysis of the long run effects of the literacy and numeracy hour programmes concentrates on three measures at the end of secondary school: whether a student leaves secondary school with a GCSE record at all or not, whether a student hits the target of at least 5 A*-C GCSE grades and the standardised Key-Stage 4 test score in GCSE exams. Also in this case, standardisation is done within school-year.

Finally, information on the criminal records of juveniles in England is extracted from the Ministry of Justice's Police National Computer (PNC). The PNC stores and shares criminal records information across England and Wales. It contains precise information on all the criminal offences committed by an individual. It contains detailed information on the nature of the criminal offence committed, on the date of the offence, as well as on the age of the offender. This information is used in our analysis to define our outcome of interest, namely the count of offences committed by an individual at the age of 16-25. Information on the nature of the offence committed allows us to group crimes into violent crime, which includes violence against the person, sexual offences and public order offences; property crime, which includes robbery, theft, fraud and criminal damage and arson; drug offences and miscellaneous offences, which is a residual category that includes miscellaneous, motoring and non-motoring offences and possession of weapons.

4.3. Descriptive statistics

Table 1 shows a set of descriptive statistics for pupils in literacy hour schools, numeracy hour schools and pupils in other schools in the school year 1996/7, i.e., one year before the

'literacy hour' and 'numeracy hour' schools implemented the policies. Table 1 shows that, except for the share of males that appears similar in both groups of schools, our outcomes of interest are imbalanced between the treatment and comparison groups. In particular, Table 1 indicates that in 1996/7 pupils in treatment group schools performed significantly worse than the national average in their Key Stage 2 exams, and this appears true for both reading and math. In 2001/2, the same individuals performed significantly worse than the national average also in their Key Stage 4 exams and committed a significantly higher number of criminal offences both at age 16-20 and at age 21-25. Appendix Table A.1 also shows that, at each age from age 16 to 25, these youth committed more violence, more property offences, more drug offences and more miscellaneous crimes.

4.4. Econometric Approach

The econometric analysis defines a set of difference-in-differences (DiD) specifications to retrieve the causal estimates of interest on all individuals observed in the 14,047 primary schools that were observed in all cohorts of study. Given the non-random nature of the literacy hour schools, the set of covariates included in the analysis are likely to play an important role here and therefore all our econometric analysis controls for a set of time-invariant binary (0/1) variables that measure the gender of the individual, free school meal eligibility status, white British ethnicity and native speaker status. For pupil *i* enrolled in primary school *s* in school-year *t*, the difference-in-differences specification can be expressed as follows:

$$Y_i = \alpha_s + \alpha_t + \beta_1 * \mathrm{NLP/NNP}_{is} + \beta_2 * Post_{it} + \beta_3 * (\mathrm{NLP/NNP}_{is} * Post_{it}) + \beta_4 \boldsymbol{X_i} + \epsilon_i, \qquad (1)$$

where Y_i is the educational or criminal outcome of pupil *i* enrolled in primary school *s* in school-year *t*, α_s is a set of primary school fixed effects and α_t is a set of school-year fixed effects. NLP_{is} is a binary variable that takes value 1 if school *s* implemented the literacy hour in 1997/8 and value 0 if school *s* implemented it in 1998/9, while NNP_{is} is a binary variable that takes value 1 if school *s* implemented the numeracy hour in 1997/8 or 1998/9 and value 0

if school *s* implemented it in 1999/2000. Schools that implemented the literacy or numeracy hour programmes in 1996/7 are excluded from the analysis because long run outcomes cannot be measured for pupils who sat Key-Stage 2 exams in 1995/6 (and, thus, a pre-period is not available for these schools). $Post_{it}$ is a binary variable that takes value 1 for individuals who sat their Key-Stage 2 exams starting from 1997/8 and value 0 for individuals who sat their Key-Stage 2 exams in 1996/97. β_3 is therefore the coefficient of interest as it captures exposure to the literacy and numeracy hour and it measures the impact of early childhood exposure to the literacy or numeracy hour on our outcomes of interest. $\boldsymbol{X_i}$ is a vector of time-invariant binary (0/1) variables that measure the gender of the individual, free school meal eligibility status, white British ethnicity and native speaker status, and ϵ_i is the error term. Standard errors are clustered in the entire analysis at the primary school level.

In a set of robustness exercises, since randomization of the literacy and numeracy hour was not possible and treatment was evidently selective on observable covariates, we also compare pupil performance in literacy hour schools with a matched sample of non-literacy hour schools using the Callaway and Sant'Anna (2021) estimator in a difference-in-differences (DiD) framework (see, also, Abadie, 2005), with estimates being derived from the improved doubly-robust DiD estimator based on inverse probability of tilting and weighted least squares suggested in Sant'Anna and Zhao (2020).

5. The impact of NLP and NNP on Pupil Achievement and Youth Crime

5.1. Pupil Achievement at the End of Primary School

Table 2 shows our first set of results. Columns (1)-(3) of the Table indicate that the literacy hour programme improved reading test scores at the end of primary school by 7.8% of a standard deviation for all pupils and by 10.2% of a standard deviation for males, while no

significant effect appears for females. In contrast, Columns (4)-(6) of the Table indicate that the numeracy hour programme improved math test scores at the end of primary school by 6.5% of a standard deviation for the first cohort of treated pupils and by 9.8% for the second cohort of treated pupils. Separate analysis by gender reveals that achievement gains were concentrated among females in this case, since the numeracy hour programme improved math test scores at the end of primary school by 8.5% of a standard deviation for the first cohort of treated females and by 13.7% for the second cohort of treated females. Some evidence of achievement gains in math exams from the numeracy hour appears also for the second cohort of treated males in column (6), but these gains do not appear as clear as those arising from the literacy hour for reading test scores, where males notoriously lag behind females.

Table 3 estimates the same set of specifications as in Table 2 and it is organised in a similar way as Table 2, but the standardised test scores are replaced by the percentile test scores. The substantive conclusions of our analysis are unchanged. In particular, Columns (1)-(3) of Table 3 indicate that the literacy hour programme improved reading percentile test scores at the end of primary school by 4.2% for all pupils and by 5.8% for males, with no significant effect for females. In contrast, Columns (4)-(6) of the Table indicate that the numeracy hour programme improved math percentile test scores at the end of primary school by 3.8% for the first cohort of treated pupils and by 6% for the second cohort of treated pupils. Arguably, the larger effects for the second cohort of pupils exposed to the numeracy hour programme reflects that, by 1998/9 teachers had improved in their ability to deliver the numeracy hour and thus this initiative became more effective.

