MATH361

Mathematics, Curriculum, and Assessment and Teaching

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Introduction

The Cockcroft report started a change in how mathematics was taught throughout the UK after it was published in 1982. I explore some of the reasons why Cockcroft suggested reform and how it would benefit students and teachers alike. Three years after this report, Her Majesty's Inspectors (HMI) released a booklet on how maths should be taught in schools. I explore a few points that the booklet made about teaching mathematics and how it followed the Cockcroft report in anticipation of the National Curriculum (NC) being introduced.

The NC has become a staple of mathematical education throughout the country since its introduction through the *Education Reform Act 1988*. It has constantly been changing through reforms made by successive governments. It brought around huge changes in how children were being taught mathematics and I link the changes brought in with the great influence that the Cockcroft report and HMI's booklet had on education a few years prior. But the NC also impacted on GCSEs that had only recently been brought in, and so I explore the controversies surrounding GCSEs along with statistical evidence as to the effectiveness of the new type of assessment. Similar to the previous reports, the Dearing review in 1994 had a big impact on the NC at the time. I explore some of the points raised in the review, from the curriculum being too expansive to the need for more focus on children with special educational needs. I also raise points about potential dangers of a narrow approach in solving these problems.

I move to changes brought about in 2006, the biggest of which was the scrapping of GCSE coursework in many subjects, including maths. I probe into why coursework was scrapped while presenting counter arguments against the change. The next changes to the NC mentioned are those in 2008, with a similar proposal to the one in Dearing's review being instituted. The Government slimmed down the NC, providing teachers with the benefit of more time in the classroom and allowing students time to gain a deeper understanding of the subject.

Finally, the recent changes of 2014 are explored as I investigate the support and criticism of changes brought about, with some feeling that with the progression of time, the NC has strayed further away from the advice given in the Cockcroft report.

The Cockcroft Report, 1982

The Cockcroft report (1982) aimed to highlight problems within the teaching of mathematics in the UK. It stressed throughout the importance of allowing pupils to develop mathematical skills, preparing them for employment with effective 'real-world' skills. For this, it encouraged a shift of focus from symbolic questions, merely asking direct mathematical questions, to asking about real-world scenarios and getting the students to infer what mathematical concepts to use based on the question context. This arose from employers having concerns that school leavers lacked the basic mathematical skills required for work. Gray & Tall (2004) recognised this need for real-world interpretation of even simple maths, with benefits extending away from

merely understanding abstract mathematics. It provides students a chance to recognise problems in the future that may occur outside of the classroom or workplace, and gives them the knowledge to solve these problems using mathematical techniques.

But concerns have been raised over the effectiveness of this type of assessment. Teachers reported that pupils whose first language was not English, and to a lesser extend those of a working-class background, struggled to infer what exactly the questions were asking for and what skills needed to be used. Demack, Drew & Grimsley's (1998) analysis of GCSE results in 1988 and 1993 found that the biggest gap in grade average was between socio-economic groups, with a large divide also being found between children of different ethnicities. Zevenbergen stresses that it is important in classrooms to consider pupils from these disadvantaged backgrounds, especially as socio-economic divide often gets overlooked. He notes that difference in up-bringing and parents attitude towards mathematics can affect a child's enthusiasm for the subject, with working-class parents "often comment[ing] that they were no good at mathematics, so they couldn't expect their own children to be otherwise" (Zevenbergen 2001, p.41).

Cockcroft also advocates interaction between parent and child, urging parents to help their child outside of school with homework. Playing 'games' involving maths also helps to create a positive attitude towards, along with familiarity of numbers, symbols, and operations. This approach to learning is explored by Barmby, Harries & Higgins (2010), with the counting of physical objects through play being used to cognise abstract constructs, but the importance of understanding these concepts is highlighted through Tall's (2013) three worlds theory. He postulates that there are three 'worlds' to mathematics, starting with perception, then symbols, and finally reason; all of which need to be developed for cognitive growth. Not only does a child need to explore these 'worlds', but new concepts need to be connected to their existing knowledge with compatibility between abstract mathematical constructs and the physical world around them needing to be established. Piaget (1968) suggested that children must restructure their current understanding to accommodate new ideas presented to them , but critics of Piaget's theory argue that he underestimates the abilities of younger children and overestimates the ability of older students to learn and comprehend concepts, leading to teachers assuming their pupils can always think logically despite this often not being the case (Eggen & Kauchak 2000).

