The Perceptions of Creativity and Mathematics in Post 16 Arts Education

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Abstract

The aim of this study is to establish the perceptions of creativity and mathematics in a specialist arts College including those of both staff and students. In addition, it aims to identify associations between the delivery of creative subjects and the potential to use these within mathematics based pedagogic strategies. Research questions explored 3 main areas, what are staff's perceptions of creativity in a specialist arts College, is there an association between the creativity of arts students and performance in mathematics in a specialist arts College and what are staff's attitudes in a specialist arts College towards mathematics in the curriculum?

Current UK educational practice has been described by Robinson (2011) as having a negative impact on the creative ability of young people identifying that many students who enter pre-school have a creative confidence that is lost by the time they leave school. In consideration of mathematic pedagogy, Dalby et al, 2016, in their study 'Locating mathematics within post-16 vocational education in England' also suggest that there is a need for widespread improvement in the approach to the delivery of Mathematics. However they suggest that achieving this is far more complex, particularly in Post 16 education. This is due to students' prior history of perceived failure in the subject resulting in students that are very demanding to teach due to their lack of interest in the subject and disaffection in their studies. The results of this study showed a clear association between the mathematical performance of students and their creative fluency and flexibility. Staff were very positive towards creative learners and have very clear ideas regarding what makes learners creative and good mathematicians and in many aspects these attributes overlap. They utilised a broad range of strategies to develop long-term creativity goals of learners and, despite strategies being under developed in the promotion of mathematics, activities that embed mathematics in the creative curriculum are broad ranging to support cognitive development associated with mathematical skills and concepts. However, it is the potential of the development of creative fluency and flexibility that remains unanswered and requires further study to identify the potential of the development of these attributes on mathematical performance.

Declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References.

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Chapter 1: Introduction

Over the last decade, whilst working as a senior manager in a specialist arts College in the North of England, there has been a significant change in emphasis on the importance of the delivery of mathematics. Now, every student studying a full time course in further education must be working towards or have achieved a grade C (grade 4) in mathematics as a condition of funding. The results of mathematics examinations in Post 16 education are poor in the region with only 23% of learners resitting mathematics GCSE achieving a grade C (RCU Market Research Service, 2016.) This is reflected in the College where comparative results are at 40% but below the high standards of its current arts provision. With the quality of mathematics provision highlighted as essential to a good Post 16 education and being increasingly recognised as a potential limiting factor in the success of an Ofsted inspection, addressing this issue has become a high priority for the College as part of its academic strategy. The challenge of raising and maintaining high standards in an arts Specialist Institution, that has not previously regarded mathematics as fundamental to its success, has created difficulties. Prior to the commencement of this study, anecdotal evidence would suggest an inconsistent view from teaching staff regarding the importance of mathematics in the future development of students on arts based courses. There appears to be a lack of motivation in students to study mathematics, teaching staff do not know how the creative personality of the arts student hinders or supports their ability to achieve in mathematics based qualifications. From a senior manager's perspective there is also limited knowledge of how the potential of the currently highly effective pedagogical approaches in arts subjects can be used to develop success with learners in mathematics. The aim of this study is to therefore explore the perceptions of creativity and mathematics in a Specialist arts College including those of both staff and students. In addition, it will aim to identify associations between the delivery of creative subjects and the potential to use these within mathematics based pedagogic strategies.

Government policy in recent years has put increasing pressure on Post 16 educators not only to provide qualifications in vocational subject areas but also other qualifications as part of a programme of study that delivers a framework of opportunities for learners including literacy, numeracy and work based skills. With this increasing demand, the necessity for College leadership teams to provide qualified staff in areas it has not previously delivered, but also upskill its current staff to achieve the requirements of these programmes of study and external stakeholders is significant. In the setting of the

Specialist Art College, some of the challenges are unique and others are common place across Post 16 providers. In the College in recent years mathematics results are inconsistent, leading some art teachers to state ‘arts students can’t do mathematics’ or ‘arts students won’t do mathematics.’ Whilst there is some evidence to support these claims with attendance in mathematics significantly lower than in arts based subjects and GCSE mathematics achievement rates inconsistent, the question remains are arts providers realising the full potential of creative learner’s academic skills and are the opportunities of an arts education within the context of academic study being fully recognised and embraced?

The arts in all sectors of education have become increasingly discussed and debated by the government and politicians. To understand the context of this study it is important to recognise the views of others regarding the role of the arts and creativity in education. The introduction of the English Baccalaureate (Ebacc) in schools, the greater emphasis on mathematics and English testing, and increased funding for STEM related subjects is leaving some to argue that the arts are falling to the bottom tier of education and in some cases being ‘systematically’ removed from the curriculum. The education secretary (Nicky Morgan) stated at the launch of the “Your Life” campaign November 2014 that arts and humanities subjects will not give young people the skills that they need to pursue a career. Although the Earl of Clancarty in his House of Lords address of November 2014 identified that firms needing employees with STEM skills and knowledge had difficulty recruiting because they were not rounded or grounded. This, he believes, can only come from the inclusion of creativity in the curriculum that is missing from the current EBacc structure.

Statistics published in 2016 reveal that the UK’s creative industries are now worth £84.1 billion per year to the UK economy (Department of Culture, Media and Sport, 2016) and Higher Education institutions are seeing a trend towards greater numbers of learners applying to arts based courses. According to HESA (2014) figures the numbers enrolled on creative art and design higher education courses rose by more than 30% between 2003 and 2012. However, more recently a drop of 13% has been seen in the study of GCSE arts based qualifications with some primary and secondary institutions arguing that a greater emphasis on results and funding constraints have resulted in the arts such as music, drama and painting being limited to the privileged (The Warwick Commission, 2015). So, whilst the demand to study arts based courses is increasing in the UK, and the creative economy continues to make a significant contribution to the UK, the government’s education agenda is focussed primarily away from creative based subjects.

There is also little agreement on the potential of arts based subjects to develop or enhance the academic ability of learners.

In 2011, the government published its response to the Wolf Report (Department for Business, Innovation & Skills and Department for Education, 2011) a review of vocational education, commissioned by the Secretary of State for Education. One of the key recommendations included introduction of new guidelines for programmes of study that ensured learners in post 16 education were gaining the appropriate skills and qualifications to progress into further learning or employment. This included ensuring that all learners achieved a good pass in both mathematics and English GCSE. As a result greater emphasis has been placed on the importance of the development of core functional skills by regulatory bodies such as Ofsted. In their Further Education and Skills Handbook (2016) they identify that leaders, managers and governors should focus on consistently improving standards in all aspects of a learner's programme of study including English and mathematics (Ofsted, 2016.) However, an article in the Times Educational Supplement (TES, 2016), states that "colleges face testing times over GCSE resits" with record numbers set to take resits in 2016 and the number to increase further with the introduction of the new GCSE qualification and what is judged as a 'good' pass to be adjusted. Managing these concerns effectively in a Specialist arts College will require greater understanding of the perception and attitudes of staff faced with these challenges. In relation to this study this should focus on their perceptions of the relationship between mathematics study and the learner's progression into an arts based vocation. Plus in addition identify if staff recognise the potential for an arts based education to support higher level ability in traditionally academic based subjects like mathematics. Initiatives by Ofsted to ensure that mathematics are embedded in all aspects of vocational education are resulting in some arts teachers questioning the relationship between mathematic study in a creative education and how developing basic mathematical skills in an arts based teaching session can influence future mathematic performance.

The TES (2016) is quick to identify that the government remains reluctant to remove their emphasis away from a curriculum with a focus on knowledge, however it is believed that they are much more willing to be influenced by more 'radical' approaches to teaching and learning such as 'free learning.' The government appears to be becoming increasingly open to approaches, although in the past Ofsted has heavily criticised approaches such as those by the Summerhill School in Suffolk described as the original free school. This move maybe unsurprising due to the current global ranking of UK schools and comments such as those by the overseer of the Programme for International Student Assessment

(Pisa.) Andreas Schleicher (2016) stated that mathematics lessons in UK schools were superficial and that the breadth of the learning was “one mile wide but no more than an inch deep.” Supporting published data shows that 37% of students in the UK, who were asked about their learning preference when preparing for mathematics tests, stated they liked ‘memorising.’ In contrast in some Asian countries, such as Vietnam who traditionally perform very well in mathematics, 5% preferred ‘memory’ (Programme for International Student Assessment (Pisa), 2016). Instead they receive a grounding in mathematical concepts. So is there potential in a specialist arts College to develop less traditional pedagogical approaches to enhance the mathematical ability of arts specialist learners? Is the creative potential of these learners the opportunity to unlock mathematical ability?

Before this can be understood it is first important to recognise what is understood by creativity and this will be achieved as part of a literature review. Much of the research into creativity identifies it as a complex subject with many contradictory views. The literature review will aim to identify a clear definition to be used within the context of this study. This will include acknowledgement of Simonton’s review of literature (2000) which identified 4 key themes in the research including cognitive process, personal characteristics, life span development and social context. It will explore the value of creativity with a review of research that has focussed on ‘Big C’ and ‘little c’ creativity such as the work of Csikszentmihalyi (1996) that reviewed creativity with the context of eminent people from history. It will also identify the importance of Guilford (1967) who suggested the ability to be creative is related to someone’s capacity to be fluent, flexible, original and elaborative. Understanding the potential of these creative abilities in mathematical study within a particular educational context such as a specialist arts College will also require understanding of the attitudes of staff towards creativity and the creative ability of students. For example it will be important to identify teachers’ attitudes regarding creativity, teachers’ definitions of creativity and teachers’ perceptions of creative students.

The review of creativity in education will look at educational theory within the context of the curriculum. This will aim to develop an understanding of the potential of creativity within an educational setting to develop learning and will include the views of policy makers and teaching practitioners. In addition the early developments of the national curriculum in 1862 and its focus on minimum standards and emphasis on reading, writing and arithmetic will be considered (Odom et al, 2010). The development of more creative approaches to the curriculum will also be reviewed including the Reggio Emilia approach

in post war Italy which took a flexible non-linear approach to the learning experience (Edwards et al., 1998). In addition the study will look at the current curriculum in the UK and discuss Sir Ken Robinson's assertions that the educational system is designed for the Industrial Revolution and not suitable for the modern World (Robinson, 2011).

In consideration of historical use of creativity in education the literature review will also explore the potential of creativity as a pedagogical concept, specifically within the domains of learning, including Guildford's (1967) view of convergent and divergent learning and the relationship between creativity and intelligence. Pedagogy and mathematics will also be considered including Ofsted's concerns with teaching approaches within the context of mathematics lessons. This includes their conclusion of an over emphasis on meeting standard thresholds by skill development designed to pass exams rather than developing the ability of learners to solve problems. Further researcher's views will be considered including Orton et al. (2004) who suggest that policy in education has resulted in teacher led mathematics delivery that supports learners through routine and practice but does not focus sufficiently on investigation and application. According to Sriraman's (2005) study a significant characteristic of mathematicians working at an advanced level is creativity. This will be researched within the context of mathematic creativity with a particular focus on types of creativity and its ability to support the development of mathematical theory, for example Leikin et al. (2014) who discuss the implications of specific and general creativity. The literature review will also define the commonality between theories of creativity and mathematical study.

As part of the study a clear methodology will be defined to support the answering of research questions linked to creativity and mathematical study. A rational related to the sustainability of an arts based educational institution will be identified including the need to better educate and support young learners to achieve mathematical ability as defined by government policy. A range of research strategies will be considered including exploring the potential benefits of quantitative, qualitative and mixed methods approaches. In addition the validity of research methods will be investigated including Newby's (2014) comparisons of Positivism and humanistic attitudes to data collection and analysis. These theories will support the development of data collection methods which include both qualitative and quantitative approaches by use of surveys and focus groups. Development of effective research instruments will be key to effectively answering the research questions, therefore the methodology will investigate effective approaches to asking survey questions including the potential of 'open' and 'closed' questions. In addition other similar research approaches related to the theme of creativity and

mathematics will be reviewed and learnt from to support the validity and reliability of the surveys and focus groups. This will include a review of Guildford's test of creativity and the Erbas and Bas (2015) study that utilised a range of commonly used questionnaires that explore personal characteristics, motivational strategies and metacognitive awareness.

The methodology used will ultimately aim to provide research data from field work in a specialist arts College that allows the making of conclusions particularly related to associations between the creativity of arts students in a specialist arts College and their performance in mathematics. It will also identify the perceptions of creativity from the perspective of the College's staff and highlights their attitudes towards mathematics in the curriculum.