Separate analysis by gender reveals again that achievement gains from the numeracy hour were concentrated among females, with the numeracy hour programme improving math test scores at the end of primary school by 5.11% for the first cohort of treated females and by 8.7% for the second cohort of treated females. Some evidence of achievement gains in math

exams from the numeracy hour still appears also for the second cohort of treated males in column (6).

As the average percentile test scores in 1996/7 reported in Table 3 suggest, before the literacy and numeracy hour programmes males tended to lag behind in reading and literacy subjects while females tended to lag behind, albeit to a lesser extent, in numeracy subjects. Thus, taking stock of the short-run analyses in Tables 2 and 3, it appears that the literacy and numeracy hour programmes were able to boost basic skills where they were most needed in childhood, i.e., where the skills of children were relatively poorer. In the case of males, this was the case for literacy subjects while for females this was the case for numeracy subjects. In contrast, the evidence in Tables 2 and 3 provides little support to the hypothesis that there may have been spillover effects between the two initiatives, as no benefit appears of the numeracy hour on reading test scores and no benefit appears of the literacy hour on math test scores.

5.2. Pupil Achievement at the End of Secondary School and Youth Crime

Table 4 shows our estimates of the impact of the literacy and numeracy hour programmes on student performance in the high-stakes end-of-secondary-school General Certificate of Secondary Education (GCSE) exams. Analysis of student performance in GCSE exams, reported in column (1), reveals that both the literacy and numeracy hour programmes raised standardised Key Stage 4 test scores in GCSE Exams. In particular, the literacy hour programme raised test scores by 2.4% of a standard deviation, while the numeracy hour programme increased test scores by 2.6% to 5.2% of a standard deviation (depending on which cohort is studied). Columns (2) and (3) reveal that the literacy hour programme raised test scores of males by 3.7% of a standard deviation and left test scores of females unaffected, while the numeracy hour programme increased test scores of females by 4.3% to 8.2% of a standard deviation (depending on which cohort is studied), while leaving test scores of males unaffected.

Columns (4)-(6) also show that the literacy hour reduced by 12.1% the likelihood of males leaving secondary school without a certificate (reported in column (6)) and it left females unaffected. The numeracy hour, instead, reduced by 16% the likelihood of females leaving secondary school without a certificate and it increased their likelihood to leave secondary school with at least 5 A*-C grades in GCSE exams by 6.3% to 8.9%, which is a key target for GCSE takers in England and it is widely regarded by employers and educators.

Analysis of post-16 educational and criminal outcomes of individuals is reported in Table 5. Columns (1)-(3) reveal that both the literacy hour and the numeracy hour increased the likelihood of enrolment in Advanced level qualifications (known as A-levels), thus increasing the chances of treated pupils to enrol at university. Overall, pupils exposed to the literacy hour programme were 5.2% more likely to enrol in A-levels while pupils exposed to the numeracy hour programme were 7.7% more likely to enrol in A-levels. When focusing on males only, for whom effects appear larger, pupils exposed to the literacy hour were 13.2% more likely to enrol in A-levels while those exposed to the numeracy hour were 8.8% more likely to enrol in A-levels. As written above, this conclusion echoes some of the findings in Aucejo and James (2021) that also shows literacy skills to play a critical role in determining access to college in the US.

Results in columns (4)-(6) also show that males exposed to the literacy hour programme committed 19.6% fewer crimes at age 16-25, while females exposed to the numeracy hour programme committed 25% to 30.8% fewer crimes at age 16-25. Separate analysis at age 16-20 and 21-25, reported in columns (7)-(12), reveals that a significant reduction in the count of crimes both at age 16-20 by 20% and at age 21-25 by 18% appears for males, whereas the reduction in the count of crimes for females appears concentrated at age 16-20 by 34.4% to 40.7%. While percent estimates for females appears larger than those for males, these are

calculated from a much smaller average count of crimes in 1996/7, i.e., prior to these initiatives, reflecting the fact that crime is predominantly a male phenomenon.

In sum, these results indicate that both the literacy hour and the numeracy hour programmes improved student performance in GCSE exams and likelihood to enrol in A-levels. These results are very important as they indicate that boosting skills in early childhood can have lasting consequences for the lives of individuals as it can increase their chances to attend university. However, our results also reveal that the literacy hour programme benefited disproportionately males, as it boosted their literacy skills where males tended to lag behind prior to the reform, while the numeracy hour programme benefited disproportionally females, as it boosted their numeracy skills where females tended to lag behind prior to the reform. This conclusion appears both in terms of Key Stage 2 test scores in reading and maths at the end of primary school, respectively, and in terms of crime reduction, since the literacy hour programme reduced "male crime" and the numeracy hour programme reduced "female crime". Therefore, a policy takeaway of these results is that boosting skills that are relatively weaker in childhood does not just have the potential to bridge the gap between males and females in achievement across subjects, but it has also the potential to reduce the respective propensities to commit crime during youth.

6. Robustness Estimates of the impact of NLP on Pupil Achievement and Youth Crime

6.1. Pupil Achievement at the End of Primary School

Since crime is predominantly a male phenomenon and a sizeable crime-reducing effect appears from exposure to the literacy hour programme for males, the remainder of the paper focuses on the literacy hour. To test robustness of our estimates, the Callaway and Sant'Anna (2021) estimator is used in a DiD framework to check robustness of our estimates for reading and English achievement at the end of primary school, for student performance in high-stakes

exams at the end of secondary school, access to Post-16 further education and criminality. Since the numeracy hour programme is not studied here, the analysis is restricted to the cohorts that sat Key Stage 2 exams at the end of primary school in 1996/7 and 1997/8, i.e., the 1998/9 cohort of exam takers is excluded from this analysis.

