An analysis and evaluation of a maths curriculum leading to a proposal for an innovation to this curriculum

The STeP Journal
Student Teacher Perspectives

University of Cumbria
Vol 4 (2) pages 79-89

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Abstract
With a focus on the new GCSE maths curriculum and in particular its implementation in a FE college in South Devon, this report aimed to evaluate and analyse different curriculum models that affect the teaching and learning process of the GCSE maths curriculum. The purpose of this research was to suggest improvements that can be made to the maths curriculum design to enhance teaching and learning of maths for post-16 learners. The key findings suggest that an hour of maths at the start of each day and/or to enable the choice of maths delivery over one or two years.

Paper
Current research has identified that 40% of learners do not achieve a GCSE C grade or above in maths by the age of 16 (DfE, 2014). Interestingly, 90% of those who do not achieve a C in maths by 16 do not achieve it by 19 (DfE, 2014). The 2016 GCSE maths results identified the greatest decline since the exams were launched in 1988 (Coughlan, 2016). The number of learners gaining A*-C grades decreased by 2.1% to 66.9% (Robertson, 2016). This decline is a result of a recent reform in the education system, the first of which demands that learners aged 16-19, who do not hold a GCSE at A*-C in maths, continue learning maths as part of their study programme (Wolf, 2011). This requirement is a 'condition of funding'. The impact of these policy changes is particularly significant for FE colleges (DfE, 2014).

This paper will focus on the new GCSE maths curriculum and in particular its implementation in a FE college in South Devon**.** This paper aims to evaluate and analyse different curriculum models that affect the teaching and learning process of the GCSE maths curriculum. The purpose of this paper is to suggest improvements that can be made to the maths curriculum design to enhance teaching and learning of maths for post-16 learners. Many of the post-16 learners who are yet to achieve a GCSE grade C or above (4 or above with the new 9-1 GCSE curriculum) have negative attitudes towards maths.

For the purpose of this paper it is important to understand what is meant by curriculum. The term curriculum can be used in a number of ways. A curriculum is intended to provide learners with the knowledge and skills required to lead successful lives (Williamson and Payton, 2009). Eckstein *et al*. (1982:5) explains that:

> If education is regarded as one of the tools for national advancement, then curriculum lays out part of the plan and serves as the means for achieving it.

Curriculum can refer to the lessons and academic content taught in a school/college or in a specific course/programme (Great Schools Partnership, 2014). The aspirations of education can be reflected in the curriculum, thus the curriculum can be determined by the demands of life and society that is subject to continuous change.

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Maths is often considered a good subject for comparative research because it is considered a universal subject, relying heavily on logic and symbolic notation (Leung, 1992). Through comparative studies the strengths of a maths curriculum can be recognised and its weaknesses exposed (Leung, 1992; Effective Practices in Post-16 Vocational Maths, 2014; Prendergast and Hongning, 2016). Maths skills are recognised globally for learners to be able to function in society. In the current world of rapid change, particularly in terms of technological change, the demand for maths skills is increasing (Burghes, 2011; Norris, 2012).

From a macro level the formal GCSE maths curriculum is part of the National Curriculum and is government led. From an instrumentalism ideology (Tyler, 1949), maths curriculum development is linear and logical, leading to a desirable end product; that is to identify learners' knowledge of certain maths topics. From this product curriculum theory perspective, maths is a body of knowledge and sets of truths and rules; teaching is authoritarian and a transmission of knowledge (Ernest, 1991). With the focus mainly on targets and outcomes of the curriculum, this product model can also be referred to as the behavioural objectives model (Tyler, 1949: Bloom, 1965). This model is the most commonly used approach due to having a syllabus and learning objectives. This model can have a positive effect on learning as it enables learners to be clear about their learning aim and for educators to assess by measuring if learning has taken place. However, this model discourages 'creativity' on the part of both the learner and educator.