An emphasis on more interaction with teachers was also urged for in the report, moving away from the traditional teaching method of dictation and towards a method that allowed students to discuss their ideas with teachers and peers. This enables pupils to realise that there may be multiple ways of thinking about mathematical concepts, strengthening their understanding whilst giving them a chance to verbally explain their train of thought to others. Davis (1984) advocates communication whilst children are answering mathematical questions. He explains the benefits of 'task-based interviews' conducted by teachers as a way to gain an insight into how individuals approach different mathematical tasks. The child is asked questions through-

out the task, like why they used a specific approach and to justify why they didn't complete it in another way. Griffin (1989) also mentioned this communication between students after writing down general comments about his teaching, noting that the class had more energy after they had discussed with a partner what they did or where they went wrong in a task. But the added interaction with teachers also allows the pupils to ask questions, not only about the subject, but also questions about the applications of concepts. This would help them in exams for contextual questions proposed in maths, as well as in related subjects like physics or chemistry.

Mathematics from 5 to 16, 1985

During the mid to late 1980s, a series of booklets that covered most areas of the curriculum taught in schools at the time were released by HMI, released under the name of *Curriculum Matters*. They were published in anticipation of the National Curriculum, provided through the *Education Reform Act 1988*, with *Mathematics from 5 to 16* (1985*a*) in this series trying to build upon and implement the Cockcroft report that had been released 3 years prior. It tried to bridge the gap between children of different abilities, sex, and social and cultural backgrounds. One suggestion that was met with support and opposition was the implementation of practical work in lessons. Whilst primary schools praised this idea due to it getting students more engaged and letting them 'see' mathematics happening, some secondary schools felt that "older children sometimes find practical work in mathematics childish whereas the opposite is probably true in other subjects"(DoES, 1985a, p.8).

The booklet does however point out that an appropriate balance needs to be struck with practical work, both in terms of individual student needs and with the needs of the topic being taught. Dickinson & Hough (2012) explore how the use of realistic mathematics with real-world problems can help a child to not only complete questions, but also to help them develop a deeper insight that can be applied outside the classroom as well. Many teachers and pupils that responded to their survey gave merit to Realistic Mathematics Education (RME), and Taylor (2014) also advocates this style of learning as it allowed students to see and interact with mathematics in their daily life.

This links with Schoenfeld (1992) and Davis, who both describe a push for mathematical thinking instead of just memorising "meaningless prescribed algorithm" (Davis 1984, p.90). Based on 'Stimulus-Response' theory developed by Thorndike and Skinner, it advocates a shift of focus towards the justification behind an answer, rather than it solely being right or wrong (Harris & Spooner 2000). It enables the students to gain the deeper apprehension that can be brought forward into later life, benefiting employers as well as the individual. Mason (1998) also touches on the difference between working on and working through problems, with the later requiring investigation from students leading them not only to gain an answer, but to gain understanding as well.

National Curriculum, 1988

The National Curriculum (NC) was established through the *Education Reform Act 1988* with its purpose being to maintain a standard of education throughout Britain, as well as to "[promote] the spiritual, moral, cultural, mental and physical development of pupils" (HM Gov., 1988, p.1). Key Stages (KS) were introduced, separating the years of study with specific targets for pupils to achieve by the end of the Key Stage. It set out to prepare students for adult life and to provide them with the skills needed for employment. The curriculum provided for mathematics drew upon the Cockcroft report, implementing real-world questions and allowing for more interaction with teachers and other pupils. Assessment at the end of the Key Stages were still based on exams, but students also sat assessments at the end of units throughout the year, complimenting the Cockcroft report and allowing teachers to track a child's progression and provide extra assistance on weaker topics before an exam.