Table 6 shows robustness estimates for test scores in Key Stage 2 exams. All estimates were derived again controlling for primary school fixed effects, school-year fixed effects and the set of individual-level characteristics described above, i.e., gender, free-school-meal eligibility status, an indicator for white British ethnicity and an indicator for whether the pupil is a native English speaker. Standard errors are clustered again at the primary school level and they are reported in parenthesis.

Panel 1 shows results for the full sample. A statistically significant improvement by 3.3% in the Reading and Math percentile score appears in column (1). Columns (2) and (3) show that a statistically significant improvement by 3.7% in the Reading percentile score also appears, while no significant impact of the literacy hour appears for Math. Looking at standardised test scores in columns (4)-(6) suggests similar conclusions, as the literacy hour seemingly led to a 6.2% of a standard deviation improvement in the Reading and Math score, with the effect being driven by the 7% of a standard deviation improvement in the Reading score displayed in column (5).

Panels 2 and 3 break down the sample between females and males. The latter group clearly appears again to drive the change in student performance in Key Stage 2 exams. While no significance in our estimates appears in Panel 2 that displays results for females, for males in Panel 3 a statistically significant improvement by 3.9% in the Reading and Math percentile score appears in column (1). For males, columns (2) and (3) show that a statistically significant improvement by 5.6% in the Reading percentile score also appears, while no significant impact of the literacy hour appears for Math. Results for the standardised test scores in columns (4)-

(6) suggest that the literacy hour led to a 7.4% of a standard deviation improvement in the Reading and Math score of males, with the effect being driven by the 9.9% of a standard deviation improvement in the Reading score in column (5).

Our causal interpretation of these and our main estimates in Table 3 crucially relies on the absence of differential pre-trends prior to the national literacy policy between treated and control schools. As mentioned above, the first available year of national Key Stage 2 data at pupil level is in 1995/96. While these data cannot be linked with long run educational and criminal outcomes, it is possible to use these data to conduct a placebo exercise. Using data until the school year of 1996/97, one can compare the evolution of outcomes from 1995/96 to 1996/97 (i.e., in the year prior to the policy) for pupils in schools that implemented the literacy hour in the school year of 1997/98 vis-à-vis pupils in control schools. Absence of significant discrepancies between treatment and control schools in the student performance in Key Stage 2 exams would mitigate concerns regarding the existence of differential pre-trends between treatment and control schools.

Table 7 shows the results of this analysis. The percentile score and the standardised score are presented again. Results are presented again for the full sample in Panel 1 and then separately for males and females in Panels 2 and 3. None of the estimates displayed in Table 7 is statistically distinguishable from zero, suggesting that pupils enrolled in treatment and control schools were on similar trends of Key Stage 2 test scores in the year prior to the adoption of the literacy hour in treatment schools. This, in turn, should hopefully mitigate the concern that we may be erroneously attributing the effect of some unobserved factor that occurred disproportionately in treatment schools to the literacy hour programme.

6.2. Pupil Achievement at the End of Secondary School and Youth Crime

The second part of these robustness checks turns the attention to a set of long run outcomes of interest. As in the main analysis, these include Key Stage 4 test scores, enrolment

in Post-16 further education and youth crime for the same juveniles for which the main results in Section 5.2 were presented. Table 8 shows a set of Callaway and Sant'Anna (2021) difference-in-differences (DiD) estimates of the impact of the literacy hour on our long run outcomes of interest, with estimates derived again while controlling for primary school fixed effects, school-year fixed effects and the set of individual-level characteristics described above, i.e., gender, free-school-meal eligibility status, an indicator for white British ethnicity and an indicator for whether the pupil is a native English speaker. Standard errors are clustered also for this analysis at the primary school level and they are reported again in parenthesis.

Panel 1 shows again results for the full sample. A statistically significant reduction by 15.5% in the likelihood that students leave compulsory schooling without a Key Stage 4 certificate appears in column (1). Panels 2 and 3 show again results separately for females and males, and they show also this result to be driven by males. While the likelihood that treated females leave compulsory schooling without a Key Stage 4 certificate appears unaffected by the literacy hour, the likelihood that treated males leave compulsory schooling without a Key Stage 4 certificate reduced by over 25%.

Coherent results appear in the remainder of the Table. Columns (2) and (3) show that exposure to the literacy hour during childhood increased the likelihood of leaving compulsory schooling with at least 5 A*-C GCSE exams by 5.1% for the full sample and by 6.4% for males, and it improved the standardised test scores in Key Stage 4 exams by a statistically significant 2.9% of a standard deviation. Column (4) shows that the literacy hour increased the likelihood to enrol in A-levels by 7.5% for all individuals and by 16.8% for males. In sum, results in Table 8 confirm the conclusion from the main analysis that the literacy hour had a significant and lasting positive impact on the accumulation of skills and then on the educational trajectories of children exposed to the literacy hour during childhood.

Columns (5)-(8) in Table 8 show robustness estimates of the crime-reducing impact of the literacy hour. In particular, the dependent variable in column (5) is a binary variable indicating whether the individual committed a criminal offence at age 16-25; in column (6) it is the count of criminal offences committed by an individual at age 16-25 and in columns (7) and (8) this is broken down between age 16-20 and 21-25. Results indicate that individuals exposed to the literacy hour committed 17% fewer offences from the age of 16 to 25, with the gap ranging from 15% at age 16-20 to 19% at age 21-25. The fact that no significance is found in column (5) at the extensive margin indicates that the literacy hour may have acted especially on serial offenders and not as much on the marginal offender. Analysis by gender shows that males exposed to the literacy hour committed 20% fewer offences from the age of 16 to 25, while no effect appears for females.

Table 9 presents the analysis by crime category. The four categories of crime that are examined here are violent crime in columns (1)-(3), property crime in columns (4)-(6), drugs crime in columns (7)-(9) and miscellaneous crime in columns (10)-(12). Analysis by crime category reveals that the crime-reduction brought about by the literacy hour involved especially violent crime, as the policy reduced the likelihood of violent offences at age 16-25 by 16% for all individuals and by 18% for males.