To be able to consider the current maths curriculum it is important to understand current conditions among political, economic, cultural and social environments. Employers have expressed concerns regarding the maths skills of school and college leavers. An Ofqual survey found that 93% of employers said that GCSEs in maths are important to obtain (DfE, 2016). A key concern amongst employers is that employees are unable to apply maths concepts to problems in the workplace (The Education and Training Foundation, 2014). The Advisory Committee on Mathematics Education (2011) reported concerns that the delivery of maths suffered from an excessive emphasis on passing exams. The need for curriculum change was recognised at a macro level by the coalition government with the introduction of the new GCSE 9-1 maths curriculum (DfE 2015). This year (2017) is the first time that the new GCSE maths exam will be sat.

The new maths GCSE curriculum has considered employers' perspectives and needs, and incorporated a more contextualised and problem solving approach to maths (The Education and Training Foundation, 2014). With a moving focus towards content, relevant knowledge and skills that can be learnt and applied, this interlinks within the process curriculum model (Stenhouse, 1975). Incorporating this progressivism ideology, learners are able to take more responsibility for their learning. Enabling opportunities to link maths with real-world problems such as population explosion not only enables deeper understanding of maths but also incorporates Education for Sustainable Development (ESD). Incorporating teaching and learning strategies which use ESD-related skills develops a better grounded understanding of maths whilst enabling every learner to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future (UNESCO, 2009). ESD can change the way in which learners act and think, enabling an inclusive and achievable environment for all.

Michael Gove (DfE, 2013) emphasised that the new GCSE maths curriculum will be more demanding and anticipated that education establishments should increase the time spent teaching maths. In England, on average, 116 hours per year are spent in a school teaching maths (DfE, 2013). In the FE College, in which I work, only 80 hours over a 31 week academic year, are spent teaching maths (both A-G and 9-1 GCSE). In comparison to international findings this is considerably less time. High-

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performing countries, such as Australia or Singapore teach 143 and 138 hours a year of maths (DfE, 2013).

In the FE college where I work, two one hour and fifteen minute sessions are allocated to the delivery of GCSE maths per week. This has differed from last year, where one two hour session was allocated per week. This can be seen as a positive change as it enables learners to practice maths twice a week, rather than in one longer session where learners often became disengaged towards the end. However, in the new GCSE maths curriculum class that I teach learners have both session one and two together on a Friday afternoon (2.15-5.00pm, with a 15min break in the middle). These learners are Access to HE learners ranging from 17-47 years old. According to research learners are more productive earlier in the school day, especially in maths (Dills and Hernandez-Julian, 2008; Pope, 2016). Thus rearranging the time allocation for the delivery of maths to an earlier time and/or at the beginning of a week could lead to increased academic performance.

Tim Oates (DfE, 2011) emphasised that:

> In all high-performing systems, the fundamentals of subjects are strongly emphasised, have substantial time allocation, and are the focus of considerable attention in learning programmes.

Nationally three to four hours is suggested for the delivery of each topic in the new maths curriculum (Pearson, 2015). The scheme of learning at my FE college allocates two and a half hours per topic. This proves challenging with the Access to HE learners as many learners have not studied maths for many years and lack confidence in basic maths skills. Maths anxiety and barriers from previous school experience are also apparent in many of my Access learners (as well as the 16-19 learners). Consequently, moving at a fast pace from maths topic to maths topic is not effective for these learners. Learner barriers towards maths need to be considered in the curriculum and sufficient time allocated to meet all learners needs.

Many learners that attend FE colleges to re-sit their GCSE maths often have barriers towards maths (Pia, 2015). One perspective on why learners have obtained a barrier towards maths is because of bad school experiences and lack of confidence (National Numeracy, 2015; Pia, 2015**).** Often learners have found themselves to struggle when they have experienced difficulty with a topic. This is especially frustrating in maths because it is a cumulative subject, where each concept builds upon the previous concepts. Consequently, when learners do not understand a maths concept they can fall behind, lack engagement and enjoyment (Trochil, 2007). This leads to learners lacking in confidence and feeling that they cannot achieve in maths. This then leads to a fixed mind-set - believing that their abilities cannot change (Dweck, 2006). Consequently, when learners attend college to retake maths it is important to teach with an inclusive approach where each learner feels valued and has the opportunity to achieve (Equality Act, 2010).

