

Chose a specific key stage and critically evaluate how current initiatives support the development of numeracy across the curriculum within your setting. Compare practice to the academic literature and policy

The purpose of this essay is to critically evaluate how current initiatives support the development of numeracy across the curriculum. It will look to compare practice against policy in a specific school environment concentrating on key stage 3 pupils using academic literature, comparing current policy across the UK and other countries.

The first important point to understand is what is numeracy? It is also important to understand the difference between numeracy and mathematics. Mathematics is usually defined as the science of numbers and their operation, and when taught in schools is the study of numbers, quantities and shapes. In 1998 the Department of Education and Employment set out a framework for teaching mathematics from reception to year 6, although this is not the key stage this essay will be focusing on, it gives an excellent explanation as to what numeracy means.

Numeracy is a proficiency which involves confidence and competence with numbers and measures. It requires an understanding of the number system, a repertoire of computational skills and an inclination and ability to solve numbers in a variety of contexts. Numeracy also demands practical understanding of the ways in which information is gathered by counting and measuring and is presented in graphs, diagrams, charts and tables (Department of Education and Employment, 1999).

The term confidence “as used here implies a feeling of security, the ability to make connections between the various aspects of numeracy and the courage to develop personal methods and vary them according to the particular problem” (Koshy and Murray, 2002, p.1).

The importance of excellent numeracy is highlighted in the Programme for the International Assessment of Adult Competencies (PIAAC), Study of Adult Skills. The survey “measures adults’ proficiency in key information – processing skills – literacy, numeracy and problem solving and gather information and data on how adults use their skills at home, at work and in the wider community” (OECD, 2019). The report found that adults “with greater proficiency in literacy, numeracy and problem solving in technology-rich environments tend to have better outcomes than their less proficient peers. They are more likely to be employed, and if employed, to earn higher wages” (OECD, 2019).

The specific age group this essay will concentrate on is 11 – 14-year olds or key stage 3, years 7,8 and 9 in England and Wales. The school it will be based on is a mixed comprehensive situated in South Pembrokeshire with approximately 1200 pupils. The local area has the highest percentage of jobs that are paid less than the applicable living wage at 32.7% (National Assembly for Wales, 2018) and 16% of school age pupils are known to be eligible for free school meals (Welsh Government, 2019).

Education has changed greatly over the past one hundred years or so – in Victorian times teachers were usually unmarried women, as the pay was so poor men could find better paid employment elsewhere. These women were very often extremely strict and discipline in these schools would have been extremely harsh, including being caned for all manner of offences from being late to working too slowly. The lessons usually involved copying down what the teacher wrote on the chalkboard and chanting out loud, repeating it until they were faultless (Victorian Children and Life in Victorian Times, 2019). Little changed in the teaching of mathematics and numeracy for many years, where the belief continued that this repetitive behaviour was an effective way of learning. Behaviourism learning theory puts the learner in this passive role where “elaborate systems and rituals for the reinforcement of correct pupil response (Polland et al. 2009, p.75). This method put much emphasis on practice and drill. I. Pavlov (1849-1936) and J. Watson (1878-1958) advocated this classical conditioning, they “believed that humans have no free will; rather were moulded and shaped by the environment” (Aubrey and Riley, 2019, p. 75). Watson believed under the right circumstances with the right stimuli anybody could be taught anything. A teacher who constantly shouts at pupils and disciplines them harshly while teaching mathematics might condition them to dislike that subject (Barlett et.al. 2001, p. 110). Behaviourism is commonly linked with ‘traditional’ teaching methods, particularly associated with whole class teaching. This association with strict discipline and strong subject teaching means it is very often seen as a negative approach, but this style of strict reinforcement can be very effective for certain children, especially those whose need tight routines.