6.3. Compositional Change

Was there a compositional change in the student population after the introduction in treatment schools of the literacy hour? One may worry that our results may be driven by the endogenous sorting of students across schools in response to the introduction of the literacy hour. However, Table 10 shows a set of unconditional estimates of the characteristics of the student population before and after the introduction of the literacy hour in treatment and control schools. Table 10 presents very little evidence in support to the notion that the student population changed endogenously and that this may be driving our results. The only statistically significant

unconditional DiD estimate indicates that treatment schools enrolled more children with free school meal eligibility after the introduction of the literacy hour. However, this does not seem to invalidate our conclusions, as pupils from lower socio-economic backgrounds are not more likely to do well in school, nor less likely to commit crime at age 16-25 (and, thus, they are unlikely to contaminate our results here).

7. Cost-Benefit Analysis of the Literacy Hour

Analysis in Section 6 has shown a significant impact of the literacy hour on reading achievement at the end of primary school, on overall student performance in high-stakes exams taken at the end of secondary school, on the likelihood to enrol in A-levels and on the count of crimes, especially violent, committed at age 16-25. The question remains as to whether the policy was cost effective. Hence the per pupil costs of the policy are compared with the economic benefits, as reflected in predicted crime reduction. This analysis complements the empirical exercise in Machin and McNally (2008), where a cost-benefit analysis of the literacy hour policy is conducted using predicted labour market earnings.

The planned cost of the NLP was £12.5 million over 5 years. The main costs were 14 local centres (each costing about £25,000 per year) and literacy consultants in each participating Local Education Authority (about £27,000 per year for each consultant). Schools also received some funding for teacher training and resources, which was broadly the same for each school (though some account was taken of the pupil–teacher ratio). However, since the national rollout took place two years after the NLP was introduced, only the first two years are relevant. The total cost per annum was thus £2.5 million (or about £2.8 million in 2001 prices) and, given how many students were affected in 1997 and 1998 (i.e., 222,261 pupils in aggregate), the cost per pupil is £25.52 per annum (Machin and McNally, 2008).

To estimate the economic value of the crime-reducing benefits of the policy, we focused on the 16% reduction in the likelihood of committing a violent crime at age 16-25 reported for the full sample in column (1) of Table 9. Thus, we first calculated the incidence of violent crime at age 16-25 for the pre-cohort, i.e., the cohort that sat Key-Stage 2 exams in 1996/97 in the schools in our analysis and thus that was unaffected by the literacy hour. Then, using the estimated 16% reduction in the likelihood of violent crime, as well as the 78.7% conviction rate of the UK Crown Court in 2018-19 for violent crimes,[17] we calculated the count of individuals in our analysis that did not commit a violent crime because of the literacy hour. Subsequently, we multiplied this number by the total unit cost of an assault without injury in England as per the UK Home Office's (2018) estimates.[18] Among violent crimes, an assault without injury, which is used here to measure the unit cost of violent crime, is deemed to cause the lowest economic and societal cost. Thus, in our calculation, we are obtaining a conservative estimate of the economic benefit of the literacy hour, because the higher is the cost of the (avoided) crime the higher would be the benefit of the reform. This empirical exercise retrieved an economic benefit of more than £32 million in 2015/16 prices.

The economic benefit stemming from the prevention of violence generated by the literacy hour was then compared with its economic cost of about £4.3 million in 2015/16 prices. Clearly, the benefits of the literacy hour outweighed its costs. The benefit/cost ratio of 7.44 clearly indicates that, for every pound invested in the literacy hour, more than 7 pounds were gained in terms of reduced youth violence. This is particularly noticeable given the recent spate in juvenile violence and knife crime in England and Wales.

[17] The conviction rate of the UK Crown Court in 2018-19 for violent crimes is publicly available at the following link: https://www.cps.gov.uk/publication/key-measures.

[18] Anticipation cost, consequence cost, response cost and total unit cost of assault without injury, as well as of other crimes recorded in the UK are taken from Table E1 of Home Office (2018) publicly available at the link below: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732110/the-economic-and-social-costs-of-crime-horr99.pdf

8. Conclusion

The construction of human capital since early childhood is a crucial determinant of life trajectories. In many countries, even relatively low levels of basic skills in numeracy and literacy attract a wage premium, and the distribution of skills and long-term economic growth across countries clearly display a positive correlation (Schwerdt et al., 2020). Policymakers therefore need robust evidence in order to devise interventions that genuinely improve basic skills. Despite the potential for cognitive and non-cognitive skills developed in early years to affect student achievement and other outcomes in adolescence, relatively little is understood around the crime-reducing impact of the set of cognitive and non-cognitive skills that can be developed in early years.

In this paper, we have considered the potential for a change in the content and structure of teaching to impact on pupil performance and youth criminality. Our analysis is facilitated by the introduction of a literacy hour to English primary schools, through the National Literacy Project (NLP), which introduced the literacy hour to around 400 English primary schools in 1997 and 1998, and a numeracy hour to English primary schools, through the National Numeracy Project (NNP), which introduced the numeracy hour to around 468 inner-city primary schools from 1997 to 1999. Although both initiatives originate from concerns about poor standards of literacy and numeracy in English schools, there was very little geographic overlap between these policies.

A set of difference-in-differences specifications is defined to investigate what happened to pupil achievement and future criminality in schools exposed to the literacy and numeracy hour. Individual-level administrative data matching education and criminal records from the UK Department for Education (DfE) and the UK Ministry of Justice (MoJ) were used for the entire population of students in primary state schools in England in 1997-99. Our estimates show that students exposed to the literacy and numeracy hour in primary school ranked higher in Key-

Stage 2 exams, and exposure to the literacy and numeracy hour in primary school also led to sizeable increases in their Key-Stage 2 test scores. While the test scores in reading and by male students drive the improvement generated by the literacy hour programme, the test scores in math and by female students drive the improvement generated by the numeracy hour.

Estimates also show that individuals exposed to the literacy and numeracy hour in primary school were less likely to leave school without any General Certificate of Secondary Education (GCSE) record, more likely to obtain at least five A*-C Grades in high-stakes GCSE exams at the end of secondary school and more likely to enrol in Advanced level qualifications (known as A-levels). Finally, males exposed to the literacy hour committed fewer offences from the age of 16 to 25 while females exposed to the numeracy hour committed fewer offences at the same age. Additional estimates focus on the literacy hour, because the vast majority of crime is committed by males, and they show our conclusions to be robust to different difference-in-differences estimators.