The NC provided British education with a more coherent structure and standardised assessment across the country, but it also drew criticism from some. Some teachers felt they couldn't offer specialised support for particular students as they had to stick rigidly to the NC. This led to those pupils falling behind and unable to receive the help they required. Griffin (1989) discussed that time was needed to teach topics to students and to provide pupils with enough time to learn and fully understand the concepts. This time however was not provided when the NC was introduced due to the large syllabus that needed to be taught. The Cockcroft report warned against this, saying that "the syllabus should not be too large so that there is time to cover the topics which it contains in a variety of ways and in a range of applications" (Cockcroft et al. 1982, p.134), advising there be a foundation list of topics to be taught to all students.

General Certificate of Secondary Education (GCSE)

GCSEs were introduced in 1986 (with the first exam in 1988) by merging together GCEs and CSEs, with standards maintained and enforced by the Secondary Examinations Council. Senior head teachers at the time thought that GCSEs would be phased out during the mid-1990s by the NC, as when they were brought in, they were met with criticism with some arguing that they had been hastily introduced. Others criticised the increase in the number of students passing exams and getting higher grades compared to O levels, with claims that the exams had become too easy. 46% passed the 1989 GCSE exams compared to 40% in the 1987 O level exams, with 10.3% achieving a grade *A* under the new exams scheme compared to 6.8% previous (Brooks 1991). Walden, Minister for Higher Education at the time, argued that the structure of GCSEs were so different from the system that it had replaced, that all claims about them being of a higher standard were invalid.

However, the former Education Minister and 1977 Black Paper co-author Boyson noted that for maths in particular, grades had not in fact seen a sharp increase, maybe due in part to the fact that mathematics was solely exam-based assessment with no coursework. The Department of Education and Science put the higher overall grades down to providing pupils that were before at a disadvantage with only exam-based assessments a chance to gain marks in coursework, with the slightly higher grades in mathematics due to the change in question style (Brooks 1991).

The Cockcroft report put forward the notion of in-class assessment, allowing teachers to monitor a student's progress throughout the academic year and provide them with specific help on weaker topics. This was broadly welcomed by teachers (DoES, 1985b), but concerns were raised over the compatibility of this kind of assessment and the introduction of the new GCSEs as it put all the pressure on students to do well in a high-stake exam at the end of the year. A study conducted by von der Embse & Witmer (2014) in the United States of America in 2014 found that students performed worse in exams when they suffered from higher levels of anxiety. Having solely end of year exams can negatively impact those students that do have increased anxiety, leading them to not performing to their full potential.

Still to the present day, debate around the effectiveness of GCSEs and exams continues. The chairman of the Education Select Committee, Halfon, branded GCSEs 'pointless' in February 2019 despite the Department for Education describing them as the 'gold standard' for exams (Coughlan 2019). The claims that the focus of schooling should be on the final exams were met with both support and criticism, with Barton, leader of the ASCL union, citing that the drop in students leaving education aged 16 as a reason to replace the current system in favour of one that broadens post-16 scopes (DfE, 2018). Baker, who originally brought in GCSEs, has said they are now 'redundant', but others feel scrapping them would be detrimental to students, especially those applying for university. Employers are also complaining that students leave school without the skills required for work and scrapping of GCSEs would make this skill shortage even worse.

The Dearing Review, 1994

Dearing published *The National Curriculum and its Assessment: Final Report* in 1994, a review into a proposal to slim down the NC for core subjects and an investigation into how exams and assessments could be improved. This arose from teachers concerned that they could not teach the whole curriculum in enough detail before the exams, leading to some students being left behind and struggling to keep up in lessons. Teachers were also unable to provide enough specialist assistance to students, leading to underachievement in exams due to the lack of support opportunity. This disadvantaged children that struggled mathematically and especially those that had special needs, as a bigger curriculum meant that there was not enough time

available to cover every topic in detail.