Learners that have experienced negative learning may require support to develop an identity through which they can consider themselves as being able to deal with real-life situations, such as money, employment and the law (The Education and Training Foundation, 2014). The maths curriculum should highlight skills necessary for learning throughout life, as well as for work, and for one's personal development and well-being. However, a curriculum is also political. Decisions about 'what's in' and 'what's out' change dependant on political needs and aspirations.

Educators often give examples of maths concepts that are unfamiliar to learners (Barba, 1993; Ninnes, 2000). Educators who enable culturally relevant instruction capitalise on learner strengths -

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what they do know instead of what they do not know. Interlinking with a situational curriculum model, Stinson (2004) explains that:

> learning becomes a process of changing participation in changing communities of practice in which an individual's resulting knowledge becomes a function of the environment in which she or he operates.

Thus, the society and context in which the learner learns the maths affects how the learner uses and understands the maths (Boaler, 2000b). Boaler (1993) emphasises that learning maths in context enhances learner motivation and interest; it enables transferable skills by linking maths with real-world maths. Linking maths to real-life contexts further supports employability skills as it involves the working world of maths.

The new GCSE maths curriculum contextualises maths, similar to functional skills maths, giving meaning and relevance to learners. Both qualifications have undergone change in order to create more parity of esteem between the two. However, although employers are increasingly recognising functional skill maths, a GCSE in maths will give a job applicant an edge (Watkin, 2016). Countries, such as Finland, with successful vocational education systems are often found to have parity of esteem, recognising that qualifications that are intended for different learners with different occupational intentions possess equal value and status (Volanen, 1999; Wolf, 2011). Thus maybe learners should have the choice to re-sit their GCSE or enrol on a functional skill maths course, depending on which is best suited to their aptitudes, interests, career choice and aspirations.

Currently in England, learners who have achieved below a D-grade in maths are enrolled on a functional skill maths course as a stepping stone towards achieving a C grade or above in maths (Wolf, 2011). Learners with a D-grade are enrolled on a one year GCSE maths course (Wolf, 2011). It is argued that a year is sufficient time for learners (who achieved a D grade) to revisit maths topics, with the aim of 'filling in the gaps' to achieve a C grade GCSE (Wolf, 2011). However, learners that have previously failed often have a fixed mind-set, believing that they are not going to achieve in maths. Therefore repeating the same qualification with the same teaching and learning approaches, in a short period of time, can be argued as an ineffective curriculum approach. If learners repeatedly face failure in GCSE exams barriers are going to become harder to break down (Johnston-Wilder *et al*., 2015). Thus, a year may not be a sufficient amount of time and functional skill maths may be a better pathway for learners whom have not achieved a C grade for maths.

Skemp (1976) identifies two types of maths learning which are equally important to embed in the maths curriculum; Instrumental learning (the how knowledge), which involves learning processes by rote and relational learning (the how and why knowledge) which involves understanding the concepts and the reasoning underlying the knowledge rather than just applying rules. Skemp (1976) suggests that instrumental and relational learning are essential as they both teach the learner the rules of maths. For example, to calculate the area of a circle, learners need to know that the A= πr^2 (instrumental knowledge). Learners also need to understand why this rule always works (relational understanding).

Particularly applicable in the maths curriculum is the constructivism approach, as learners build new knowledge upon their previous knowledge. Bruner (1960) highlights that learning is a cumulative process and therefore requires previous learning to be frequently revisited, interlinking with the spiral curriculum. Additional allocation to time in maths would increase elements of the 'spiral curriculum', supporting continuous revision and progression through logical steps but with key aims

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of mastery in each topic. This spiral process enables continual development to challenge the most able learners, while also revisiting earlier areas of knowledge for less able learners.

Maths problems should build upon and develop learner thinking and reasoning by putting learners in the position of working at their limit, the place between what they know and do not know; what Vygotsky (1978) explains as the 'zone of proximal development'. Differentiating the maths curriculum enables less able learners to achieve as well as the more able learners to feel challenged. Having a wide range of preferences, strategies, understandings and progresses can be seen as a disadvantage as it splits up the class, lacking community cohesion. Thus, differentiating the same task enables all learners to achieve and collaborate as the more able learners can scaffold less able learners (Vygotsky, 1978).