The evidence reported here therefore suggests that public policy aimed at changing the content and structure of teaching can raise pupil achievement and life chances in a lasting manner. These findings are of considerable significance when placed into the wider education debate about what works best in schools for improving pupil performance. They are also of considerable significance for education policies in countries which have problems with their levels of literacy and numeracy skills. As suggested in the paper, the research remit of economists has tended to be rather narrow in comparison with educationalists in this area.

Our approach shows that one of the areas receiving much less attention from economists in the past, namely looking at the content and organisation of what is taught, matters for English and reading as well as for mathemathics. This is particularly important given that it will almost certainly be the case that the same teachers were teaching literacy and numeracy before and after the introduction of the literacy and numeracy hour. Indeed, as the effects we identify come

from a government policy aimed at improving literacy and numeracy, the evidence we report suggests that public policy aimed at changing instruction methods can significantly raise pupil achievement and can do so in a highly cost-effective manner. Moreover, the evidence reported here suggests that boosting skills that are relatively weaker in childhood does not just have the potential to bridge the gap between males and females in achievement across subjects, but it has also the potential to reduce the respective propensities to commit crime during youth.

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Table 1. Balancing Tests between Treatment Schools and Control Schools in 1997

	Literacy Hour Programme			Numeracy Hour Programme		
	(1)	(2)	(3)	(4)	(5)	(6)
	Treated Schools	Control Schools	Difference	Treated Schools	Control Schools	Difference
Male	0.496	0.503	-0.007	0.499	0.503	-0.004
			(0.005)			(0.004)
Percentile Reading	39.850	49.756	-9.906	42.156	49.699	-7.543
			(0.592)			(0.574)
Percentile Math	40.872	50.542	-9.671	43.209	50.484	-7.275
			(0.636)			(0.614)
Standardised Reading	-0.325	0.025	-0.350	-0.240	0.023	-0.263
			(0.022)			(0.021)
Standardised Math	-0.305	0.034	-0.339	-0.220	0.032	-0.252
			(0.023)			(0.022)
KS4 5 A*-C Grades	0.361	0.504	-0.143	0.396	0.503	-0.107
			(0.008)			(0.008)
Ever Crime	0.244	0.201	0.043	0.232	0.201	0.031
			(0.005)			(0.005)
Ever Property Crime	0.163	0.116	0.047	0.148	0.117	0.032
			(0.005)			(0.005)
Ever Violent Crime	0.100	0.068	0.032	0.101	0.068	0.033
			(0.004)			(0.003)
Ever Drugs or Other Crime	0.372	0.283	0.090	0.361	0.283	0.078
			(0.010)			(0.009)
Observations			541,123			541,123

Notes: Columns (1), (2) and (3) in the Figure show balancing tests in 1997 between students enrolled in 1997 in schools that implemented the Literacy Hour Programme starting from 1997 (Treatment Schools) and students enrolled in 1997 in other schools (Control Schools). Columns (4), (5) and (6) in the Figure show balancing tests in 1997 between students enrolled in 1997 in schools that implemented the Numeracy Hour Programme starting from 1997 (Treatment Schools) and students enrolled in 1997 in other schools (Control Schools). Estimates in all Columns were calculated on a sample of 541,123 juveniles who enrolled in 14,047 primary schools in England.

Table 2. Estimates of the Impact of the Literacy and Numeracy Hour Programmes on Standardised Key Stage 2 Test Scores

	Reading Standardised Test Score			Math Standardised Test Score			Overall Standardised Test Score		
	Full Sample	**Female Sample**	**Male Sample**	**Full Sample**	**Female Sample**	**Male Sample**	**Full Sample**	**Female Sample**	**Male Sample**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Literacy Hour x 1997/8	0.078	0.047	0.102	0.006	-0.005	0.015	0.032	0.013	0.047
	(0.028)	(0.030)	(0.034)	(0.025)	(0.030)	(0.031)	(0.025)	(0.030)	(0.031)
Numeracy Hour x 1997/8	0.049	0.055	0.044	0.065	0.085	0.044	0.071	0.085	0.056
	(0.031)	(0.035)	(0.036)	(0.023)	(0.027)	(0.030)	(0.025)	(0.028)	(0.032)
Numeracy Hour x 1998/9	-0.012	0.020	-0.039	0.098	0.137	0.062	0.072	0.108	0.041
	(0.030)	(0.035)	(0.034)	(0.030)	(0.033)	(0.035)	(0.030)	(0.034)	(0.036)
School Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Primary School FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1534880	763491	771384	1543616	762233	781376	1513203	752767	760430
Primary Schools	14047	14047	14047	14047	14047	14047	14047	14047	14047
Adjusted R-squared	0.16	0.152	0.144	0.146	0.153	0.139	0.153	0.161	0.148

Notes: ITT status defined as students enrolled in 1997 in schools that implemented the Literacy or Numeracy Hour Programmes starting from 1997. Comparison group includes students enrolled in 1997 in other schools (Control Schools). Estimates were calculated on a sample of 1,534,880 juveniles enrolled in 14,047 primary schools in England.

Table 3. Estimates of the Impact of the Literacy and Numeracy Hour Programmes on Percentile Key Stage 2 Test Scores

	Reading Percentile Test Score			Math Percentile Test Score			Overall Percentile Test Score		
	Full Sample	Female Sample	Male Sample	Full Sample	Female Sample	Male Sample	Full Sample	Female Sample	Male Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Literacy Hour x 1997/8	2.079	1.269	2.692	0.114	-0.211	0.361	0.824	0.343	1.178
	(0.749)	(0.832)	(0.906)	(0.691)	(0.824)	(0.867)	(0.689)	(0.809)	(0.860)
Numeracy Hour x 1997/8	1.376	1.452	1.323	1.895	2.476	1.299	2.041	2.379	1.658
	(0.858)	(0.978)	(0.969)	(0.658)	(0.763)	(0.839)	(0.707)	(0.794)	(0.894)
Numeracy Hour x 1998/9	-0.215	0.543	-0.841	3.002	4.222	1.904	2.277	3.286	1.367
	(0.822)	(0.979)	(0.932)	(0.827)	(0.917)	(0.977)	(0.833)	(0.934)	(0.993)
School Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Primary School FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var. in 1996/7	49.085	51.924	46.278	49.610	48.452	50.736	49.986	50.277	49.698
Observations	1534880	763491	771384	1543616	762233	781376	1513203	752767	760430
Primary Schools	14047	14047	14047	14047	14047	14047	14047	14047	14047
Adjusted R-squared	0.156	0.148	0.139	0.144	0.152	0.137	0.15	0.158	0.144

Notes: ITT status defined as students enrolled in 1997 in schools that implemented the Literacy or Numeracy Hour Programmes starting from 1997. Comparison group includes students enrolled in 1997 in other schools (Control Schools). Estimates were calculated on a sample of 1,534,880 juveniles enrolled in 14,047 primary schools in England.