Education is becoming more child-centred with the focus moving towards a child’s individual needs rather the learn and punishment scheme of learning. Constructivism suggests that people “learn through an interaction between thinking and experience, and through the sequential development of more complex structures” (Polland at al. 2009, p. 175). Constructivist learning theory puts the learner in a very active and independent role. Teaching influenced by constructivism can be seen across all schools today, it is reflected in the rich, varied and stimulating learning environments modern schools have become. L. Vygotsky's (1896-1934) scaffolding theory works extremely well in the teaching of numeracy, the teacher lays down the basic skills of adding, subtraction, multiplication etc as the foundation from which all the other numeracy skills are built on. Although J. Piaget’s (1896-1980) research was not aimed at education it has long been used in this setting. Prior to the Plowden Report

(1967) a typical primary school classroom saw children still sat in rows, learning through repetition and copying off the board with the assumption that all children had the capacity to learn this way, and those that could not were either left behind or punished (Aubrey and Riley, 2019, p. 48) The Plowden report had the child at the heart of its recommendations “No advances in policy, no acquisitions of new equipment have their desired effect unless they are in harmony with the child...” (The Plowden Report, 1967).

Following on from the Plowden Report the attitudes in education did change as did the curriculum but in 1982 another very important report was published. The Cockcroft report “Mathematics Count” (Cockcroft, 1982) was commissioned to “offer constructive and original proposals for change”. The report highlighted the importance of mathematics, the element we now refer to as numeracy, in the fields of geography, economics, science, business and management studies - “mathematics provides a means of communication which is powerful, concise and unambiguous”. The report also documented how the application of mathematics was used to the plan of the journey of the Voyager Spaceship – once again emphasising the importance of the subject outside of the classroom. The report also goes onto detail how during their investigations they found “even an apparently simple and straightforward piece of mathematics could induce feelings of anxiety, helplessness, fear and even guilt...” Reiterating the importance for the need of excellent numeracy skills.

In Wales all schools are currently working towards a new curriculum. In 2015 “Successful Futures - Independent Review of Curriculum and Assessment in Wales” by Professor Graham Donaldson was published. The new curriculum has four key purposes underpinning every element – the Welsh Government want all young people to be “ambitious, capable learners, ready to learn throughout their lives; enterprising, creative contributors, ready to play a full part in life and work; healthy, confident individuals, ready to lead fulfilling lives as valued members of society” (Welsh Government, 2019). The Mathematics and Numeracy area of Learning and Experience is concerned with “developing a good, lasting understanding of mathematical concepts and the confidence to use and apply numerical skills in everyday life. It includes experiences that enable children and young people to develop their broader numeracy and financial skills by exploring relationships in quantities, space and data, and to apply them to real life situations” (Donaldson, 2015). The new curriculum realises the importance of numeracy as a stand-alone subject and how it helps “children and young people to make sense of the world around them...It gives them the skills they need to interpret and analyse information, solve problems and make informed decisions” (Donaldson, 2015). The day to day reality is that if you do not have a good understanding of numeracy, working out your bills and even budgeting your shopping is going to be huge undertaking.

“78% of adults have numeracy skills below level 2 (the same level as a good GCSE pass) and would therefore struggle to answer a question such as ‘A TV has been reduced by 20% and now costs £280. What was the original price?’” (National Numeracy, 2019).

The New Frameworks for numeracy and Literacy are now shown along progression steps rather than year groups. This change is to ensure the framework meets the needs of the learners. The Numeracy Framework is broken down into strands and elements. Each strand is broken down into four headings of “developing numerical reasoning, using number skills, using measuring skills and using data skills” (Welsh Government, 2019). Each of these strands is broken down into elements appropriate to the specific topic being taught, the expectations within these elements' changes through each of the five-progression steps. For example, an element of ‘using measuring skills’ is ‘time’ within progression step 1 a pupil will be expected to understand the concepts of ‘before’ and ‘after’ in relation to daily routines. At progression stage 3 they will be taught to tell time on both analogue and digital clocks, use a calendar and carry out practical activities involving timed events. Then at step 4 use time zones and interpret fractions of a second. This topic does not have any elements in step 5 as pupils will be expected to be fully competent by this level (Welsh Government, 2019).