If learner's social and cultural values are encouraged and supported in a maths class, their learning will develop meaning (Parker, 2007). This situated model suggests different ideas of what it means to have maths ability, changing the notion from 'you either can or cannot do maths' to an analysis of how the environment plays a part in maths knowledge that is learned (Boaler, 2000a; Parker, 2007). Boaler (1993:118) explains that:

> Changing how maths ability is assessed in the situated perspective could move maths education away from the discriminatory practices that produce more failures than successes toward something considerably more equitable and supportive of social justice.

This in turn could help change the negative culture of maths learning in England and increase social cohesion (National Numeracy, 2015).

Competition makes differences visible. A common political and professional reaction is to compete nationally and internationally (Braathe and Ongstad, 2001). Enabling competition in the class can decrease social cohesion and other differences. The maths curriculum needs to move away from an individualised competition approach in understanding fast to an understanding collectively approach. This would enhance social cohesion. Lack of time allocated to a task can also lose the togetherness of the class which further threatens the quality of learning (Braathe and Ongstad, 2001).

Context is vital in delivering a meaningful maths curriculum and this is extremely pertinent in FE when teaching learners with barriers towards maths who are required to retake their maths GCSE. If the maths curriculum is not constructed towards achieving achievable goals for the learners, then learners will continue to lack confidence and self-esteem. Thus, efforts to address the maths curriculum implementation have tended to focused on international comparisons but whether educational practices from other nations hold the key to improvement is arguable, since this approach overlooks cultural and contextual considerations that may affect the implementation and the effects of any reform.

Cultural context contributes to international differences in maths education, learners' development and wider societal attitudes towards the learning of maths (The Education and Training Foundation, 2014). It is culturally acceptable in England to be negative about maths. It is socially acceptable to say 'I cannot do maths' (Kowsun, 2008). Mistakes are also seen as negative, whereas, making mistakes should be seen as a positive as learning is taking place. Research has found that when a learner makes a mistake the brain is challenged resulting in growth (Moser *et al*., 2011). Moser *et al*. (2011) explains that when a mistake is made, synapses fire and learning occurs. Creating a more positive and confident culture around maths would have a positive impact on maths skills and

attainment (National Numeracy, 2015).

There are many different methods and approaches to the design and implementation of a curriculum and a lot can be dependent on the educators' approach of it. Having background knowledge and experience in Education and Child Development has enabled me to take a different perspective on maths teaching. Approaching maths from a psychological perspective focusing on a learner-centred approach to increase motivation is an important related factor to learning, behaviour and achievement (Rodgers, 2003). Motivation is the psychological climate of the educational experience that influences the amount and type of learning which takes place (Rogers, 2003).

An area that has emerged in recent years is brain plasticity, also known as neuroplasticity (Boaler, 2010). Historically it was believed that the brains people were born with could not really be changed, but this perception has now been challenged (Kolb and Gibb, 2011). When a new concept is learnt an electric current fires in the brain, crossing synapses and connecting different areas of the brain (Boaler, 2010). If something is learnt deeply the synaptic activity will create a lasting connection in the brain, forming structural pathways, but if a concept is only visited once, the synaptic connections will disappear (Boaler, 2010). Thus, visiting a concept in maths only once, for a brief amount of time, will lack learner understanding. The synaptic connection in the brain will also disappear. With sufficient time allocation and effective teaching and learning every learner has the ability to achieve in maths.

The delivery of the new GCSE math curriculum enables concepts to be revisited as topics are interlinked. For example rather than teaching all algebra topics followed by all geometry topics, different topic areas are visited weekly (Pearson, 2015). This enables learners to revisit topic areas, creating a lasting connection in the brain (Boaler, 2010). However sufficient time is still required to ensure no one gets left behind and that topics can be explored in depth to enable deep understanding.

Equity is positively associated with the overall achievement and attainment in maths. Shanghai is a top performing city in maths across the whole learner population, not simply among the most able (The Education and Training Foundation, 2014). Equality as well as quality has been recognised as an important component of their success by the Shanghai PISA centre (The Education and Training Foundation, 2014). From a ‘progressive educator' perspective maths is a tool for developing the whole learner, a personalised maths, and the focus is on the learner not on maths (Braathe and Ongstad 2001). Included in this approach is community cohesion and inclusion. There is a great opportunity to promote community cohesion in the maths curriculum with learners who are studying a vast range of other topics and all have different knowledge and experiences to bring to the classroom to contextualise maths.