Table 4. Estimates of the Impact of the Literacy and Numeracy Hour Programmes on End-of-Secondary-School GCSE Exams

	Standardised Key Stage 4 Test Scores in GCSE Exams			Likelihood to Leave Secondary School without GCSE Exams			Likelihood to Leave Secondary School with 5+ A*-C Test Scores in GCSE Exams		
	Full Sample	Female Sample	Male Sample	Full Sample	Female Sample	Male Sample	Full Sample	Female Sample	Male Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Literacy Hour x 1997/8	0.024	0.007	0.037	-0.005	0.002	-0.012	0.009	0.001	0.015
	(0.014)	(0.021)	(0.020)	(0.005)	(0.006)	(0.006)	(0.008)	(0.011)	(0.010)
Numeracy Hour x 1997/8	0.026	0.043	0.007	-0.008	-0.008	-0.008	0.017	0.033	0.000
	(0.014)	(0.020)	(0.022)	(0.005)	(0.007)	(0.007)	(0.008)	(0.011)	(0.012)
Numeracy Hour x 1998/9	0.052	0.082	0.023	-0.014	-0.013	-0.015	0.032	0.047	0.016
	(0.017)	(0.022)	(0.023)	(0.005)	(0.007)	(0.006)	(0.008)	(0.011)	(0.011)
School Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Primary School FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var. in 1996/7				0.090	0.081	0.099	0.471	0.525	0.419
Observations	1620410	796534	823872	1620410	796534	823872	1620404	796531	823869
Primary Schools	14047	14047	14047	14047	14047	14047	14047	14047	14047
Adjusted R-squared	0.181	0.175	0.163	0.301	0.285	0.317	0.136	0.131	0.125

Notes: ITT status defined as students enrolled in 1997 in schools that implemented the Literacy or Numeracy Hour Programmes starting from 1997. Comparison group includes students enrolled in 1997 in other schools (Control Schools). Estimates were calculated on a sample of 1,620,410 juveniles enrolled in 14,047 primary schools in England.

Table 5. Estimates of the Impact of the Literacy and Numeracy Hour Programmes on Likelihood to Enrol in A-Levels and Crime Count Aged 16-25

	Likelihood to Enrol in A-Levels			Count of Crimes Committed Aged 16-25			Count of Crimes Committed Aged 16-20			Count of Crimes Committed Aged 21-25		
	Full Sample	Female Sample	Male Sample	Full Sample	Female Sample	Male Sample	Full Sample	Female Sample	Male Sample	Full Sample	Female Sample	Male Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Literacy Hour x 1997/8	0.079	-0.041	0.186	-0.247	0.027	-0.536	-0.131	0.040	-0.310	-0.116	-0.013	-0.226
	(0.034)	(0.056)	(0.043)	(0.120)	(0.088)	(0.237)	(0.082)	(0.059)	(0.163)	(0.058)	(0.043)	(0.108)
Numeracy Hour x 1997/8	0.026	0.008	0.034	-0.031	-0.115	0.020	-0.000	-0.082	0.073	-0.031	-0.032	-0.053
	(0.033)	(0.051)	(0.049)	(0.130)	(0.078)	(0.249)	(0.085)	(0.051)	(0.164)	(0.064)	(0.038)	(0.120)
Numeracy Hour x 1998/9	0.117	0.104	0.125	-0.049	-0.141	0.040	-0.016	-0.097	0.064	-0.034	-0.044	-0.024
	(0.042)	(0.059)	(0.049)	(0.121)	(0.072)	(0.237)	(0.077)	(0.045)	(0.151)	(0.061)	(0.037)	(0.119)
School Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Primary School FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var. in 1996/7	1.527	1.646	1.411	1.617	0.457	2.735	0.887	0.238	1.513	0.729	0.218	1.222
Observations	1620410	796534	823872	1620410	796534	823872	1620410	796534	823872	1620410	796534	823872
Primary Schools	14047	14047	14047	14047	14047	14047	14047	14047	14047	14047	14047	14047
Adjusted R-squared	0.188	0.197	0.181	0.05	0.011	0.036	0.044	0.01	0.032	0.033	0.006	0.023

Notes: ITT status defined as students enrolled in 1997 in schools that implemented the Literacy or Numeracy Hour Programmes starting from 1997. Comparison group includes students enrolled in 1997 in other schools (Control Schools). Estimates were calculated on a sample of 1,620,410 juveniles enrolled in 14,047 primary schools in England.

Table 6. Robustness Estimates of the Impact of the Literacy Hour Programme on Key-Stage 2 Test Scores

	KS2 Reading & Math Percentile Score	KS2 Reading Percentile Score	KS2 Math Percentile Score	KS2 Reading & Math Standardised Score	KS2 Reading Standardised Score	KS2 Math Standardised Score
	(1)	(2)	(3)	(4)	(5)	(6)
Panel 1. Full Sample	1.642	1.827	1.277	0.062	0.070	0.047
	(0.847)	(0.907)	(0.815)	(0.031)	(0.034)	(0.029)
Mean Dep. Var. in 1997	49.986	49.085	49.610			
Observations	1116882	1116882	1116882	1116882	1116882	1116882
Primary Schools	14365	14365	14365	14365	14365	14365
Panel 2. Female Sample	1.298	1.049	1.056	0.048	0.041	0.037
	(0.989)	(1.057)	(0.964)	(0.036)	(0.038)	(0.035)
Mean Dep. Var. in 1997	50.277	51.924	48.452			
Observations	548170	548170	548170	548170	548170	548170
Primary Schools	14348	14348	14348	14348	14348	14348
Panel 3. Male Sample	1.957	2.587	1.461	0.074	0.099	0.055
	(1.036)	(1.070)	(1.005)	(0.038)	(0.040)	(0.036)
Mean Dep. Var. in 1997	49.698	46.278	50.736			
Observations	568712	568712	568712	568712	568712	568712
Primary Schools	14356	14356	14356	14356	14356	14356
Primary School FEs	Y	Y	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y	Y	Y
Male FEs	Y	Y	Y	Y	Y	Y
FSM Eligible FEs	Y	Y	Y	Y	Y	Y
White British FEs	Y	Y	Y	Y	Y	Y
Native English Speaker FEs	Y	Y	Y	Y	Y	Y