Chapter 2: A Literature Review

This literature review will focus on current research and studies that have investigated perceptions of creativity and mathematics and consider the implications of these within the context of a specialist post 16 art institution. In exploring the theme of this study, it is essential to understand theories of creativity. In fully understanding the potential of creativity as a pedagogical concept, in a post 16 setting, a definition of the term needs to be clarified. Society often uses the phrase he or she is very creative but what does that actually mean? In addition the literature review will explore key pedagogical approaches in both creativity and mathematics in order to identify associations and similarities in an attempt to discover the key challenges faced by educators and learners in this sector.

Theories of Creativity

What does it mean to be creative? Many researchers have explored theories of creativity and identify that they can broadly be defined within several key themes. This review will focus on defining a common definition of creativity to be used within the study and will focus on key research themes.

Simonton (2000) identifies that the research literature related to creativity is very broad and has been an interest for researchers and theorists for many years. He identifies 4 main research themes related to creative people. These are their cognitive processes, their personal characteristics, their life span development and their social context. The theme cognitive processes relates primarily to scientific understanding of creativity and the mental activity that takes place in the creative process. This includes insightful problem solving, which is associated with the act of stimulating information from the unconscious to create inspiration. It also includes creative cognition, the ability to be able to process information fluently and flexibly, and the acquisition of expertise. Personal characteristics are another theme, related to intelligence and personality. Simonton (1999) has argued that creative people have a particular personality including being more independent and open to new ideas. Simonton (1999) further states our life experiences are also significant with much research into themes related to life span development. For example we all have the possibility of developing creative potential from our life experiences such as family circumstance and the situations we live. Research in this theme has also included the actualisation of creative potential with studies into human achievement, for example, across the length of a career. Finally, social context is

concerned with the creative process within the context of a social setting where creativity takes place with intrinsic or extrinsic motivation being the key driver. An example of this is how people work within a work setting where external rewards are present potentially affecting individual creativity, or where creativity is dependent on more than one constituent part maybe including more than one person.

According to Banaji et al. (2010) many theories of creativity coexist in contemporary discourses. In their literature review 'The Rhetorics of Creativity' they identify two strands of creativity. The first related to genius and conservative understandings of creativity and the second are liberal or democratic understandings. The term genius applied to an artistic or creative practice was first applied to the Renaissance artists. This strand of creativity suggests only some people have the potential to be creative. This argument links to Simonton's (1999) research theme of personal characteristics and that creativity is a natural phenomenon that comes from human unconscious, suggesting therefore it cannot be nurtured or taught. This is reminiscent of Kant (1790/2016) who explains this phenomenon of human nature as the genius to which provides the rule to art, rather than art being defined by rules. In arguing this he suggests that genius can only be determined where production of work or an idea has not been predetermined by a rule. Originality must be a key component. The theory suggested by Kant raises an interesting question regarding the formation of ideas, with Kant implying that they are provided by nature and even the genius artist would not be able to identify how the ideas entered their head. Kant believes that learning is a cognitive process where the acquisition of knowledge through the processing of rules and information can therefore never reach or be equivalent to genius status alone. Genius is therefore, in Kant's opinion, limited to the creative. Other theorists, however, challenge this theory.

Sir Ken Robinson (2011), in his publication 'Out of our Minds: Learning to be Creative' appears to support theory defining creativity as 'The greatest gift of human intelligence.' However he also suggests creativity is not just about being an artist or working within the arts but it is a complex process with many aspects including specialist skills and techniques. It includes everyday capabilities such as use of imagination, awareness and perception. In contrast to Kant's (1790/2016) view he uses the word 'fostered' when explaining how creativity can be encouraged, stating it requires many different ways of thinking, intuition and gut feeling. He also recognises in a complex and ever changing world the need to be evermore creative as essential if we are to meet its challenges. We should therefore also distinguish how theories of creativity have developed beyond those of the 18th Century when they were limited to those involved in fine arts.

Personal characteristics are also a key component of Vygotsky's (1930) theory of creativity. Vygotsky describes creativity in its truest form as the play of children. For example when a child imagines that she is a mother when playing with her doll, or a stick to represent the riding of a horse or a soldier's rifle. This appears to support Kant's theory that creativity is not taught but is evident in all children naturally. Vygotsky, however, challenges the concept that creativity is limited to a few individuals, for example, those who have designed highly conceptual architecture or developed advances in technology or those who have produced outstanding works of art. He prefers to recognise that creativity is present not only in major historical inventions or human developments but also whenever anything new is created such as when two ideas are combined, a new idea imagined or a simple alteration is made. He therefore believes that creativity is not inclusive to the work of a genius. Also, unlike Kant, Vygotsky suggests that even the most fantastical ideas are just a combination of ideas from a range of influences from reality that have been brought together and reimagined in in our minds. Therefore there is a connection between our imagination and Simonton's (1999) research theme life span development as suggested in Vygotsky's proposal that imagination always builds using materials supplied by reality. In other words the acquisition of creative potential is subject to the quality or richness of our life experiences, the richer the experience, the richer the imagination, and therefore the greater the creative potential.

Another theory of creativity identifies it as having three key aspects, effect, cause and interaction (Cropley, 2001). Creativity as effect can be defined as a product which can take the form of a piece of art such as a painting, a music composition, a furniture design or form of writing. In addition they can also be less physical such as a strategy to solve a problem or a business plan. These forms of creativity require the acquisition of expertise and the actualisation of creative potential both present in the development of cognitive processes through human life span development. A judgement can be made about the products creativity for example is it unique or novel, is it effective or is it ethical?

Creativity as cause is related to the concept of creative people who create the products previously discussed. In particular it is a series of psychological factors such as knowledge, skills, attitudes values, openness, flexibility and courage which when present allow us to define someone as creative. Often this can be present in a person whose personal characteristics can be defined as a natural talent for a creative activity such as painting, drawing or music making. Cropley believes that more key to educators is those creative talents which can be developed through training or experiential learning. He

defines the personal characteristics of creative people as flexible, having an active imagination, being curious, independent, acceptance of own differentness, tolerance of ambiguity, trust in own senses, openness to subconscious material ability to work on several ideas simultaneously, the ability to restructure problems and the ability to abstract from the concrete.

Creativity as interaction relates to the environmental factors or social context an individual is exposed to. This can be a positive or negative interaction with material objects such as musical instruments or literature. The interaction may be human which fosters or promotes positive attitudes or provides opportunities creating an appropriate environment for creativity. Often the timing and quantity of these interactions, either positive or negative, can be key to the development of creativity including the skills and knowledge required (Cropley, 2001). In addition to Cropley's key aspects of creativity it can also be defined as the opposite of conformity. Amabile (1996) stated creativity is based around intrinsic motivation where an activity is carried out for the sake of the activity itself and not because there is an extrinsic motivator enforcing compliance. Learners that shape their behaviour only to receive the reward or avoid the punishment enforced by the extrinsic motivator are doing so to conform and the implication is that this does not nurture creativity.

A large quantity of research into theories of creativity have focussed on 'Big C' and 'little c' creativity. 'Big C' creativity can be described as a focus on a type of creativity that is acknowledged by others as being of value, such as works by leading artists previously discussed and recognised by Kant. Rich (2009) suggests research termed 'Big C' such as research by Csikszentmihalyi (1996) into 100 eminent creative people, and Gardner's (1993) concentration on the greatest minds of the 20th Century, have yet to be related to 'little c'. 'Little c' can be defined as research into creativity that is expressed as creative by an individual or just a few people and may have a minimal spread of social impact. Again this raises the questions of what we define as creative and re-iterates the belief of Kant that creativity is linked to genius and limited to the eminent few. Rich's view does however create doubt on Kant's theories. He suggests that whilst there is clear evidence that multicultural experiences (social contexts) do have an impact on 'little c' creativity, evidence of the impact of this on 'Big C' is less clear.

In conclusion it is clear that whilst many theorists explore similar themes related to creativity, as recognised by Banaji et al. (2010), these theories do exist in contemporary discourse. However, this study exists within the context of a post 16 educational setting

and is therefore focussed primarily on ‘little c’ creativity, that is creativity that will not have a broad spread of social impact. However, it should be recognised that the learners within the context of this study are on their journey towards ‘Big C’ creativity of which only the few will reach genius status as defined by Kant (1790/2016). The focus on creativity within the context of this study should therefore consider Vygotsky (1930) theory that creativity can be defined as developments where simple alteration is made or two ideas are combined effectively. It is therefore sensible to suggest that creativity should be defined as a process which can be fostered by learners within the context of the development of their imagination, awareness and perception as recognised by Sir Ken Robinson (2011). In addition the development of a learner’s cognitive ability, nurturing of personal characteristics and the provision of opportunities to develop life experiences and social environments are central to the development of the creative learner.

Creativity in Education

Having identified what we can define as ‘creativity’ or what makes people creative this section will explore the role creativity has had in education including historical developments and current policy and practice. This includes a review of the limited role of arts education in early development of the National Curriculum, the creative Reggio Emilia approach in Post Second World War Italy and current UK educational practices. By reviewing the practice of creativity in education this literature review aims to establish if there is a relationship between creativity or creative development and academic study.

Odem et al. (2010) state that in a world, which is fundamentally changing at a fast rate, where young people are trying to play an active part employers are looking for specific skills. These skills include problem solving, the ability to communicate ideas, the ability to question, innovate and develop new ways of thinking through making connections. As already recognised these skills can be nurtured, developed and enhanced through creativity. But from the early days of education teaching of some creative subjects and the arts, such as drama, music, and arts and crafts, has been seen as a luxury. Unsurprisingly, teaching during the 19th Century was focussed on developing basic skills such as literacy, school attendance and health and wellbeing. In 1862 government policy had a major impact on the curriculum and performance of learners. When Lowe (as cited in Fleming, 2010) revised the Code of Regulations for educational establishments it allowed for performance based grants to be given to schools on the basis that they achieved minimum standards in reading, writing and arithmetic. The impact was significant and schools minimum targets became the maximum they were required to

achieve. As a result education was recognised as becoming too mechanical in its approach by school inspectors in their report of prevalent practice which highlighted a preferred approach involving free play which would allow learners to develop their learning and skills through curiosity and investigation. The report recognised that schools had lost their spirit and inventiveness.

Throughout the history of education there have been many innovative approaches to education practice including creativity as a principal pedagogical notion. The Reggio Emilia approach, shortly after the Second World War in Italy, was initiated by Malaguzzi for pupils in their early childhood. The approach encouraged learners to learn through creative opportunities and through use of their senses (Marsh, 2010). The learner experience at Reggio Emilia encouraged learners to repeat significant practices. This included observation, consideration and representation skills being developed and repeated. Their education was flexible and non-linear where learners were not moved quickly and sequentially through a series of tasks (Edwards et al., 1998).

In contrast, current UK educational practice has been described by Robinson (2011) as having a negative impact on the creative ability of young people identifying that many students who enter pre-school have a creative confidence that is lost by the time they leave school. He describes the reasons for this is an education system that is designed for a previous age, and that despite the many passionate and committed teaching staff and politicians their efforts are wasted due to these flaws. His greatest concerns are that the education system is designed to meet the needs of the Industrial Revolution, a time where systems to educate mass populations were required to ensure that they prepared learners for work that was often labour intensive. The curriculum was designed to mirror these principals and required learners to develop the attributes of conforming, education was linear and standard. At that time life was predictable, in contrast current lifestyles and the professions people undertake are anything but predictable. As new technologies develop more increasingly employment is moving away from labour demanding roles and people are moving into new industries where skills such as innovation, creativity, lateral and conceptual thinking are essential to the economic development of businesses and nations. However the education system remains predominately unchanged since the days of the Industrial revolution. Robinson believes that there is recognition by the government and educators that innovation and creativity skills need to be developed to make an adaptable and flexible workforce and the creation of new products and services allowing businesses and corporations to be the leaders in their fields. In concluding Robinson states that “The challenge now is to transform education systems into

something better suited to the real needs of the 21st century. At the heart of this transformation there has to be a radically different view of human intelligence and of creativity." But he believes reforms are led by political and commercial policies and are not actually focussed on what works for learners or how great schools achieve their goals. Robinson's preferred approach is to take a much more holistic approach where learners are nurtured to develop their diverse talents. Achieving this is a challenge and he claims that the standards movement is only concerned with raising academic standards and that there are many other forms of education. He believes education is dominated by propositional knowledge where learners learn knowledge and facts about what is the case (Robinson & Aronica, 2015).