The curriculum as a praxis can be considered a development of the process model. Grundy (1987:115) explains:

> The curriculum is not simply a set of plans to be considered but rather is constituted through an active process in which planning, acting and evaluating are all reciprocally related and integrated into the process.

Thus, the teaching process is an ever evolving progressive action. The primary goal of maths education is transfer learning, for learners to use their knowledge and acquire flexible adaptation to new problems (Freire, 1972; Dixon and Brown, 2012).

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Learners should be able to do more than what the educator has taught. This reconstructionism ideology focuses on learner experience and taking social action on real problems and inequalities. This further incorporates ESD and enabling learners to attach meaning to maths. Optimal learning, human development and growth occur when learners are challenged with real problems to solve (Walter, 2006). In agreement with Dewey (1938) the maths curriculum would benefit from integrated, community grounded activities that engage learners in a form of pragmatic social action that have real value in the world.

Enabling opportunities for group work and whole class discussions promotes community-based learning, as learners are learning to cooperate with each other in order to achieve and enable others to achieve. Teaching and learning should be actively participating in discussion and questioning the content matter (Ernest 1991). The new GCSE maths curriculum is beginning to incorporate this with discussions and reasoning being embedded into the curriculum (Edexcel, 2015). However, discussions are often moved at a fast pace due to the time constraints in the classroom.

From a holistic picture, from both a micro and macro level the curriculum needs to change for learners retaking their GCSE maths. The formal maths curriculum is what the governing bodies have decided should be taught. They have set in advance what learning is going to be planned, achieved and what goals should be produced (C/4 grade or above). Challenging the view that educators should be objective in their view of curriculum, a balance should be sought between the intentions (macro) and the realities (micro). For example the reality for learners with low self-esteem, barriers towards maths and have faced repeated exam failure, are unlikely after a year of repeating the same content going to pass their exam. Enabling the choice of having one or two years to achieve their GCSE maths would be more appropriate, especially with the new GCSE maths curriculum. Curriculum delivery needs to differ from learner to learner, reflecting the learner's needs, making it effective and intrinsically worthwhile for every learner.

For some learners having a year to re-engage with maths to increase their confidence and self-belief (with no formal exam at the end) will enable them to progress with a growth mind-set. A curriculum can be perceived as a subject of experiment, building on knowledge each time. Stenhouse (1975) explains the process of a curriculum in comparison to a recipe; a recipe can vary according to taste, so can a curriculum. Like many recipes it does not always turn out the way you planned; often ingredients and/or timings need to be adjusted. Thus depending on the learners, adaptions may need to be made and time allocation needs to be an option.

An inclusive curriculum is one in which all educators and learners feel valued. Equal opportunities are a needs based approach. It cannot work on a 'one size fits all' approach to curriculum (Equality Act, 2010). Curriculum delivery is always going to be subjective as the educator brings to the classroom situation their own cultural context, situational factors and moral beliefs. Qualifications are intended for different learners with different occupational intentions and not all qualifications are right for all learners. Maths skills are a necessary for both vocational and academic courses. However, maths skills vary between professions and the motivation to learn maths can depend on learner interests and relevance to their lives. Thus, contextualising and recognising the value of practical skills as well as academic skills matters for learners, society, and for the economy (Wolf, 2011). Difference, and diversity should to be embraced and celebrated and approaches to the curriculum need to be widened to embrace the full range of learners' intelligences and achievements (Equality Act, 2010).

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From a macro curriculum design down to the micro curriculum delivery a political struggle will meet and distort with ideologies of subcultures, such as different kinds of didactics and pedagogical practices (Braathe and Ongstad 2001). Consequently, what becomes the highest meaning or the deepest sense with education and maths for society, teachers and learners becomes uncertain (Braathe and Ongstad 2001). Notions of context are crucial in this enterprise to support a nationally shared egalitarianism. Through embedding ESD into the maths curriculum learners will embrace a more meaningful curriculum.