Notes: ITT status defined as students enrolled in 1997 in schools that implemented the Literacy Hour Programme starting from 1997. Comparison group includes students enrolled in 1997 in other schools (Control Schools). Estimates in Panel 1 were calculated on a sample of 1,116,882 juveniles who enrolled in 14,365 primary schools in England. Estimates in Panel 2 were calculated on a sample of 548,170 females who enrolled in 14,348 primary schools in England. Estimates in Panel 3 were calculated on a sample of 568,712 males who enrolled in 14,356 primary schools in England. Standard errors are clustered at the primary school level and they are reported in parenthesis.

Table 7. Placebo Estimates of the Impact of the Literacy Hour Programme on Key-Stage 2 Test Scores using 1996-97 KS2 Takers

	KS2 Reading & Math Percentile Score	KS2 Reading & Math Standardised Score
	(1)	(2)
Panel 1. Full Sample	1.336	0.049
	(0.876)	(0.032)
Mean Dep. Var. in 1996	49.875	
Observations	1116882	1116882
Primary Schools	14365	14365
Panel 2. Female Sample	1.283	0.046
	(1.075)	(0.040)
Mean Dep. Var. in 1996	51.004	
Observations	548170	548170
Primary Schools	14348	14348
Panel 3. Male Sample	1.391	0.052
	(1.021)	(0.037)
Mean Dep. Var. in 1996	48.746	
Observations	568712	568712
Primary Schools	14356	14356
Primary School FEs	Y	Y
Year FEs	Y	Y
Male FEs	Y	Y
FSM Eligible FEs	Y	Y
White British FEs	Y	Y
Native English Speaker FEs	Y	Y

Notes: ITT status defined as students enrolled in 1997 in schools that implemented the Literacy Hour Programme starting from 1997. Comparison group includes students enrolled in 1997 in other schools (Control Schools). Estimates in Panel 1 were calculated on a sample of 1,116,882 juveniles who enrolled in 14,365 primary schools in England. Estimates in Panel 2 were calculated on a sample of 548,170 females who enrolled in 14,348 primary schools in England. Estimates in Panel 3 were calculated on a sample of 568,712 males who enrolled in 14,356 primary schools in England. Standard errors are clustered at the primary school level and they are reported in parenthesis.

Table 8. Robustness Estimates of the Impact of the Literacy Hour Programme on Key-Stage 4 Test Scores, Post-16 Education and Crime

	No GCSE Records	5+ A*-C Grades in GCSE Exams	KS4 Standardised Score	A-Levels	Any Crime Aged 16-25	Count of Crimes Aged 16-25	Count of Crimes Aged 16-20	Count of Crimes Aged 21-25
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel 1. Full Sample	-0.014	0.024	0.029	0.115	-0.009	-0.273	-0.136	-0.137
	(0.006)	(0.009)	(0.017)	(0.040)	(0.007)	(0.136)	(0.089)	(0.069)
Mean Dep. Var. in 1997	0.090	0.471		1.527	0.178	1.617	0.887	0.729
Observations	1116882	1116882	1116882	1116882	1116882	1116882	1116882	1116882
Primary Schools	14365	14365	14365	14365	14365	14365	14365	14365
Panel 2. Female Sample	-0.002	0.021	0.027	-0.011	-0.002	0.003	0.036	-0.034
	(0.008)	(0.013)	(0.024)	(0.062)	(0.008)	(0.094)	(0.057)	(0.049)
Mean Dep. Var. in 1997	0.081	0.525		1.646	0.086	0.457	0.238	0.218
Observations	548170	548170	548170	548170	548170	548170	548170	548170
Primary Schools	14348	14348	14348	14348	14348	14348	14348	14348
Panel 3. Male Sample	-0.025	0.027	0.031	0.237	-0.016	-0.549	-0.308	-0.241
	(0.009)	(0.012)	(0.024)	(0.052)	(0.013)	(0.270)	(0.174)	(0.134)
Mean Dep. Var. in 1997	0.099	0.419		1.411	0.267	2.735	1.513	1.222
Observations	568712	568712	568712	568712	568712	568712	568712	568712
Primary Schools	14356	14356	14356	14356	14356	14356	14356	14356
Primary School FEs	Y	Y	Y	Y	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y	Y	Y	Y	Y
Male FEs	Y	Y	Y	Y	Y	Y	Y	Y
FSM Eligible FEs	Y	Y	Y	Y	Y	Y	Y	Y
White British FEs	Y	Y	Y	Y	Y	Y	Y	Y
Native English Speaker FEs	Y	Y	Y	Y	Y	Y	Y	Y

Notes: ITT status defined as students enrolled in 1997 in schools that implemented the Literacy Hour Programme starting from 1997. Comparison group includes students enrolled in 1997 in other schools (Control Schools). Estimates in Panel 1 calculated on a sample of 1,116,882 juveniles who enrolled in 14,365 primary schools in England. Estimates in Panel 2 (3) calculated on a sample of 548,170 females (568,712 males) who enrolled in 14,348 (14,356) primary schools in England. Standard errors are clustered at the primary school level and they are reported in parenthesis.