The review sought to change this, recommending that the NC be slimmed down to provide teachers more time to provide help to those students struggling. This added time could be used by students to gain what Skemp (1978) describes as 'relational understanding', a deeper mathematical knowledge of concepts and a comprehension of how topics may link together, as compared to the shallower 'instrumental understanding'. The deeper understanding could be used by students in other subject areas as well, along with being brought forward into later life to the benefit of employers. Holt offers a further insight into what understanding is, with a checklist that could possibly be used in the classroom. He feels he has not fully understood something until he can "(1) state it in [his] own words; (2) give examples of it; (3) recognize it in various guises and circumstances; (4) see connections between it and other facts or ideas; (5) make use of it in various ways; (6) foresee some of its consequences; (7) state its opposite or converse" (Holt 1964, p.107-108).

Dearing also believed that the curriculum must be available to those with special needs, citing that 20% of students will require special needs at some point in their educational career (DfE, 1993). The review suggested that, although the 'rigour' of the NC must be maintained, changes should be made to allow pupils to not only pass exams, but also provide them with skills for independent living, such as visually impaired individuals learning Braille. Ernest (2011) stressed the importance of this, exploring the theories behind teaching children that require special needs. He notes that the correct identification of these children is required so that they have the right aid available to them. But he not only analyses those with learning difficulties, but also gifted and talented students that need the right support for them to flourish.

The suggested changes would come in part from assessments, with the aims of testing arrangements being simplified to reflect the slimmed down curriculum and the broad range of abilities present within schools. The review recommends that teacher assessment should be used alongside end of year exams, and that parents should be informed of their child's progression throughout the Key Stages. This would allow parents to recognise and support their child on specific topics that they are struggling with. This links to Skemp (1978) and the Cockcroft report (1982), as they also promoted the idea of a stronger connection between parent and child regarding school work and progression. But these changes also need to be extended to students with special needs, while also taking into account their progress capabilities. The review states, regarding pupils with special educational needs, that "[a]though the steps of progress may be small compared to those of other pupils, they often represent huge progress for individual children" (Dearing 1994, p.54).

However, Dearing warns against the dangers of "fragmented teaching and learning", as teachers constantly comparing to the NC can lead to a 'tick-list' style approach to assessments, going against the Office for Standards in Education's (OFSTED) National Curriculum 1992/94 reports. Cockcroft also reported this in 1982, with some teachers only able to answer that the

purpose of a specific task was to "pass your exams". Skemp (1978) also observed that the same was true for students with what he described as 'rules without reasons'. This type of learning was not adequately preparing students for work, or for using mathematics in the real-world.

The Dearing review formed the basis of the *Education Act 1996*, a reform to the National Curriculum under Shephard, the Secretary of State for Education (HM Gov., 1996).

National Curriculum, 2006/08

After becoming compulsory in the 1990s, Johnson, the Education Secretary, scrapped coursework for GCSE mathematics in 2006 due to students copying their peers' work by exploiting greater access to the internet (QCA, 2005). Although seemingly contradictory to the reports aforementioned, support was given due to some seeing coursework in mathematics as inappropriate, praising the Government for keeping up with technological change. Some subjects retained coursework that would be sat under 'controlled conditions', with ASCL general secretary Dunford agreeing that "coursework remains a legitimate way to test a wide range of skills and knowledge in other subjects" (politics.co.uk 2006). Opposition to the change have claimed that examinations cause stress and anxiety for students, with coursework in mathematics allowing pupils the chance to receive feedback on work, and in turn allowing them to grasp concepts with greater detail. The broader range of coursework also let teachers assess students throughout the year with a range of tasks. Hiebert & Carpenter argue the case for varied and multiple assessments, explaining that "any individual task can be performed correctly without understanding" (Hiebert & Carpenter 1992, p.89), and hence can't be used as an indicator of knowledge or comprehension.