Enabling choice is empowering so it is important that there is an element of choice in every maths lesson. When learners see benefit or reason for doing something their interest increases. Real-life contexts increase interest and engagement for learners, stimulate imagination, assist in making connections and provides useful functional maths knowledge (Johnston-Wilder, 2015). The maths curriculum is strongly integrated into society. Equality in education cannot be achieved without progress towards equality in the political, economic, cultural and social environments in which it is embedded.

This paper has identified that the maths curriculum cannot be built from the foundation of a single theory or ideology. Within curriculum study progressive (child-centred, creative, co-operative and full of experience), reconstructionism (Socially relevant, problem solving and vocational) and instrumentalism (utilitarian, practical and technological) ideologies have been reflected within the models of curriculum, having valuable perspectives to consider within a maths curriculum design. This paper has identified that an effective teaching and learning process of the GCSE maths curriculum is more than just the design of the formal curriculum. The informal maths curriculum is equally important.

Every learner acquires attitudes, values, skills and knowledge from daily experiences and the educative influences and resources in the learners' environment; such as, community, work and media. Learners require an enabling learning environment with appropriate aims and motivations linked within the learner's own cultural context of learning. To incorporate an inclusive practice it is important to understand learners' needs and then personalise both the content and process (or delivery) of the learning.

To enable a positive step to incorporating a more inclusive, achievable and sustainable maths curriculum my curriculum innovation would be to have an hour of maths at the start of each day and enable the choice of maths delivery over one or two years. This would provide learners with sufficient time to understand a concept and enjoy learning through multisensory approaches, such as games, out of the classroom learning and discussions without time constraints. This would enable opportunities for deep learning, increased interest and motivation, equality and social cohesion.

References

Advisory Committee on Mathematics Education (2011) *The mathematical needs of learners*. Available at: http://www.acme-uk.org/media/7627/acme_theme_b_final.pdf (Accessed: 3 Novemeber 2016).

Bloom, B. (1965) *Taxonomy of educational objectives: the classification of educational goals*. New York: David McKay Company, Inc.

Barba, R. H. (1993) 'A study of culturally syntonic variables in the bilingual/bicultural science classroom', *Journal of Research in Science Teaching*, 30, pp. 1053-1071.

Boaler, J. (1993) 'The role of context in the mathematics classroom: do they make mathematics more "real"?', *For the Learning of Mathematics*, 13(2), pp.12–17.

Citation

Hayes, D. (2017) 'An analysis and evaluation of a maths curriculum leading to a proposal for an innovation to this curriculum', *The STeP Journal*, 4(2), pp. 79-89.

Boaler, J. (2000a) 'Exploring situated insights into research and learning', *Journal for Research in Mathematics Education*,31(1), pp.113–119.

Boaler, J. (2000b) 'Mathematics from another world: traditional communities and the alienation of learners', *Journal of Mathematical Behavior*, 18(4), pp. 379–397.

Boaler, J. (2010) *The Elephant in the Classroom: helping children learn and love maths*. London: Souvenir Press.

Braathe, H.J. and Ongstad, S. (2001) 'Egalitarianism meets ideologies of mathematics education – instances from Norwegian curricula and classrooms', *Zentralblatt fur Didaktik der Matematik*, 33(5), pp. 1–11.

Bruner, J. S. (1960) *The Process of education*. Cambridge, Mass.: Harvard University Press.

Burghes, D. (2011) *International comparative study in mathematics teacher training*. Available at: https://www.educationdevelopmenttrust.com/~/media/cfbtcorporate/files/research/2011/r-international-comparative-study-in-mathematics-teacher-training-research-2011.pdf (Accessed 20 December 2016).

Coughlan, S. (2016) *GCSE results show record decline*. Available at: http://www.bbc.co.uk/news/education-37175848 (Accessed 21 December 2016).

Department of Education (2011) *Michael Gove to Twyford Church of England high school*. Available at: https://www.gov.uk/government/speeches/michael-gove-to-twyford-church-of-england-high-school (Accessed 23 November 2016).

Department of Education (2013) *Reformed GCSEs in english and mathematics*. Available at: https://www.gov.uk/government/speeches/reformed-gcses-in-english-and-mathematics (Accessed: 14 November 2016).