Alexander et al. (2009) argue that in England, compared to other countries in their review, assessment policies designed to bring education establishments to accountability are much more prevalent. There is more standard testing, testing occurs more frequently and starts at a younger age, occurs in more subjects, published in external league tables. They define the assessment testing as 'high stakes.' The setting of attainment targets in England are very unequivocal thus creating a 'complex assessment industry and machinery in English schools that is not paralleled in other countries.' This accountability of education providers has seen significant improvement in attainment throughout England, however researchers argue that whilst the results of tests have definitely improved that this only identifies that learner's ability to do better in tests has increased but learning has not actually changed. Some are led to believe that a continuous emphasis on assessment has resulted in learner's motivation and self-esteem being reduced and that the approach has resulted in a narrowing of the curriculum with heavy focus on numeracy, literacy and sciences. This is relevant to this study as it implies that there is a significant focus on educators to achieve results and less emphasis on the journey to achieve those goals. It implies that this approach is not effectively developing flexible learners who have an ability to apply learning to new situations and contexts. Furthermore it suggests that less emphasis on creativity and creation as a process is creating one dimensional learners.

Alexander et al. (2012) believe this is a this is a result of the government's ignoring of suggested reforms to the education system provided by the Cambridge Primary Review launched in October 2006. The review aimed to independently review primary education detached from political prejudice and unfounded information and to create a vision for primary education that was appropriate to learners at a vital stage of their education. Concerns regarding assessment and accountability are not new to education as identified

by Lowe in 1862 (as cited in Fleming, 2010). More recently the White Paper 'All Our Futures: Creativity, Culture and Education' a report to the Secretary of State for Education and Employment and the Secretary of State for Culture, Media and Sport (1999) raised concerns regarding standardisation. A recommendation in the report concerned with raising standards identified that whilst assessment and Inspection had a role in improving standards that they should not hinder creativity and cultural development of learners and educators. There was recognition that there were different forms of attainment targets required and that the introduction of standardisation would have the potential to risk the objectives of creative and cultural education to be disadvantaged. The White Paper was clear to identify the essential requirement to develop literacy and numeracy skills but also highlighted that this alone would not effectively develop an education system suitable for the 21st Century. Instead preferring an approach that is flexible and provides an education that is adaptable to the broad ranging talents of young people. This, it defines as crucial to the economic and social development of Britain. The report highlights creative potential as being relevant to all aspects of human activity, that learners who find their creative abilities can see dramatic improvement in their confidences and this impacts on their achievement in all aspects of their academic and social lives. It also defines creativity as not merely as a subject within education curriculums but a process that is relevant to all aspects of the curriculum. The report calls for creative development as a key component to education and challenges some of the perceptions that people have of creativity, arguing it is not associated with a lack of academic discipline, or the privilege of the gifted, or just a subject within the arts but an ability that is evident in all learners. Educators need to be trained and supported to create a pedagogical approach that provides opportunity for innovation and risk taking.

So, is there a relationship between creativity and an improvement in academic study? It is clear that many researchers and influencers, such as Alexander et al. (2009), believe that creative approaches to academic study throughout history provide significant evidence that a creative approach in classrooms can have substantial impact on academic performance. However despite noteworthy discussion and lobbying by researchers such as Sir Ken Robinson and reports such as the Cambridge Primary Review (2012) and the 'All Our Futures' White Paper (1999) the national curriculum continues to have a heavy emphasis on academic subjects such as mathematics and literacy with very limited opportunities for learners in the arts.

Pedagogical Approaches in Creativity and Mathematics

This section will explore creativity as a pedagogical concept and in particular identify the relationship between creativity and definitions of intelligence. It could be argued that learners who are described as intelligent display creative attributes because intelligence is the most significant attribute in the creative learner irrelevant of any other of their personal characteristics. In other words, creativity has no part in academic ability, it is just intelligence that makes learners creative and good mathematicians? To establish an answer to this, pedagogical approaches to mathematics will be considered, including the views of key influencers such as Ofsted, and the challenges that are faced by mathematics educators. By identifying key research and the findings of studies, such as those by the National Council of Teachers of Mathematics (1980), this section aims to establish best practice in the delivery and learning of mathematics. In doing so comparisons will be made in the relationship between pedagogical approaches to creativity and their association to best practice in mathematical study.

Many researchers have explored the theme of creativity and its potential to work as a pedagogical concept to unlock domains of learning. This includes its relationship with cognitive learning and intelligence. By making choices within the development of the National Curriculum between creative arts and academic subjects such as mathematics and English, the suggestion by policy makers is that creativity and intelligence are seen as diversely separate. More recently modern research has begun to identify greater associations. Theorists such as Kaufman (2013) suggested that a disservice to both abilities was being made by suggesting they were separate. The argument being that closed ended problems solved in tasks associated with high intelligence required the same thought processes as creative tasks associated with the creation and development of ideas with no pre-conceived answer. These views are however in contrast to previous writing that has explored concepts of creativity and intelligence including the introduction of convergent and divergent learning. Guildford (1967) developed the terms when associated with learning identifying a convergent processes as narrow thought process leading on a single path to a correct answer. Divergent process is broader where the thinking process leads to an undefined outcome. Guildford recognised that divergent thinking included the ability for thinkers to develop fluently many solutions to a problem in a short period of time. They were able to work flexibly and provide a variety of approaches, develop original ideas and also elaborate with the ability to organise and carry out solutions. Guildford recognised these attributes were characteristics that were

significant in creative people.

With a greater emphasis on post 16 educators to develop learner's mathematics skills many challenges are faced by educators in this sector. This section will also focus predominately on standards and approach of teaching and learning when meeting the needs of learners. At the better Mathematics Conference in Spring 2015 Ofsted highlighted a range of findings from inspections during 2015. Key concerns relating to achievement included application of mathematics and that students of all ages were not encouraged to solve problems, resulting in learners who are not made to think hard enough or independently. In addition, it was considered that students do not learn the key foundations for the next stage of learning due to teaching being more concerned with meeting standards thresholds. Ofsted recognise that the best mathematics teaching develops conceptual understanding when combined with knowledge and the development of problem solving skills. In addition, that teaching practice is most effective when teachers' best understand their learners and adapt and create teaching that meets their needs. This includes listening to students, discovering through effective asking of questions, about what they know and understand. Finally, they argue that too much teaching is based around the acquisition of skills related to passing exams which do not prepare them effectively to meet their progression goals including education and work. Ofsted highlight that their findings on effective teaching in schools are in keeping with the aims of the National Curriculum. This includes developing students to develop conceptual understanding whilst being fluent at the fundamentals of mathematics, being able to reason mathematically and solve problems. Standards in mathematics are raising in general, but Ofsted have concerns. Too often teaching is focussed on how to complete tasks without fully understanding why, resulting in learners that progress to the next stage of their learning without the necessary foundations on which to build their knowledge. Ofsted also identify that teachers do not fully explore learners understanding of the contents of lessons and adapt their approach as a consequence. Glenda and Walshaw (2009) argue when considering pedagogy in mathematics classrooms that if we are going to address underachievement our approach to teaching must change. However, it is recognised that within educational institutions that diverse groups of learners have differing educational needs and responses to teaching approaches and that there is an expectancy that the effect of these is minimised.

Findings such as those highlighted by Ofsted and Glenda and Walshaw (2009) are not new, in 1982 the Cockcroft report 'Mathematics Counts,' an inquiry into the teaching of mathematics in schools, identified that effective teaching of mathematics at all levels

should involve a range of opportunities for learners. This includes teacher led delivery including discussion between both the teacher and learners and between the learners themselves; practical work related to the theme; the practice of skills and approaches to encourage consolidation of ideas; the application of mathematics to everyday scenarios including problem solving; and appropriate investigational work.

When considering these approaches Orton et al, 2004 suggest that teachers have traditionally become effective at teacher led delivery and at supporting learners in the consolidation of skill development through practising and routine building, but believes that other aspects of the Cockcroft proposals are under developed. Recognising this their argument is that learning mathematics should incorporate some development of the skills it requires to be a mathematician including problem solving and investigation. In addition it is suggested that teaching that is merely exposition and repetition develops mathematics skills but does not lead to mastery. Furthermore, it can lead to many learners becoming confused between different theories and some procedures not even remembered at all. Promoting mathematics as a process rather than just subject content allows the development of a broader range of skills such as analysing, collecting data, generalising and proving.

The National Council of Teachers of Mathematics (NCTM) supported this as far back as the 1980s in their Agenda for Action. Their recommendations said that 'problem solving' is key to the development of mathematics skills in schools. By linking mathematics delivery to everyday activities we are investing in the development of the economy, whereas teaching exposition is most suitably aligned with an individual's knowledge and intelligence building and not their ability to contribute to the development of society. Whilst there is much criticism for exposition as a teaching approach in mathematics, in contrast Grandi (2013) suggests that a research based approach by a teacher allows them to be more selective in what they 'tell' learners ensuring what learners learn is focussed and relevant to their development. She maintains whilst there is strong arguments against a transmissive teaching style there is very little guidance on how to achieve reforms in mathematic delivery. By using a coded framework in a study into teacher student dialogue there is a belief that an individual deliverer can develop their practice by changing their approach questioning learners more effectively making teaching by telling relevant and effective.

Dalby et al, 2016, in their study 'Locating mathematics within post-16 vocational education in England' also suggest that there is a need for widespread improvement in

the approach to the delivery of Mathematics. However they suggest that achieving this is far more complex, particularly in Post 16 education. This is due to students' prior history of perceived failure in the subject resulting in students that are very demanding to teach due to their lack of interest in the subject and disaffection in their studies. The groups of learners in their study were predominately vocational students who were disengaged with the mathematics they had learned at school and were unable to see the relevance to their studies dismissing GCSE as an academic subject that was isolated from their current learning experience. Dalby et al therefore conclude that it is essential in this sector to develop strategies to engage students and create meaningful learning experiences that engage them in mathematics.

In 2005, Sriraman suggested that mathematical creativity was a significant quality found in mathematicians working at an advanced level. So, how is this relevant to students working in a post 16 educational environment? Sriraman (2005), recognises that in most situations teachers are not expecting students of this age to produce work of 'extraordinary creativity' or 'originality'. However, does believe that work produced can show evidence of new insights. This raises the question of what we determine as mathematical creativity. Leikin et al. (2014) believe that in determining an answer to this question we should identify the distinctions between general and specific creativity. Specific creativity is different to general because it is concerned with the logical deductive nature of a particular area of study. Unlike general creativity where patterns of problem solving can be brought in from a range of different areas. However, in current research there is a lack of a definitive meaning of what mathematical creativity actually is. This literature research has attempted to define a broad range of creative definitions and it is clear that much of these models of creativity have commonality with mathematical study. For example, Ofsted have identified that pedagogical approaches to mathematics should develop learners who are good problem solvers who have skills to work independently and are made to think harder. They should be fluent and be able to reason effectively in the problem solving process. It is clear that much of the evidence in research regarding Creativity there are parallels between mathematic pedagogical theory and creative development. This is clear in Guildford's (1967) creativity test which measures divergent thinking in categories similar to the demands of Ofsted, such as fluency and flexibility. Another significant researcher on creativity, Torrance (1962, p.663) offered this definition of creativity which further supports the need to develop fluency and flexibility skills: "Creativity is a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficult; searching for solutions, making guesses or formulating hypotheses about the deficiencies; testing

and re-testing these hypotheses and possibly modifying and re-testing them; and finally communicating the results."

Other categories of creativity recognised by Guildford including originality and elaboration are still relevant, however, more so to the advanced mathematical practitioner. Bloom (1985) suggests that mathematical talent is developed throughout 3 stages of the learning process where at stage 1 the student falls in love with mathematics, the second stage is where students develop the values and key concepts associated with creative mathematics and the third stage is where learners become successful in their field. As already stated, considering Sririman's suggestion that mathematical creativity is most significantly found in advanced mathematicians it is at the final stage where the creative skills of originality and elaboration would have more relevancy. At stage 2, however, if a learner is to develop knowledge of the values and concepts associated with creative mathematics the creative abilities associated with flexibility and fluency should be a consideration. Bloom (1985) suggests that the development of this type is often very limited in our schools and that this type of development more often takes place in learner's activities outside of school such as in clubs.