Within the new Welsh curriculum importance is placed on both mathematics and numeracy as separate entities. “Mathematics is an international discipline, and numeracy, the application of mathematics, plays a critical part in our private, social and civil lives, and in the economic health of the nation” (Welsh Government, 2019). The proposals set out in “Successful Futures” is that each school can design their own curriculum within the boundaries set out in the paper. High importance is being placed on three cross-curricular areas of literacy, numeracy and digital competence. This means that within this new curriculum it will be the responsibility “of all teachers to plan progression across the full range of literacy, numeracy and digital skills” (Welsh Government, 2019).

Within the educational setting this essay is concentrating on this cross-curriculum activity is already starting to take place. The challenge the mathematics, science and IT departments undertook was to get all the children in Key Stage 3 involved in a project designing a new roller-coaster ride. For the numeracy element students had to think about the measurements of the track, what they should be measured in, angles and degrees of the turns and drops. This information was translated into graphs and charts, giving the children different methods of seeing, reading and interpreting the data. In physics, pupils had to apply the laws of gravity and G-Force and it was all put together using several different IT programmes. This project shows how closely linked the three disciplines are.

One of the advantages of doing such a cross-curriculum project is that it shows pupils the ‘why’ when they question if they ever need or will use the knowledge of trigonometry for example. Seeing

numeracy and science working in a real-life scenario gives children more confidence when using these skills. Teachers within this setting also commented how it gave children an opportunity to stretch their critical thinking skills and working together as a team – another vital skill when it comes to real-life situations especially in an employment environment.

Speaking to the Head of Key-Stage 3 Numeracy whilst discussing all the above positives there are also negatives to cross-curriculum working. Lack of time to spend collaborating with staff from different facilities, so much emphasis is placed on lesson planning, marking and resource preparation this was a real cause for concern. Lack of confidence amongst staff who may feel underprepared for such a huge change in the curriculum. Lack of confidence in teaching staff who may never have taught numeracy before, for example a science teacher. A third drawback is keeping this momentum going through all the key stage levels, it needs to be well planned, well resourced, well-structured and implemented by well-supported, well-trained teachers.

The importance of numeracy in everyday situations was emphasised in the National Numeracy programme (2012), following on from this, students in the U.K. now sit four G.C.S.E. papers, a calculator and non-calculator in both mathematics and numeracy. In order to support this, the school studied introduced 'quick maths' exercises for the beginning of each mathematics lessons. In Key Stage 3 especially, they found the five-minute numeracy intervention 'Numeracy Ninjas' an extremely helpful tool. Although it is not government policy, it was taken on as a whole school initiative to start a lesson. Each test comprises of ten questions "on mental numeracy calculation strategies, ten timetables questions on key topics that must be mastered before studying G.C.S.E maths and numeracy. The tests are marked in class by fellow students who record their 'ninja' score out of thirty. The result they get will dictate what colour ninja belt they will have earned, only a score of thirty will earn a black ninja belt (Numeracy Ninjas, 2019). The skill of 'peer-assessment' is an "important learning experience...as thinking about the performance of others...requires a depth of understanding of the nature of the learning itself in order to make such evaluations". This skill as well as 'self-assessment' is highlighted on the new curriculum as an important way of helping children take more responsibility for their own learning "by reflecting on their understanding and performance...they can identify areas of difficulty" (Donaldson, 2015).

Mathematics as a subject in the UK is traditionally treated as a 'means to an end'. Teaching a child to recite their times tables in a parrot like fashion, learning to add and subtract in a very structured format. The new welsh curriculum stresses how mathematics and numeracy surround us in our everyday lives in "architecture, art, music, money and engineering" (Welsh Government, 2019). Other countries have long since held this belief, in Japan for example students spend less time "practising