Department of Education (2014) *Maths and english provision in post-16 education*. Available at: https://www.gov.uk/government/speeches/maths-and-english-provision-in-post-16-education (Accessed 14 November 2016).

Department of Education (2015) *2010 to 2015 government policy: school and college qualifications and curriculum*. Available at: 2010 to 2015 government policy: school and college qualifications and curriculum (Accessed 14 November 2016)

Department of Education (2016) Departmental advice for education providers on the planning and delivery of 16 to 19 study programmes. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/493452/16_to_19_study_programmes_departmental_advice_Jan_2016_update.pdf (Accessed 15 November 2016)

Dewey, J. (1938) *Experience and education*. New York: Collier Books.

Dills, A. K. and Hernandez-Julian, H. (2008) 'Course scheduling and academic performance', *Economics of Education Review*, 27, pp. 646–654.

Dixon, R. A., and Brown, R. A. (2012) 'Transfer of learning: connecting concepts during problem solving', *Journal of Technology Education*, 24(1), pp. 2-17.

Dweck, C. S. (2006) *Mindset: the new psychology of Success*. New York: Ballantine Books.

Eckstein, M. A., Travers, K. J. and Shafer, S. M. (1982) *A comparative review of curriculum: mathematics and international studies in the secondary schools of five countries*. Washington, DC: National Commission on Excellence in Education (ED).

Edexcel (2015) *Guide to Edexcel GCSE Mathematics (9-1)*. Available at: http://qualifications.pearson.com/content/dam/pdf/GCSE/mathematics/2015/misc/T772%20GCSE%20Maths%20Guide%20(web%20-%20final).pdf (Accessed 2 January 2017).

Equality Act 2010, c. 15. Available at: http://www.legislation.gov.uk/ukpga/2010/15/contents (Accessed: 12 December 2016).

Ernest, P. (1991) *The Philosophy of Mathematics Education*. London: Falmer.

Freire, P. (1972) *Pedagogy of the Oppressed*. Harmondsworth: Penguin.

Citation

Hayes, D. (2017) 'An analysis and evaluation of a maths curriculum leading to a proposal for an innovation to this curriculum', *The STeP Journal*, 4(2), pp. 79-89.

Great Schools Partnership (2014) The glossary of education reform. Available at: http://edglossary.org/curriculum/ (11 November 2016).

Grundy, S. (1987) *Curriculum: product or praxis?* Lewes: Falmer Press.

Johnston-Wilder, S., Lee, C.,Brindley, J. and Garton, E. (2015) *Developing mathematical resilience in school students who have experienced repeated failure*. Available at: http://blogs.warwick.ac.uk/files/maths_resilience/iceri_2015_paper_2_submitted.pdf (Accessed 17 November 2016)

Kolb, B., and Gibb, R. (2011) 'Brain plasticity and behavior in the developing brain', *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, 20(4), pp. 265-276.

Kowsun, J. (2008) *This innumerate isle*. Available at: http://www.tes.co.uk/article.aspx?storycode=2033102 (Accessed 14 November 2016)

Leung, F. K. S. (1992) *A comparison of the intended mathematics curriculum in China, Hong Kong and England and the implementation in Beijing, Hong Kong and London*. Available at: http://eprints.ioe.ac.uk/6573/1/DX186959.pdf (Accessed 14 December 2016)

Moser, J. S., Schroder, H. S., Heeter, C., Moran, T. P., and Lee, Y. H. (2011) 'Mind your errors: evidence for a neural mechanism linking growth mindset to adaptive post-error adjustments', *Psychological Science*, 22, pp. 1484-1489.

National Numeracy (2015) *Attitudes towards maths*. Available at: https://www.nationalnumeracy.org.uk/sites/default/files/attitudes_towards_maths_-_updated_branding.pdf (Accessed 1 November 2016)

Ninnes, P. (2000) 'Representations of indigenous knowledge in secondary school science textbooks in Australia and Canada', *International Journal of Science Education*, 22(6), pp. 603-617.