Haylock (1985) believes that educators need to give students the opportunity to develop their creative exploration whilst expanding their knowledge and this will encourage the development of mathematical creativity. Furthermore, it is suggested that not doing so results in the development of learners who do not diverge from a systematic approach to problem solving and only develop their abilities within their own knowledge limitations. This is also recognised by Mann (2006) who suggests that for the more advanced mathematics student who develop high level mathematics ability early usually results in them receiving more of the same work or the opportunity to move to the next stage more quickly. Furthermore, these type of student are not stretched to consider exploration of mathematical problems but instead are given closed problems that help them develop their computational skills but rarely results in these skills being developed and applied in meaningful ways that a creative approach to teaching and learning mathematics can provide. These theories suggest that the teachers approach and attitude towards creativity and the studying of mathematics is essential. Lev-Zamira and Leikin (2011) support this view stating that teachers are essential to achieving the goal of developing mathematical creativity in every student. This is supported in a range of publications, however, Shriki (2009), argues that teachers' knowledge of creativity is underdeveloped preventing them being involved in a discussion about its implementation in the classroom.

Teachers not only have a significant role in providing opportunity but also development of personality traits of learners.

In conclusion of this literature review we can define creativity within the context of this study as the personal characteristics, cognitive ability, life experiences and social context that allow learners to create original new ideas. Personal characteristics can be further defined as the ability for learners to be fluent, flexible and original with the ability to elaborate. In consideration of pedagogy and mathematics the literature review highlights the similarities between characteristics of the creative learner and those required to study mathematics effectively. In particular, the ability to solve problems and investigate requires learners to be fluent in their thinking and flexible in their approach to problem solving and investigation.

Chapter 3: Methodology

Research Questions

The perceptions of Creativity and Mathematics in post 16 arts Education have been explored in the literature review with a particular focus on theories of creativity, creativity in education and pedagogical approaches in creativity and mathematics. This study aims to identify what are the perceptions of creativity and mathematics in a specialist arts College and determine if there are any relationships with previous research studies. The research questions for this study are:

Research Question 1	What are staff's Perceptions of Creativity in a Specialist arts College?
Research Question 2	Is there an association between the creativity of arts students and performance in mathematics in a specialist arts College?
Research Question 3	What are staff's attitudes in a specialist arts College towards mathematics in the curriculum?

Appropriate research questions are important to a research project. Throughout the literature review very broad questions were considered and these have been refined and redefined several times to narrow down the focus to ensure that answers within the context of the study can be sought. Andrews (2005) believes that as a researcher you are in control of the study and despite there being the necessity to ensure that the methodology is valid, by controlling the research questions you are in turn in control of the responses. He also identifies that it is not uncommon to find that broad aims are narrowed down from often large 'unanswerable' questions to manageable questions that support the progress of the research. This was evident in this study.

Throughout the study a range of research questions were considered and initially research question 1 was considered to be research question 2, but moved to question 1 as it was determined that participants' 'perceptions of creativity' underpinned the research. Research questions were also changed to reflect the researcher's findings and reflections following the literature review. In this case the terminology originally used for research question 1 had a focus on 'understanding of creativity.' However the researcher determined that 'understanding' did not have the breadth required. The term 'understanding' can be defined as to "be sympathetically or knowledgeably aware of the character or nature of something." The term 'perception' was preferred as this can be

defined as “the way in which something is regarded, understood, or interpreted.” In this definition the terms ‘regarded’ and ‘interpreted’ were considered important due to the literature review recognising that ‘creativity’ is multi-faceted and has many often-contradicting definitions. The research question therefore needed to recognise how the term was considered beyond just ‘understanding’ and also be sympathetic to ‘theories of creativity’ already established. Whilst it is recognised that interpretation and understanding of terminology has its complexities, identifying staff’s perceptions of creativity in a specialist Art College was considered important to allow the researcher to ensure that any conclusions made regarding creativity and mathematics in combination are understood within the context of their interpretation of creativity.

The second research question aims to establish if there is an ‘association between creativity and performance in mathematics in a specialist arts College.’ Throughout the literature review connections were made between creativity and mathematics in particular the section on pedagogy and mathematics, which explored theorists who attempted to make connections between the domains of learning in creativity and their association with mathematical study. This research question will explore if there is an association between creativity and mathematical performance in a specialist arts College. In creating the structure of the research question careful consideration was given to the term ‘association.’ Originally the term ‘link’ was considered. That is, ‘is there a link between creativity and mathematics?’ It was perceived that this terminology could result in the capture of irrelevant or misleading results, as inevitably there would be a link made, although this link could be irrelevant to the context of the original supposition of the question. Instead the term ‘association’ was preferred as this was more focussed, it can be defined as ‘The state of occurring with something else; co-occurrence.’ It is this co-occurrence that the researcher is interested in ascertaining or refuting.

The final research question will explore staff’s attitudes in a specialist arts College towards mathematics in the curriculum. Having made conclusions in research question 1 regarding staff’s perceptions of creativity and in research question 2 the associations between creativity and mathematical performance, research question 3 provides opportunity to examine attitudes of staff and identify potential opportunities or barriers to developing pedagogical approaches. Careful consideration was given to the term ‘attitudes’ with staff’s ‘beliefs’ and ‘behaviours’ also considered as potential phrases to be used in the research question. Attitudes can be defined as “a general enduring positive or negative feeling about some person, object or issue” (Petty & Cacioppo & Goldman, 1981). Abell & Lebermann (2007) suggest that attitudes determine if a participant will

engage in a behaviour, whilst beliefs are the determinant of the attitude. Furthermore, they propose that attitude is the overall evaluation of an action, situation or time. Therefore, in the context of this study, attitudes in relation to the embedding of mathematics in a creative curriculum will have been determined by their beliefs but can be recognised by the staff's behaviours.

Participants and Procedures

The research methodology in this study will gather research from a specialist arts College in the North of England. Participants will include 25 academic teaching staff. Of these teaching staff the majority are creative practitioners who are teaching in Further Education at Levels 1, 2 and 3 in a range of art and design related subjects including Graphic Design, Photography, Fine Art, 3D Design, Textiles and Fashion. The participants will also include the Colleges mathematics and English teaching team, although this is limited to just 3 teaching staff. The research gathered from teaching staff will provide the data appropriate for answering research question 1 and 3 identifying staff's perceptions of creativity and staff's attitudes towards mathematics in a creative curriculum. The research will be gathered in the summer months in between academic years.

Research question 2 will be answered from research data gathered from the arts students studying in the College. The students will all be newly enrolled in the College and studying an art and design based subject as their primary course aim. Students who have not previously achieved a grade 4 (or equivalent grade C) at GCSE level in mathematics will have recently been enrolled to re-sit GCSE mathematics. Those who have already achieved this level will only participate in mathematics based activities as part of their art and design based qualification. The majority of students will be recent school leavers and aged between 16 and 18. A small minority will be 19+. The research will be gathered as part of the students' induction to the College and the data primarily will be used to answer research question 2 and establish if there is an association between the creativity of arts students and performance in mathematics in a specialist arts College.

Out of 500 learners in the College approximately 100 will study a mathematics qualification in 2016 /17 due to not achieving a grade 4 (or grade C equivalent) in GCSE mathematics. To ensure participation rates in the survey are high and that the data reflects a broad spectrum of learner's prior level of performance all new first year students

will be asked to participate. This will be a maximum participation rate of approximately 350 learners although it is anticipated that not all learners will complete the survey.

In the selection of a research methodology when approaching this study, a broad range of frameworks were considered. Theory suggests that whatever framework we consider, as a researcher our task is to find truth, and in finding that truth researchers have a responsibility to ensure that the findings are valid. In addition researchers need to convince others that the findings are not false and therefore conclusions can be trusted. Therefore the process of 'how' research is carried out is an essential consideration for a researcher and a reader who is determining the validity. In particular they will consider how the knowledge is developed, determined and acquired (Newby, 2014). Significant consideration to two methodologies were undertaken by the researcher, namely quantitative and qualitative approaches. Newby suggests the best way to define and draw out the characteristics of social research is to fall back on the division between quantitative and qualitative research traditions. When considering these methodologies it is useful to identify a quantitative researcher as someone who tests a hypotheses by finding quantitative data to see if the original theory can be confirmed and that a qualitative researcher would find data through exploration and description often to identify and develop new theories (Burke Johnson and Christensen, 2014).

When considering the title 'The Perceptions of Creativity and mathematics in Post 16 arts Education' it would initially seem logical that a qualitative methodology would be highly appropriate to gather views from experts within their field, but this does not provide results with the factual nature of quantitative data. Burke Johnson and Christensen, 2014, state that quantitative researchers like the 'hard' facts that the data provides. However, criticism of this approach questions the validity of quantitative research. Cohen et al. (2007) suggest that whilst the validity of quantitative research can be improved by using effective sampling techniques and instrumentation to provide careful and more accurate handling of data, there will always be some level of standard error which needs to be built into the findings and acknowledged when making conclusions. In addition they identify that in quantitative research validity must be obtained by having belief in the data set provided and used to create the final conclusions. This they describe as being faithful to ideas of Positivism which Newby defines as a philosophical approach to research, linked to Scientism, and often associated with quantitative methodologies. He refers to the scientific approach to research associated with quantitative data and that Scientism is a philosophical approach that is rigorous and methodological created by observation, experimentation and the testing of theories. Furthermore, it is suggested that positivism

relies on having faith in the process of research, and a belief that the researcher is looking for truth, is neutral and is uninfluenced by external pressures.

When considering research questions 1 and 3 it could be assumed that a qualitative approach towards the study would be suitable due to the requirement to identify 'perceptions' and 'attitudes' of staff. Qualitative data can provide detailed understanding and knowledge of observable and non-observable actions, attitudes, purposes and behaviours. It allows participants in the research to have a voice and share their views that may not be addressed in factual data (Cohen et al. 2007).

Philosophically humanistic and postmodernism attitudes have a natural association to qualitative methodologies. Humanists and Postmodernists, unlike the philosophy of scientism, do not believe that there is only one explanation to any research study and that two people will not always have the same view (Newby, 2014). For example hypothetically, a teacher in a post 16 College teaching Fine Art may have a very different attitude towards mathematics in the curriculum than a teacher delivering 3D Design.

In selecting the appropriate methodology, it is a researcher's role to ensure that the research they provide has validity and in doing this they must ensure that the results can be trusted. However, many researchers have differing views about what methodologies should be used to ensure validity. Research traditions that have developed such as qualitative and quantitative methodologies have a range of assumptions associated with them and it is these assumptions where most disagreement is concerned. When grouped together these assumptions have been labelled 'paradigms' which can be defined as a way of working that can be accepted by people working in that area. Therefore it can be assumed that if you work in a specific 'paradigm' in this case, quantitative or qualitative, with a clear set of rules that determine your research approach there will be a group of people who will value your approach. (Newby, 2014). With this in mind, selecting a methodology that will be valued by arts practitioners and mathematicians is challenging.

In considering this complexity consideration should be given to a mixed methods approach. The development of the mixed method approach, where both quantitative and qualitative approaches are utilised is aligned to the pragmatist values. Pragmatism can be defined as problem solving, in other words if an idea works then we should use it. For example utilising the benefits from both quantitative and qualitative methodologies allows the researcher to bring together the single truths of the quantitative approach and the many realities that can be defined by qualitative studies. Another advantage is that in

many studies there are different levels of inquiry and a mixed method approach allows the researcher to explore both of these in one study (Newby, 2014). In this study quantitative data can explore a link between creativity and performance in mathematics. Qualitative data can identify the perceptions and attitudes of teaching staff.

Materials and Measures

The research instruments for this study will include 2 questionnaires, one for teaching staff and one for students of the College (see appendix 1 and 2). This section will identify the key components of these questionnaires and highlight the measures that will be taken to answer the 3 research questions.