routine procedures and more time inventing, analysing and proving than their peers in other countries" (Sutherland, 2007, p. 23). In Russian textbooks it is common practice to mix in different mathematical problems, so a child is not having to do long sequences of a problem which can only be solved by using the same repetitive strategies. They believe this approach is less likely to make the child see the subject as a task in itself (Wood, 1998, p. 271). According to a Telegraph newspaper article Switzerland need a "constant supply of smart, numerate people" (The Telegraph, 2013). The countries high dependency on tourism and financial sectors means expectations in mathematics and numeracy are high, children there do around six 45-minute lessons a week and are expected to do homework every night. The teaching of mathematics is a very structured subject within the curriculum and teaching standards are very high. Swiss schools have very strict rules and generally abide by them, detention and expulsion are routinely used as methods of punishment (The Telegraph, 2013). This type of high expectations can also be seen in education in China. It is normal for secondary and high school students to spend more than fifteen hours a week on mathematics and numeracy a week, both in the classroom and at home. From the age of seven Chinese children use the method of repeating and reciting their times-table "the cultural traditions of Chinese maths education lead people to believe that routine practice is the most efficient way to learn" (Wei, The Conversation, 2014). In 2011 a revised curriculum in China meant students are taught to understand numerical relationships which allow them to apply this knowledge in other topics. Testing in Chinese schools is also placed in high importance, but the quality of education can vary greatly in rural communities.

These differences in attitudes and different methods of teaching, as well as the similarities can be hard to compare and evaluate but every three years the Organisation for Economic Co-operation and Development measure fifteen-year-old school pupils' performance across 78 countries. It is known as the PISA (Programme for International Student Assessment) test. The aim of the test is to analyse how educational systems are working in different countries and means of letting other countries compare how effective their own policies work in preparing young people for entering the workforce. The latest PISA report was published in December 2019, the Dominican Republic scored the lowest in numeracy with 325 points (education is only compulsory there till the age of fourteen), China scored the most points with 591. The United Kingdom was 14th highest with 502, Switzerland was 6th (513), Japan was 5th (527 points) whereas Russia scored just below the average score of 489 with 488 (OECD, 2019). So, where Japan and Switzerland have very different teaching methods the emphasis on spending time and effort on numeracy and Mathematics seemingly pays dividends.

In this country especially there is an acceptable and almost always unquestioned attitude to numeracy - "I am rubbish at maths". C. Dweck, a Professor of Psychology at Columbia University, USA has studied learner's beliefs to mathematics and numeracy. She found that some believe that intellectual levels

are basically fixed or 'a fixed mindset'. In a study done in 2007, 373 students were followed whilst studying mathematics and numeracy through grade 7. Students with a growth mindset, those who believed they could develop their intelligence levels, compared to those with a 'fixed mindset' had a far "stronger belief in the power of effort" and although they cared about their grades, "they cared even more about learning". Those students with the growth mindset were much more likely to "employ positive strategies" and more effort (Dweck, 2008, p.3). This growth mindset is an important attitude to instil in children and young people today, so they do not think they are 'rubbish' at numeracy and thus lack confidence when applying these skills to real life scenarios.

The Skills for Life Survey (2011) interviewed and tested 7230 people between the ages of 16 and 65, the impact on educational attainment in numeracy, literacy and ICT very clear cut. Those who stayed on in education the longest scored the highest in the assessments, there was also a clear link between poor parental education and poorer results in the participants. In 2011 there was a slight decline in the numeracy skills results going down to 76% from 79% when the tests were last taken in 2003. The results also showed "respondents in employment tended to outperform those who were unemployed...this may suggest at poor numeracy skills were a large barrier to labour market entry or that employed people use numeracy skills more often, therefore keep them relatively fresh". The results also showed that respondents from professional households tended to have stronger numeracy skills than those from 'working class' households. The survey also emphasised the direct relationship between infrequent or no computer use and weak numeracy and literacy skills (Department of Business Innovation and Skills, 2011). These statistics reinforce the importance of good numeracy (and literacy) skills and how they can potentially affect the futures of children. It also highlights that the education in the UK, as it stands, is not fulfilling the potential of many of our young people. Much of this essay has concentrated on the New Welsh Curriculum and what is to come in, there will be massive change over the next couple of years in policy and initiatives. It has the possibility of greatly improving numeracy skills and in realising the importance of cross-curriculum work, hopefully improving the futures of generations to come.

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