However, the removal of coursework from GCSE maths has led to a surprising difference between male and female grade achievement, with a higher proportion of boys receiving an A^* to C grade in mathematics despite girls statistically achieving higher grades over all subjects (DfES, 2007). This phenomenon is explored by Richardson (2015) in *Coursework versus examinations in end-of-module assessment: a literature review*, as well as being observed in von der Embse & Witmer's (2014) study.

The National Curriculum was reformed again in 2008 under Balls, the Secretary of State for Children, Schools and Families, with the curriculum focus being on the basics of education while reinforcing the three R's; Reading, wRiting, and aRithmatic. The Children, Schools and Families Committee took the view that "the main purpose of a national curriculum is to set out clearly and simply a minimum entitlement for every child" (CSFComm, 2009, p.3). Similar to the *Education Act 1996*, it aimed at reducing the amount of content being taught in schools at KS3 and KS4, whilst also setting out to add flexibility in how mathematics was taught. It allowed teachers to deviate slightly from a rigorously set curriculum and provide extra support to those who needed it. This also provided an opportunity for teachers to be

more creative in the classroom, so they could best engage pupils in the subject; this being one of the main criticisms of the NC since its introduction in 1988, with learning set such that interesting tangents can't be explored.

National Curriculum, 2014

In 2014, the National Curriculum was reformed again under Gove, the Education Secretary at the time. The main aims of the newly published maths National Curriculum were to "become fluent in the fundamentals of mathematics", "reason mathematically", and "solve problems" (DfE, 2014). But these changes were branded by some as being too hard, with more content being expected to be learnt at an earlier age as compared with the previous NC (Pearson, 2015). This was seen as a step back, with the curriculum overall being criticised as a "distinct break [from] the route laid down by Cockcroft" (Brown 2014). Mason (2002) explains that although a challenge is needed to test students, a balance needs to be found. He describes how challenges set need not be insufficient, leading students to not fully engage with the task set, or be too excessive, as to discourage the students attempting the task. Halmos backs up the need for a sufficient challenge, saying "[c]hallenge is the best teaching tool there is, for arithmetic as well as for functional analysis, for high-school algebra as well as graduate-school topology" (Halmos 1985, p.271).

A change in exam structure was introduced however, with three exams based on arithmetic, problem-solving, and reasoning replacing two exams; calculator and non-calculator. Exam questions are also favouring a less guided approach, which has been praised by some as students now have to use more mathematical reasoning to obtain an answer. Others though have mentioned that it doesn't encourage investigation nor discussion, with a broad curriculum still being implemented by examination boards rather than the focus being on procedure (Brown 2014).

Conclusion

The National Curriculum in the UK has changed significantly throughout time, with major changes stemming from a variety of reports as well as pressure from outside the educational system. The NC was first introduced due to the Cockcroft report and HMI's booklet raising issues within current teaching methods, coupled with suggestions based on theories of how children learn mathematics. Employers have had an impact on these changes as well, with complaints of students being unable to use mathematical skills in later life, with the Cockcroft report advocating problem solving as a solution to this.

But these changes also impacted children of different ethnic and socio-economic backgrounds, with studies finding lower grade attainment being caused by their struggle to understanding

questions due to the system in place. These concerns were noted upon in reports, with the Dearing review extending this emphasis to the assistance of children with special educational needs. These issues formed an important part of the reform that was instituted in 1996, along with a slimmed down curriculum.

GCSEs have also been strongly debated and altered since 1986, with initial consequences of their introduction being the rise in top grades achieved by students. Debate as to the cause of this was rife at the time, but over the years changes in exams and assessments have tried to normalise grades attained. One major change was the scrapping of coursework for mathematics, which consequently saw the divide between grades of male and female students become more prominent.

The changes to the NC and GCSEs have sparked much debate and disagreement, but all the reforms mentioned, whether originating from psychological theories or observations and studies in the classroom, have shared the common goal of trying to support the individual student and prepare them for later life.

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