The research instrument used for question 1 will be a staff questionnaire which will be used to identify teaching staff's perceptions of creativity. The staff questionnaire will be completed by participants online through use of Qualtrics, a web based survey platform. Bell (2005) suggests that when developing a questionnaire considerations include 'open' and 'closed' questions. Open questions are designed to allow the participant to define the structure of the response including the wording and length. The advantages of this type of question is that they allow the respondent to give a full and complete answer ensuring the researcher receives a measure of the complexity of their views. Furthermore, Bell (2005) advises, this does rely on the participant's willingness to commit their efforts to answer appropriately and also leaves the researcher with the challenge of analysing complex raw data. Closed questions, on the other hand, are more structured and require the participant to answer within defined categories by selecting from alternative answers. Unlike 'open' questions 'closed' questions are easier and less time consuming for the participant and easier for the researcher to analyse. However, researchers risk not fully understanding their true and full feelings or facts associated with the question (Denscombe, 2014). For this reason a combination of open and closed questions were devised in the staff questionnaire to quickly ascertain some facts, but also to ensure that a deeper understanding of their perceptions of creativity are considered.

The staff questionnaire (appendix 1) comprises of 10 questions which can be defined by two sections. Section 1 will use a quantitative data approach and identify staff's perceptions through a Likert scale response to a series of statements. These statements can be seen in Q2 of the staff questionnaire. For research question 1 results from the following statements in Q2 will be used as measures. Creativity can be taught; student creativity can be taught in the school classroom; all teachers should have knowledge

about creativity; a regular classroom teacher is responsible for helping students develop creativity and I employ many methods in my classroom to foster creativity. These statements have been chosen to identify staff views relating to the theories of creativity as highlighted in the literature review. For example Kant (1790/2016) who stated that creativity is a natural phenomenon that comes from the human unconscious, suggesting therefore it cannot be nurtured or taught. Also, Robinson (2011) who asserted that creativity is the greatest gift of human intelligence but it can be encouraged and fostered but requires many different ways of thinking, intuition and gut feeling.

Section 2 of the questionnaire will focus on qualitative data by providing opportunities for staff to respond to a series of 'open' questions. For research question 1 the responses to be measured will be from the following questions. When you think of creativity, what comes to mind? Discuss what you believe to be the essential features of creativity. What percentage of your students do you believe to be highly creative? List the top five characteristics that best describe the creative student. List activities and strategies you use in the classroom to support creativity. The questions were devised to explore staff's perceptions of creativity within the context of a definition and characteristics, their thoughts on creative pedagogy and their opinions of creativity within the context of their learners. Consideration was given to literature review in particular on theories by Vygotsky. Personal characteristics are a key component of Vygotsky's theory of creativity. Vygotsky's descriptions of creativity as the play of children and the concept that creativity is not limited to a few individuals, for example, those who have designed highly conceptual architecture or developed advances in technology or those who have produced outstanding works of art. Understanding staff's views on the characteristics of creative students will give greater insight into their perceptions of creativity as a pedagogical tool.

Another significant consideration when designing questionnaires is to ensure that your survey is reliable and valid. Reliability of a survey can be defined as a measure of how the data in a survey can be reproduced. Litwin (1995) suggests that no survey can be 100% reliable however, believes that whenever anyone looks at a set of data they should begin by looking at the reliability of the instrument used to measure. Similarly, validity also measures the effectiveness of a research instrument. In this case it is concerned with ensuring that an instrument or question measures what it is required to measure and not a similar but different variable. Litwin (1995) describes validity as an important measure of the instrument's accuracy and that validity should be documented when new surveys are

carried out. For the small-scale social researcher, the issue of reliability and validity can create a significant challenge including financial and time constraints. One way to address this, as suggested by Hyman et al. (2006), is the potential inclusion of existing questions in a researcher's survey. They identify advantages and disadvantages to this approach, however, in conclusion suggest that the disadvantages associated with 'originality' and or 'recycling' of questions is far outweighed by the reliability and validity, and therefore quality, that these surveys provide. With regards to research question 1, relating to teachers' perceptions of creativity open and closed questionnaire method was adapted and utilised by a range of researchers (Aljughaman and Reynolds, 2005, p.2-3) The closed questions were adapted from other studies (Busse, Dahme, Wagner, & Wieczerkowski,1986; Fryer & Collings, 1991; Patchett & Gauthier, 1991.)

Specifically the closed questions will include staff responding to statements, which are: creativity can be taught; student creativity can be taught in the school classroom; the College where I teach places emphasis on fostering student creativity; all teachers should have knowledge about creativity; creativity is essential for enhancing student learning in schools; and a regular classroom teacher is responsible for students to develop creativity. The questions were considered relevant to this study after completion of the literature review highlighted views of Robinson (2011) that the challenge now is to transform education systems into something better suited to the real needs of the 21st century. Do staff agree that the lack of creativity in current approach to teaching in the UK needs development and that at the heart of this transformation there has to be a radically different view of human intelligence and of creativity? In addition do staff consider creativity to be a key component in education as advised by the White Paper 'All Our Futures: Creativity, Culture and Education' (1999) that highlights creative potential as being relevant to all aspects of human activity, that learners who find their creative abilities can see dramatic improvement in their confidences and this impacts on their achievement in all aspects of their academic and social lives.

Open ended questions associated with research question 1 include, when you hear the word creativity what comes to mind? List the top 5 characteristics that describes the creative student. What are the essential features of creativity? Finally, what strategies do you use to promote creativity? The closed questions were particularly selected to see if staff's behaviours supported their attitudes as defined by the closed questions.

A self-administered questionnaire will be used to form part of the quantitative data to be gathered to answer research question 2 'is there an association between the creativity of

arts students and performance in mathematics in a specialist arts College?' The objective will be to measure mathematical performance against levels of creativity. However, it is important not to mistake 'ability' for 'performance.' Ability is difficult to measure from a quantitative perspective as hard facts such as results in mathematics examinations or tests do not necessarily reflect mathematical ability alone, but instead measure performance in tests. To identify a participants 'ability' it would require the collection of quantitative data from interviews of a participant's teacher or observations of them at work. Instead the participants will be asked to identify their previous highest grade in GCSE mathematics and it will be recognised that this is a measure of their prior mathematic performance.

To establish students' levels of creativity the Guilford Alternative Uses test will be used (as identified in the literature review.) Dippo (2013), in a research paper 'Evaluating the Alternative Uses Test of Creativity' suggests that whilst the Guilford test does not fully represent general creativity in an individual it is a reliable indicator of creative potential. The Alternative Uses test will be completed by all participants in their creative studios and their tutor who will act as administrator. Students will be given the same guidance as all other groups, as identified by their administrator, who has been given clear instructions to read out only the guidance given to ensure every approach is consistent and to avoid researcher bias. The students will be given ten minutes to identify alternative uses for a shoe and their level of creativity identified by their ability to be fluent, flexible, original and elaborative. The tests will be completed using the form provided and the students own pen or pencil and completed forms will be submitted for marking at the end of the allocated time. All test will be scored by the researcher to ensure consistency of approach.

The students' fluency score will be calculated by identifying the number of answers they gave as alternative uses for the shoe in 10 minutes, with one point given for every answer. Flexibility will be determined by identifying how many different categories were recognised in the respondent's answers to the alternative shoe question. Categories are determined by the reviewer of the test who recognises common answers relating to similar themes. For example, 'use as a cup' and 'use as bowl' would receive only 1 flexibility point as both answers come from the category container for food and drink. The range of categories are identified below. Originality will be calculated by awarding points to respondents for answers that only a small or very small percent of respondents suggested. For example, very common answers could include use as a plant pot and would receive no originality points, whereas if only one respondent gives the answer use

as a decoration, or a designer hat, they would receive 1 originality point. This total is then divided by their previously calculated fluency score, to get a final originality score. The elaboration score will be calculated by the level of detail that was provided by a respondent. For example, 'to make ink prints', would receive no elaboration points, but 'to make a picture of the Mona Lisa using ink prints' would receive an elaboration point.

Table 1 - Categories used in the Guilford Alternative uses test

Container for Food and Drink	Use as a form of decoration
Use as a weapon, or to cause harm	Use as a form of tool
Use as a storage device	Use as a toy
Use as protective clothing	Use in the production of art
Use to create noise or music	Use in role play (for example pretending it is a phone)

Finally, to establish if there is an association between the creativity of arts students and their performance in mathematics, students' mathematics performance (identified by their GCSE grades) will be compared with their creative fluency, flexibility, originality and elaboration scores to identify any associations.

In addition to exploring associations with creativity and mathematical performance, the student questionnaire will also use a series of closed questions to identify students' attitudes towards mathematics. Although this is not a key focus of research question 2, recognising the literature review's arguments that creative and mathematical skills are highly influenced by individual personal characteristics, for example Cropley (2001) and Dalby et al, (2016), it was important to consider other key influencers on mathematical performance. In the student questionnaire the Likert scale statements in section Q5 were used including 'I like problem solving', 'I don't give up easily in mathematics.' To ensure validity of this approach the questions were influenced by the Erbas and Bas study in 2015 which looked into personality characteristics and their contribution to mathematical creativity. This included adapting a range of survey models associated with personality traits, student motivation, academic risk taking and metacognition. In this study the following measures were considered, and adapted appropriately to form the basis of the statements used - the Big Five Inventory (BFI), the Motivated Strategies for Learning Questionnaire (MSLQ) and the Metacognitive Awareness Inventory (MAI). Whilst acknowledging that adapting the survey questions could potentially reduce their validity it was considered essential to ensure they were appropriate for the context of the study. For example the original questions 'It is important for me to understand what is being taught

in this class' and 'I think what I am learning in this class is important for me to know' were both adapted to remove the words 'this class'. As the study was taking place in a specialist art College and that it was understood that the participants would complete their questionnaire in their art and design studios the researcher wanted to ensure that all participants were clear that they were answering with reference to their mathematics classes. Therefore 'this class' was changed to read 'mathematics'. For the same reasons another original question 'I ask myself questions to make sure I know the material I have been studying' was adapted to include 'In mathematics' at the start of the question.

These questions were considered appropriate in this study, particularly with reference to personal characteristics in the research of Cropley (2001) and Dalby et al. (2016). Cropley suggests that creativity is a series of psychological factors such as knowledge, skills, attitudes values, openness, flexibility and courage and Dalby et al. believe that teaching mathematics to post 16 students is impacted greatly by students' prior history of perceived failure in the subject resulting in students that are very demanding to teach due to their lack of interest in the subject and disaffection in their studies.

Research question 3, to establish staff's attitudes towards mathematics in the curriculum, will also use qualitative data collection from the staff questionnaire. The particular questions that will form the measures will include the following. Should creativity be enhanced and taught in non-art and design classrooms? Why?; List the top five characteristics that best describe a student who is good at mathematics and list the strategies and characteristics you use in the classroom to promote mathematics. These questions will be used to measure their attitudes as recognised through their behaviours towards mathematics rather than simply asking their beliefs, as previously discussed from the research of Abell & Lebermann (2007). These behaviours will be compared with the findings of the literature review, which discussed creativity, and pedagogy in mathematics and similarities, challenges and opportunities will be identified.

In parallel to the questionnaire a focus group will be used with regards to research question 3, to formulate further the attitudes of staff. Collective views regarding a research theme can be gained through focus groups. The interactive nature of the focus group relies on discussion and interaction between the researcher and the group. Morgan (1997) identifies that often the opinions declared by the group as a whole are as important as the opinions of individuals but also that consideration should be given to the fact that the results that you have are a reflection of the group's thoughts and not the individual opinions. In the context of this study the focus on 'attitudes' will include teacher

practitioners working within an arts education institution and their attitudes towards mathematics in the curriculum. Cousin (2009) suggests that the focus group can be used for a broad range of purpose including co-constructing new knowledge with the participants or generating theory. They are effective as the researcher can quickly gauge multiple views or perspectives and they are far quicker at establishing opinions and views than individual interviews which can be time consuming to arrange and carryout. Newby (2014) believes that this type of qualitative data is related to how people think, their feelings on an issue and that the data is only 'valid in terms of an individual's representation of reality.'

All 25 staff participants who took part in the study attended the focus group. They were asked to consider 4 questions. Question 1 'is there an association between creativity and mathematics performance?' This was influenced by Sriraman's (2005) views that recognises that in most situations teachers are not expecting students in mathematics to produce work of 'extraordinary creativity' or 'originality', however they should be able to develop new insights. Question 2 is 'what do you understand about convergent and divergent learning?' Guilford's (1967) alternative usage test was designed with consideration to convergent and divergent thinking. Guildford developed the terms when associated with learning, identifying convergent processes as a narrow thought process leading on a single path to a correct answer. Divergent process is broader where the thinking process leads to an undefined outcome. Understanding staff's views on the relevance of these terms in creative and mathematical pedagogy will help further understand commonalities in teaching approaches. Question 3 'Do you think creative sessions can develop fluency and flexibility?' also links to the Guilford test and theories of convergent and divergent thinking. Guildford recognised that divergent thinking included the ability for thinkers to develop fluently many solutions to a problem in a short period of time. Question 4 'Do you think this can support performance in mathematics and how can be it achieved?' is asked to see if the staff's beliefs regarding teaching approaches is consistent with their attitudes.