Table 9. Robustness Estimates of the Impact of the Literacy Hour Programme on Crime by Category

	Violent Crimes Aged 16-25	Violent Crimes Aged 16-20	Violent Crimes Aged 21-25	Property Crimes Aged 16-25	Property Crimes Aged 16-20	Property Crimes Aged 21-25	Drugs Crimes Aged 16-25	Drugs Crimes Aged 16-20	Drugs Crimes Aged 21-25	Miscellan. Crimes Aged 16-25	Miscellan. Crimes Aged 16-20	Miscellan. Crimes Aged 21-25
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel 1. Full Sample	-0.008	-0.005	-0.006	0.002	0.001	0.001	-0.002	-0.000	-0.002	-0.014	-0.011	-0.012
	(0.004)	(0.003)	(0.003)	(0.006)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.007)	(0.006)	(0.006)
Mean Dep. Var. in 1997	0.050	0.035	0.022	0.072	0.056	0.030	0.046	0.029	0.047	0.138	0.102	0.083
Observations	1116882	1116882	1116882	1116882	1116882	1116882	1116882	1116882	1116882	1116882	1116882	1116882
Primary Schools	14365	14365	14365	14365	14365	14365	14365	14365	14365	14365	14365	14365
Panel 2. Female Sample	-0.000	0.004	-0.003	0.000	0.000	-0.002	-0.001	0.001	-0.001	-0.007	-0.004	-0.005
	(0.003)	(0.003)	(0.002)	(0.006)	(0.006)	(0.004)	(0.003)	(0.002)	(0.003)	(0.007)	(0.005)	(0.006)
Mean Dep. Var. in 1997	0.017	0.012	0.007	0.038	0.029	0.015	0.011	0.006	0.011	0.057	0.038	0.030
Observations	548170	548170	548170	548170	548170	548170	548170	548170	548170	548170	548170	548170
Primary Schools	14348	14348	14348	14348	14348	14348	14348	14348	14348	14348	14348	14348
Panel 3. Male Sample	-0.015	-0.014	-0.009	0.003	0.001	0.003	-0.004	-0.002	-0.004	-0.020	-0.018	-0.019
	(0.008)	(0.006)	(0.006)	(0.010)	(0.010)	(0.006)	(0.009)	(0.007)	(0.009)	(0.012)	(0.010)	(0.009)
Mean Dep. Var. in 1997	0.081	0.057	0.037	0.105	0.083	0.044	0.080	0.051	0.080	0.216	0.164	0.133
Observations	568712	568712	568712	568712	568712	568712	568712	568712	568712	568712	568712	568712
Primary Schools	14356	14356	14356	14356	14356	14356	14356	14356	14356	14356	14356	14356
Primary School FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Male FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FSM Eligible FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
White British FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Native English Speaker FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: ITT status defined as students enrolled in 1997 in schools that implemented the Literacy Hour Programme starting from 1997. Comparison group includes students enrolled in 1997 in other schools (Control Schools). Estimates in Panel 1 were calculated on a sample of 1,116,882 juveniles who enrolled in 14,365 primary schools in England. Standard errors are clustered at the primary school level and they are reported in parenthesis.

Table 10. Unconditional Estimates of the Impact of the Literacy Hour Programme on Student Composition

	ITT Pupils	Other Pupils	Difference ((1) - (2)) & DiD
	(1)	(2)	(3)
Panel A. Male			
Pre	0.504	0.509	-0.005
Post	0.515	0.509	0.005
	0.010	0.000	0.010
			(0.010)
Panel B. FSM Eligible			
Pre	0.276	0.117	0.159
Post	0.296	0.121	0.175
	0.020	0.004	0.016
			(0.008)
Panel C. White British			
Pre	0.477	0.722	-0.245
Post	0.529	0.751	-0.222
	0.051	0.029	0.023
			(0.017)
Panel D. Native English Speaker			
Pre	0.618	0.807	-0.188
Post	0.658	0.849	-0.191
	0.040	0.043	-0.003
			(0.013)
Observations	6062	535061	
Primary Schools	134	13913	

Notes: ITT status defined as students enrolled in 1997 in schools that implemented the Literacy Hour Programme starting from 1997. Comparison group includes students enrolled in 1997 in other schools (Control Schools). Estimates were calculated on a sample of 541,123 juveniles who enrolled in 14,047 primary schools in England. Standard errors are clustered at the primary school level and they are reported in parenthesis.

APPENDIX

Table A.1. Additional Balancing Tests between Treatment Schools and Control Schools in 1997

	Literacy Hour Programme			Numeracy Hour Programme		
	(1)	(2)	(3)	(4)	(5)	(6)
	Treated Schools	Control Schools	Difference	Treated Schools	Control Schools	Difference
Crime Aged 16	0.049	0.036	0.013	0.047	0.036	0.012
-			(0.002)			(0.002)
Crime Aged 17	0.054	0.041	0.014	0.049	0.041	0.008
-			(0.002)			(0.002)
Crime Aged 18	0.064	0.049	0.015	0.061	0.049	0.012
-			(0.003)			(0.002)
Crime Aged 19	0.066	0.053	0.014	0.069	0.052	0.017
-			(0.002)			(0.002)
Crime Aged 20	0.067	0.051	0.017	0.067	0.051	0.016
-			(0.002)			(0.002)
Crime Aged 21	0.058	0.044	0.014	0.059	0.044	0.015
-			(0.002)			(0.002)
Crime Aged 22	0.051	0.038	0.014	0.051	0.038	0.013
-			(0.002)			(0.002)
Crime Aged 23	0.043	0.032	0.010	0.043	0.032	0.011
-			(0.002)			(0.002)
Crime Aged 24	0.039	0.028	0.012	0.038	0.028	0.010
-			(0.002)			(0.002)
Crime Aged 25	0.036	0.024	0.011	0.032	0.024	0.007
-			(0.002)			(0.002)
Observations			541,123			541,123

Notes: Columns (1), (2) and (3) in the Figure show balancing tests in 1997 between students enrolled in 1997 in schools that implemented the Literacy Hour Programme starting from 1997 (Treatment Schools) and students enrolled in 1997 in other schools (Control Schools). Columns (4), (5) and (6) in the Figure show balancing tests in 1997 between students enrolled in 1997 in schools that implemented the Numeracy Hour Programme starting from 1997 (Treatment Schools) and students enrolled in 1997 in other schools (Control Schools). Estimates in all Columns were calculated on a sample of 541,123 juveniles who enrolled in 14,047 primary schools in England.