Norris, E. (2012) *Solving the maths problem: international perspectives on mathematics education*. Available at: https://www.thersa.org/globalassets/pdfs/reports/rsa_maths_report_10_2_12.pdf (Accessed: 8 November 2016).

Parker, K. (2007) *Cultural diversity in the mathematics classroom*. Available at: http://jwilson.coe.uga.edu/EMAT6680Fa06/Parker/4650%20Special%20Focus/Cultural%20Diversity%20Website.htm (Accessed: 18 November 2016).

Pearson (2015) *Edexcel GCSE mathematics (9-1) from 2015*. Available at: http://qualifications.pearson.com/en/qualifications/edexcel-gcses/mathematics-2015/teaching-support/planning.html (Accessed: 20 October 2016).

Pia, K. F. (2015) 'Barriers in teaching learning process of mathematics at secondary level: A quest for quality improvement', *American Journal of Educational Research*, 3(7), pp. 822-831.

Pope, G. N. (2016) 'How the time of day affects productivity: evidence from school schedules', *The Review of Economics and Statistics*, 98(1) pp. 1-11.

Prendergast, M. and Hongning, Z. (2016) 'A comparative study of students attitudes towards mathematics in two different school systems', *International Journal for Mathematics Teaching and Learning*, 17(2), pp. 1-24.

Robertson, A. (2016) *GCSE A*-C pass rate drops sharply*. Available at: http://schoolsweek.co.uk/gcse-a-c-pass-rates-drops-sharply/ (Accessed: 23 November 2016).

Skemp, R. (1976) 'Instrumental understanding and relational understanding', *Mathematics Teaching*, 77, pp.20–26.

Stenhouse, L. (1975) *An Introduction to Curriculum Research and Development*. London: Heinemann

Stinson, D. W. (2004) 'Mathematics as gate-keeper (?): three theoretical perspectives that aim toward empowering all children with a key to the gate', *The Mathematics Educator*, 14(1), pp. 8-18.

Citation

Hayes, D. (2017) 'An analysis and evaluation of a maths curriculum leading to a proposal for an innovation to this curriculum', *The STeP Journal*, 4(2), pp. 79-89.

The Education and Training Foundation (2014) *Effective practices in post-16 vocational Maths*. Available at: http://www.et-foundation.co.uk/wp-content/uploads/2014/12/Effective-Practices-in-Post-16-Vocational-Maths-v4-0.pdf (Accessed: 23 November 2016).

Trochil, E. A. (2007) *Making math matter - a grant proposal*. Available at: https://pdfs.semanticscholar.org/4e32/308ff418a4415e1879e1f42bd75afd9d886e.pdf (Accessed: 13 November 2016).

Tyler, R. W. (1949) *Basic principles of curriculum and instruction*. Chicago: University of Chicago Press

Volanen, M. V. (1999) *European strategies for parity of esteem between academic and vocational education: the strategy of mutual enrichment*. Available at: http://www.leeds.ac.uk/educol/documents/000001164.htm (Accessed: 23 November 2016).

Vygotsky, L. (1978) *Mind and. Society*. Cambridge, MA: Harvard University Press

Walter, J. (2006) *Values education for Australian schooling: increasing student engagement – the theory behind Learning Journeys*. Available at: http://www.curriculum.edu.au/verve/_resources/Walter_Learning_Journeys.pdf (Accessed: 5 December 2016).

Watkin, B (2016) *GCSEs vs functional skills: which english and maths resits should your students take?* Available at: http://feweek.co.uk/2016/09/11/gcses-vs-functional-skills-which-english-and-maths-resits-should-your-students-take/ (Accessed: 23 December 2016).

Williamson, B. and Payton, S. (2009) *Curriculum and teaching innovation transforming classroom practice and personalisation*. Available at: http://admin.futurelab.org.uk/resources/publications-reports-articles/handbooks/Handbook1246 (Accessed: 15 December 2016).

Wolf, A. (2011) *Review of vocational education – the Wolf Report*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/180504/DFE-00031-2011.pdf (Accessed: 3 November 2016).

Citation

Hayes, D. (2017) 'An analysis and evaluation of a maths curriculum leading to a proposal for an innovation to this curriculum', *The STeP Journal*, 4(2), pp. 79-89.