Pilot of Questionnaires

Both the staff and student questionnaires were piloted prior to the commencement of the research gathering. The staff questionnaire was completed by a College academic staff member working at the Higher Education site. She did not participate in the main survey. Minor alterations to the survey questions were made following the pilot. The main issues were regarding terminology, in particular around the term 'academic subject.' For

example in Q2 the statements referenced ‘creativity in academic subjects.’ The staff member was confused stating that A Level Art and Design could be described as an academic subject or did it actually mean subjects like science or mathematics. The terms were altered to read ‘in the school classroom’ and ‘in academic subjects in schools.’ Bell (2005) suggests that developing a questionnaire is a complicated task that should not be underestimated, but if designed well will give researchers the information they need, be suitable and acceptable to participants and be unproblematic at the data collection and analysis stage. To achieve this, she suggests that all questions should use language that participants will understand, they should be non-ambiguous, precise and make no assumptions. Furthermore, questions should not be hypothetical or have the potential to offend.

The student questionnaire was piloted by a 16 year old female drama student who had recently completed and passed GCSE qualifications and was preparing to study A Levels. The Guildford test was completed very effectively, under timed conditions in line with the criteria of the survey. However, the following questions relating to the students’ personal characteristics were very time consuming to complete. In total the questionnaire took almost 50 minutes to complete. This was considered by the researcher to be too long, the participant stated that she was not giving careful consideration to the content of the final questions due to fading interest. As a result the character questionnaire was reduced significantly. The majority of the questions removed from the questionnaire were the repeat questions that tested the respondent’s responses by repeating similar questions in various ways of phrasing. For example the statement ‘I give up easily in mathematics’ was similar to the question ‘when I find mathematics hard I work hard to find the right answer.’

Ethics

The research undertaken for this project has been conducted in a manner that complies with ethical guidelines for research in education. This has included seeking ethical approval which was achieved and approved by the University Chair of the Ethics Committee and the Director of Undergraduate Studies. The British Educational Research Association’s publication Ethical Guidelines for Educational Research state that:

“The Association considers that educational researchers should operate within an ethic of respect for any persons involved in the research they are undertaking. Individuals should be treated fairly, sensitively, with dignity, and within an ethic of respect and freedom from

prejudice regardless of age, gender, sexuality, race, ethnicity, class, nationality, cultural identity, partnership status, faith, disability, political belief or any other significant difference." (BERA, 2011 p.5)

Completion of the Ethical issues audit form supported the application for approval and identifies that the research did not involve children, vulnerable participants, sensitive topics or an intervention into normal education practice. In ethical discussions regarding the student questionnaires it was identified initially that student participants could include high needs learners. Due to time constraints with the study and the very limited of numbers of students it was decided that the high need learners, who could be deemed as vulnerable, would not be included in the study. In addition to the ethical issues audit form consent forms for both the staff participants and the student participants were issued. These can be seen at appendix 3 and 4. Approval from the full ethics committee was not required.

Data Analysis

In this study a mixed method approach is used and therefore the researcher will collate both qualitative and quantitative data. With reference to the quantitative data in the student questionnaire there are two main variables – 'creativity' and 'mathematical performance'. The approach to analysing the data will include producing graphical representations of the quantitative data which will be analysed, allowing their qualitative features to be inspected visually and resulting themes and trends to be recognised. Producing graphical representations is important because they provide a representation of the statistical data visually and directly. The choice of graphical representation to be used will be bar graphs. They have been selected in preference to other graphical representations such as pie graphs because they allow visual analysis of the data to be performed more easily. The bar graphs provide less clutter than pie graphs which can be more challenging to read particularly small demarcated slices. In addition the statistical values of a pie graph are difficult to identify without further cluttering the graph with written statistical values. Bar graphs are also more effective at displaying rank. They allow data to be ranked in order from left to right or top to bottom and can be displayed in ascending or descending order aiding the process in identifying visual trends in the data (Singer & Feinstein, 1993).

For all aspects of the qualitative data gathered in the study thematic analysis will be used. This includes qualitative data for research question 1 and 3 exploring ‘perceptions’ and ‘attitudes.’ Thematic analysis has been described by Boyatzis (1998) and Roulston (2001) as a previously undefined yet very commonly used method of analysing qualitative data. Braun and Clarke (2008, p.79) describe thematic analysis as “a method for identifying, analysing and reporting patterns (themes) within data. It minimally organizes and describes your data set in (rich) detail.” There will be six stages to the qualitative data analysis including familiarisation of the data gathered and highlighting initial ideas for themes; creating initial codes and collating appropriate information to these codes; searching for themes; reviewing the selected themes; defining the themes and finally writing the report. However, Braun and Clarke (2008) suggest that this process is not a linear approach and that variations to the approach will naturally occur in individual research projects.

In conclusion the methodology to be used for this study will explore 3 research questions. The participants will include staff and students teaching and learning in a specialist art and design College. Each participant will complete a questionnaire, one designed for staff using both open and closed questions related to the delivery and learning in arts based and mathematic teaching. The other questionnaire for students designed to identify their creative potential through use of the Guilford Alternative usage test and also their personal characteristics in relation to study skills. The qualitative and quantitative data collected will be analysed and used to answer the 3 research questions and in conclusion answer the wider study question regarding the perceptions of creativity and mathematics in a specialist art and design College.

Chapter 4: Findings - What are Staff's Perceptions of Creativity in a Specialist Arts College?

Chapters 4, 5 and 6 will report the findings of the research gathered as described in chapter 3. Each chapter will report an individual research question. The literature review highlighted key theories of creativity establishing that personal characteristics, cognitive ability, life experiences and social context were substantial areas of research in this area (Simonton, 2000). In addition personal characteristics of learners were identified as the ability to be fluent, flexible, and original with the ability to elaborate (Guilford, 1967). This section of the study will focus on teaching staff, in a specialist arts College and their perceptions of creativity through a research questionnaire that will ask staff their views. This will be categorised into a range of sections including teachers' beliefs regarding creativity, teachers' definitions of creativity and teachers' perceptions of creative students. Pedagogical approaches highlighted as good practice in the literature review will also be compared against the staff's perceptions of creative teaching.

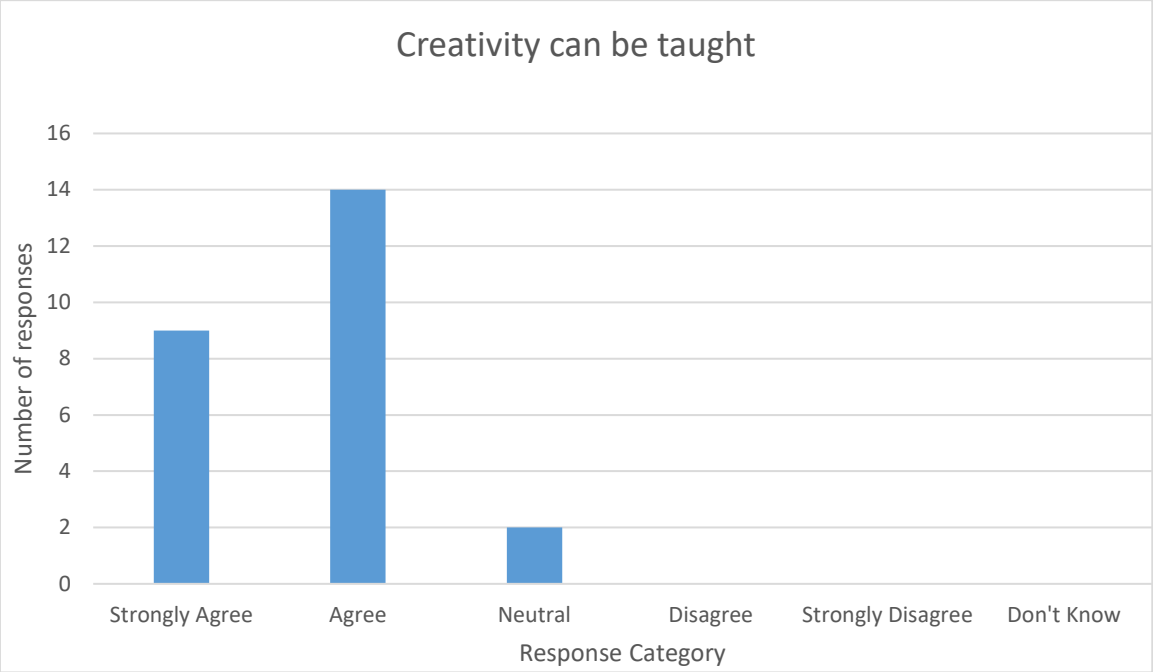
There were 25 respondents to the survey. They were asked to identify the subject and department where they delivered their primary teaching role. 22 out of the 25 respondents taught in an art and design based subject including Graphic Design, Photography, Fashion, Textiles, 3D, Fine Art and Interactive Media. 3 respondents were from non-art and design based subjects including Mathematics, English and Psychology. Respondents taught in a range of levels including level 1(pre-GCSE level) and 2 (GCSE Level), but most were predominately level 3, preparing learners for progression to University. All respondents have (or are working towards) a PGCE qualification and a minimum of a degree qualification in the subject they teach.

Teachers responded to 8 questions and were asked to identify how they felt about each statement on a scale from strongly agree to strongly disagree. The results were generally very positive towards creativity.

Teachers beliefs regarding creativity

Figure 1 shows the results for Q2 statements ‘creativity can be taught’ and ‘students’ creativity can be taught in the school classroom. The staff participants answered on a Likert scale ranging from strongly agree to strongly disagree.

Figure 1

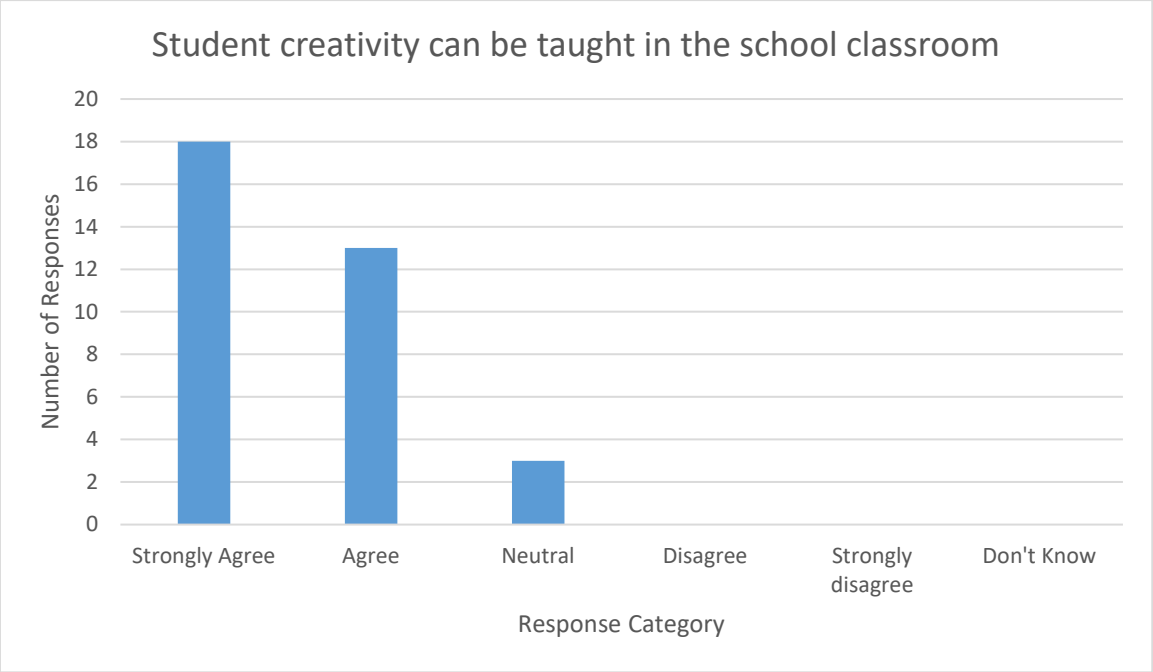


The results highlighted that 23 out of 25 staff agreed or strongly agreed that ‘creativity can be taught’ and 21 agreed or strongly agreed that ‘student creativity can be taught in the school classroom.’ However, the assertion is not strong in these statements with more than half only ‘agreeing’ and not ‘strongly agreeing.’ The charts show that the results were very similar for the two questions with only a 1 participant difference between the results.

Table 2 – Creativity can be taught

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
Creativity can be taught	9	14	2	0	0	0
Student creativity can be taught in the school classroom	8	13	3	0	0	0

Figure 2



Staff responded most positively towards the statement 'The College where I teach places emphasis on fostering student creativity' with 23 out of 24 strongly agreeing.

Table 3 – Where I work fosters creativity

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
The College where I teach places emphasis on fostering student creativity	23	1	0	0	0	0

The responses to the 3 statements 'all teachers should have knowledge about creativity'; 'Creativity is essential for enhancing student learning in schools in academic subjects' and 'a regular classroom teacher is responsible for helping students develop creativity' can be seen below. There were very similar responses to the statements 'all teachers should have knowledge of creativity' with all participants at least agreeing (16 strongly) and also the statement 'A regular classroom teacher is responsible for helping students develop creativity' with 23 of 24 participants agreeing (14 strongly). 23 of 24 participants at least agreed to the statement 'Creativity is essential for enhancing student learning in schools in academic subjects' and this time the response was more assertive with 19 strongly agreeing.

Figure 3

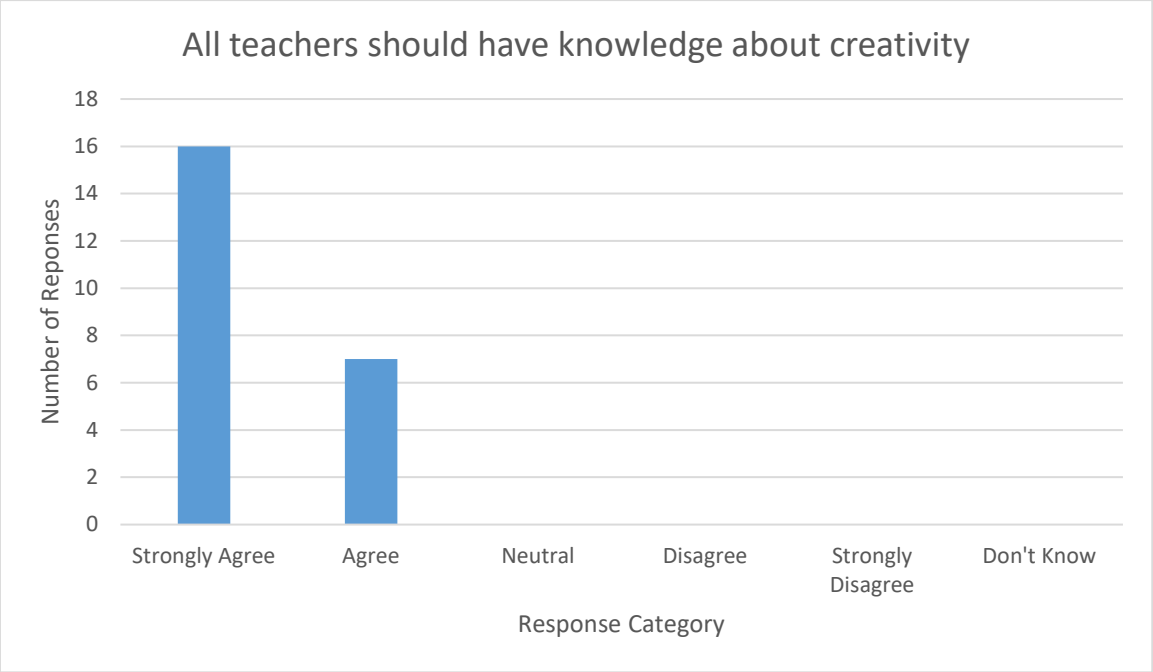


Figure 4

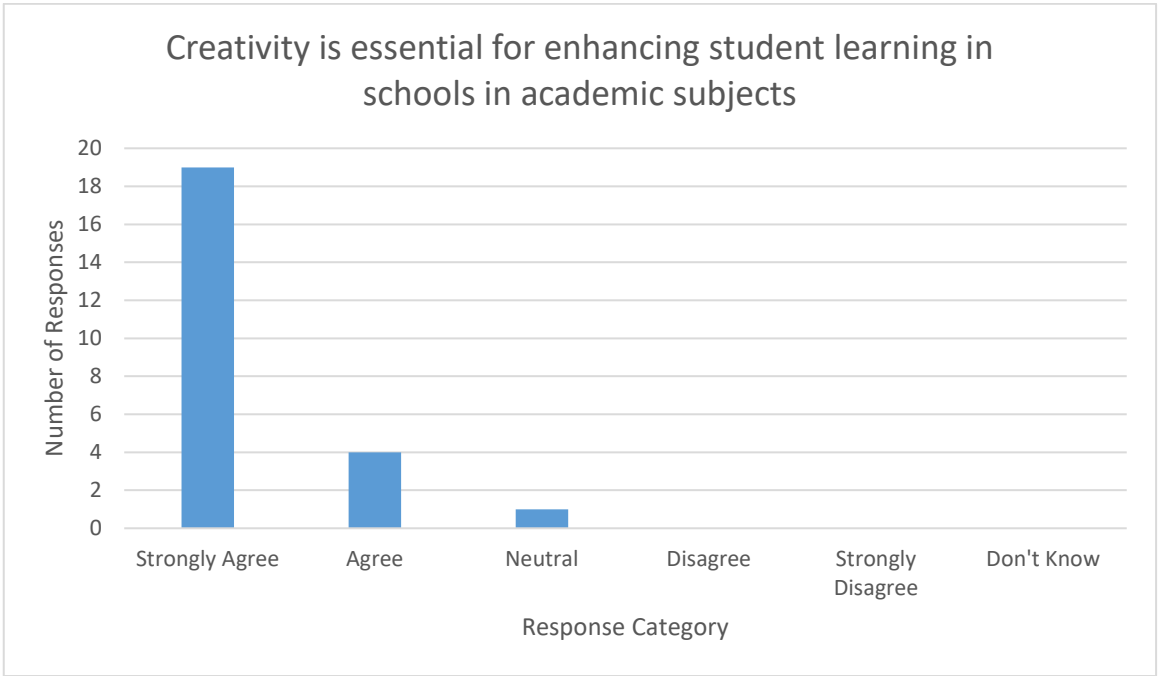


Figure 5

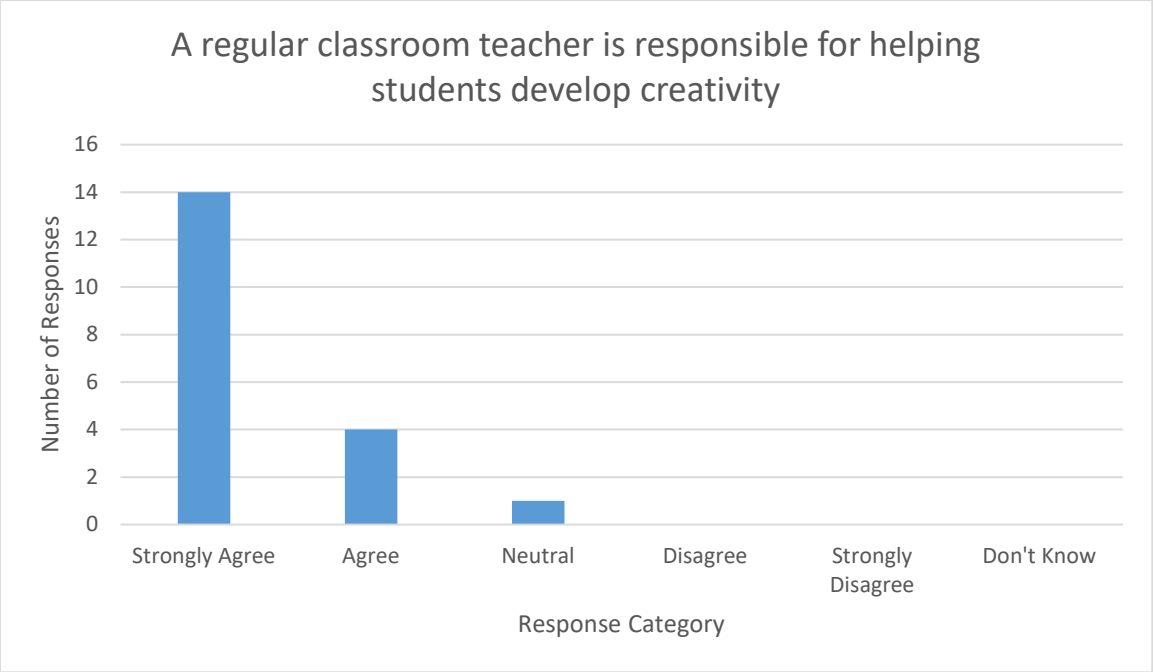


Table 4 – Creativity and teaching in the classroom

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
All teachers should have knowledge about creativity	16	7	0	0	0	0
Creativity is essential for enhancing student learning in schools in academic subjects	19	4	1	0	0	0
A regular classroom teacher is responsible for helping students develop creativity	14	9	1	0	0	0

Teachers' definitions of creativity

The following table shows the teachers' definitions of creativity. This data was provided by the question 'When you see or hear the word creativity, what comes to mind?' Thematic analysis was utilised to identify a broad range of themes as identified in the methodology. The most frequently referred to theme was related to divergent thinking with 52% of participants making reference to this theme in their answer. The theme

problem solving (or use of the design process) was next most popular referenced in 44% of answers.

Between 20% and 30% of participants referenced aesthetic products, original ideas and inventiveness. Less regularly referenced were the themes linguistic product, imagination, self-expression, intelligence and enjoyment. They were referenced by less than 20% of participants.

Table 5 – Teachers' definitions of creativity

Creativity involves:	**% Agreement**
Divergent thinking	**52%**
Problem solving / design process	**44%**
Aesthetic product	**28%**
Original ideas	**24%**
Inventiveness / Innovation	**24%**
Linguistic product	**16%**
Imagination	**12%**
Self-expression	**12%**
Intelligence	**8%**
Enjoyment	**8%**

Teachers' perceptions of the creative student

In question 7 of the survey the teaching staff were asked to list the top five characteristics that they felt describe the creative student. The results were analysed and the following table shows the top 12 characteristics from the 43 themes identified.

Table 6 – Teachers' perceptions of the creative student

Creativity involves:	**% Agreement**
Open Minded	**60%**
Independent	**32%**
Enthusiastic	**28%**
Experimental	**28%**
Deep / Lateral Thinkers	**28%**
Curious	**24%**
Imaginative / Innovative	**24%**
Confident	**16%**
Motivated	**16%**
Reflective	**16%**
Unique	**12%**
Analytical	**12%**

Of these 60% were in agreement regarding open mindedness and this was ranked the most important factor. Imagination (24%) and curiosity (24%) were also defined. Intelligence was not highly ranked with only 2 people defining it as a factor in their creative students, and whilst courage was not highlighted two respondents recognised the need to be resilient. Independence was a major factor ranked second in the table with 32% of respondents agreeing.

Whilst no participant suggested divergent thinker as a characteristic of a creative student the theme lateral / deep thinker was suggested by 28%. Other characteristics related to cognitive ability were highlighted including reflection (16%) and analytical (12%).

Other significant themes included the personality traits of enthusiasm (28%) experimental (28%) confident (16%) and motivated (16%).

What percentage of their students do staff consider to be highly creative?

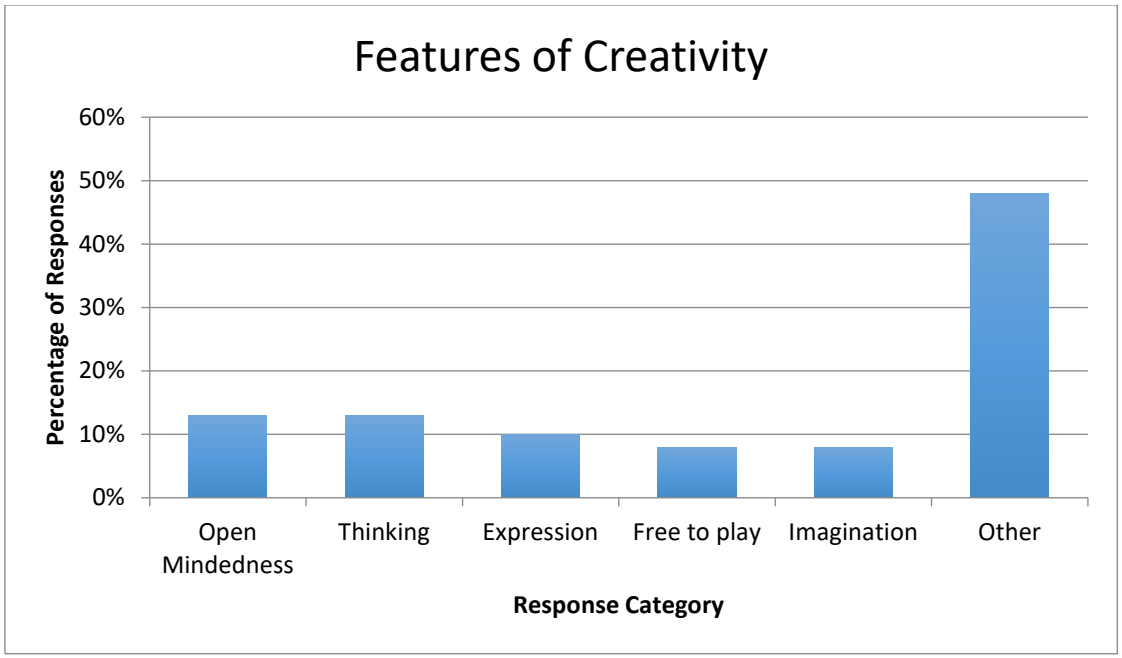
The range of answers to this question was very broad. Some staff participants provided just a percentage and others an explanation and percentage. Others provided just an explanation. Where there was a percentage suggested again the answers are very broad ranging. The lowest respondent stated 15% with others suggest 100%. Explanations included ‘if you ask Ken Robinson 3% by the time they leave secondary school’. Another participant highlighted their belief in the transformative nature of their course ‘at the beginning of the course 25%, at the end of the first year 60%, and at the end of the year 90%’. One participant linked levels of creativity with grade profiles stating ‘As in most likely to achieve ‘A’ grade in their chosen subjects – at least 40%’. Finally, one participant stated ‘All, but not all of the time’.

What are the staff’s beliefs regarding the essential features of creativity?

Q4 asked staff to identify what they believe to be the essential features of creativity. The majority of responses were provided as a defined statement. Thematic analysis was used although this was challenging as the responses were broad ranging and could not be defined easily. The chart below shows the percentages of responses within each theme. The most common theme was open mindedness (13%) and thinking (13%). Thinking in this context was varied from reflection to lateral thinking and thinking ‘outside the box’. Other significant themes were expression (10%), freedom to play (8%) and use of imagination (85%). Outside of these themes a very broad range of answers were

provided. These can be seen in the chart identified in the 'other' segment (48%). These responses were primarily given by singular participants and include responses such as originality, intuition, invention and knowledge.

Figure 6



What strategies and activities do staff use to promote creativity?

This section will review the responses by staff participants to the question 'what strategies and activities do you use to promote creativity?' Thematic analysis was used to review the responses and can be seen in the following tables.

The following table shows the themes generated from the staff responses. Predominately the focus was on developing independence and confidences with many staff highlighting the importance of 'freedom' and the development of the working environment to allow students to work without fear of mistake allowing them to take risks. Experiential learning was regularly referenced with suggestions that students should be given time to develop ideas and explore with materials. Skill development was referenced, although the responses were often with respect of the development of attitudes rather than focussed on the skill. For example one participant stated 'lots of opportunities to push the boundaries of the tools and techniques taught'. This statement is about skill development but the emphasis strongly suggests the strategy is about developing attitudes towards tools and techniques rather than the discipline of using them.

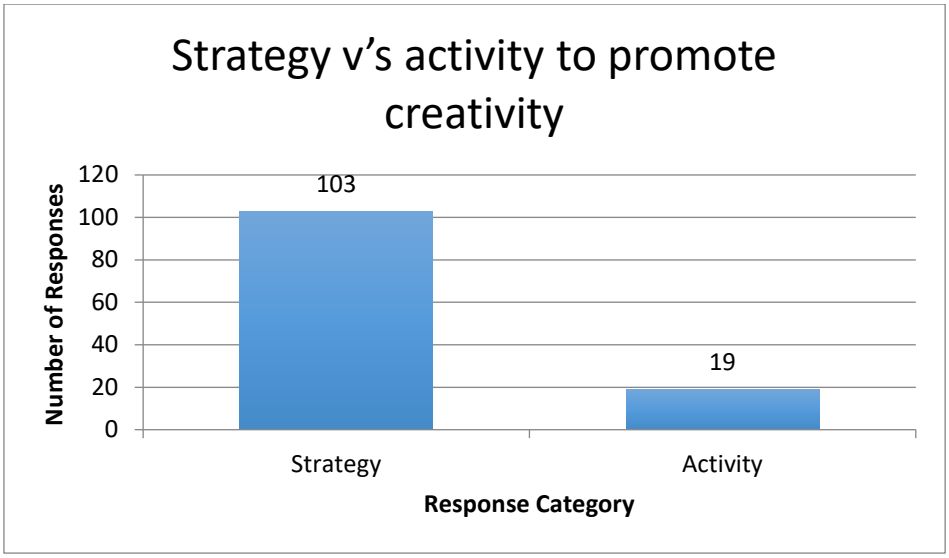
Table 7 – Activities and strategies to promote creativity

Confidence and Resilience Building	Skill Development	Development of Cognitive Skill
Promote 'mistakes' as a positive progression	Lots of opportunities to push the boundaries of tools and techniques taught	Group and individual thinking through discussions
Confidence boosting - give them the tools to achieve the best of their abilities, let them fall over and pick themselves up	Experimentation with materials	Nurture all students to think for themselves
By creating a safe environment where play and risk taking (materials, thoughts, research, process, and outcomes) are encouraged and celebrated.	Drawing to music and other drawing techniques like blind etc.	Give students the building blocks to allow for higher levels of thinking, not just criteria lead teaching
Reassure students that mistakes are part of the creative process and build resilience.	All sitting on the floor to draw	Provide learners opportunities to 'reflect'
		Open opportunities to question, debate, discuss and expand ideas
Experiential learning	Develop independence	
Learning through experimentation, play and exploration	Where ambition and motivation are aspirations.	
Role Play	An ethos of freedom to experiment and take risks	
	Independent working/learning time	

Whilst development of theory was never mentioned, many staff participants referenced opportunities to reflect and independent thinking skills were a significant component of many responses. Strategies or activities to develop intelligence or knowledge sharing was not clearly defined, however was inherent in a lot of responses that referred to group critiques and discussions of work and or creative practitioners. The graphic below highlights the most popular words used in the staff responses. There is clear focus on experimentation, discussion, exploration, independence, development and the learning environment.

Within this question consideration should be given to the response rates that identify strategies and those that identify an activity. A strategy can be defined as a plan of action that aims to achieve long-term goals. Activity can be defined as a thing that a person or group does. The question clearly asked for ‘strategies and activities.’ The following chart shows the response rates for both strategies and activities. The staff participants were particularly focussed on strategies when considering how they promote creativity. In other words focussed on the development of long-term goals related to creativity. From 122 identified approaches to promote creativity 103 were strategies with longer term goals and 19 were activities.

Figure 7



In Conclusion - What are Staff's Perceptions of Creativity in a Specialist Arts College?

Teachers' beliefs regarding creativity are very positive. Only 2 staff respondents failed to agree with the statement that 'creativity can be taught' this suggests that they do not believe that creativity is purely a naturally occurring event. This contradicts Kant (1790/2016) who stated that creativity is a natural phenomenon that comes from the human unconscious, suggesting therefore it cannot be nurtured or taught. It does however support Robinson (2011) who asserted that creativity is the greatest gift of human intelligence but it can be encouraged and fostered but requires many different ways of thinking, intuition and gut feeling.

The staff beliefs that 'Creativity is essential for enhancing student learning in schools in academic subjects' also suggests they would support approaches such as those that encourage learners to learn through creative opportunities such as the learner experience at Reggio Emilia. This included observation, consideration and representation skills being developed and repeated. Their education was flexible and non-linear where learners were not moved quickly and sequentially through a series of tasks (Edwards et al., 1998). It also suggests they would support the government White Paper findings, as highlighted in the literature review, that creative potential is relevant to all aspects of human activity, stating that learners who find their creative abilities can see dramatic improvement in their confidences and this impacts on their achievement in all aspects of their academic and social lives. It also defines creativity as not merely as a subject within education curriculums but a function that is relevant to all aspects of the curriculum. The staff

responses also show that there is belief that school staff should have knowledge of creativity and that a regular classroom teacher has responsibility for helping students develop creativity. Although, it is noticeable that whilst generally they strongly agree that creativity should be taught they are less assertive regarding whose responsibility this is with a larger percentage of responses agreeing rather than strongly agreeing that this should happen in the regular school classroom by regular teaching staff.

Staff's views on the essential features of creativity identify the complex nature of creativity as highlighted in the literature review. Robinson (2011) said creativity is a complex process with many aspects. This is very evident in the staff's response with 48% of responses identifying unique aspects not highlighted by their colleagues. It could be said that this suggests a general lack of agreement on the essential features of creativity. It could, however, relate to the organic and divergent nature of creativity. Robinson (2011) also states that creativity exists in a complex and ever changing world where we need to be evermore creative to meet its needs. The staff's perceptions of the essential features of creativity are complex as is the modern world that it exists.

Staff's perceptions of 'The percentage of highly creative students' are also inconsistent. The broad range of percentages offered as a response to the question highlight this with staff disagreeing regarding the amount of their students are highly creative, i.e. between 15% and 100%. This disparity suggests staff cannot agree on what we define as highly creative. This links to the theories highlighted by Rich (2009) that explore Big 'C' and little 'c' creativity. It was suggested that Big 'C' creativity can be defined as limited to the eminent creative people and little 'c' creativity recognised as creative by a minimal spread of society. From these theories and the participants' feedback it is clear that defining what is creative is challenging and often relative to the context.

The list of activities and strategies that staff use to promote creativity were clear evidence of their wish to develop the long-term creativity of their learners. A large percentage of their responses were strategies rather than activities, which have been defined as more about doing in the moment, rather than the long-term goal development of strategies. This is also linked to little 'c' and big 'C' theories of creativity. Activities will support achievement of little 'c' creativity, however strategies will help support student towards achieving big 'C' creativity. Significantly, the staff's strategies were mostly related to character development as defined by Cropley (2001) and Vygotsky (1930). For example, there was an emphasis on risk taking and exploration. Independence was also significant

with many staff identifying their strategies to allow learners to spend time exploring and developing their practical work. Cognitive skill development was evident although this was related more clearly to reflection and contemplation rather than computational cognitive development.

The staff participants' definitions of creativity can be established from their most frequent responses to the question 'when you hear or see the word creativity what comes to mind'. In conclusion from these findings we can define their understanding of creativity to be a divergent thinking process that requires problem solving through a design process, resulting in an aesthetic or linguistic product, that is original, inventive or innovative and that has been produced with imagination, self-expression, intelligence and enjoyment.

The most significant attribute of creativity mentioned by staff participants was divergent thinking. When we consider Guildford's (1967) labelling of divergent thinking relating it to fluent and flexible thinking we can assume teachers definitions of creativity are related to the importance of fluency when solving problems and the ability to work with flexibility with a variety of approaches.

Another significant attribute of creativity highlighted by staff was the importance of the creative process. 44% defined creativity linked to problem solving and use of the design process compared to 28% who suggested it was creating an aesthetic product. Whilst the definition relating to creativity being an aesthetic product was third on the list of common definitions 28% it is significantly lower than the 44% who focused on the process or problem solving. Using Cropley's (2001) terminology when defining creative theory staff favoured cause rather than effect. However, consideration should be given to the level of students the staff teach and therefore the result may be related to the fact that their learners are at the early stages of their art and design education where creative process and creative thinking may be given greater importance than end results. However, it does support Torrance (1962, p.663) who defined creativity as "a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficult; searching for solutions, making guesses or formulating hypotheses about the deficiencies; testing and re-testing these hypotheses and possibly modifying and re-testing them; and finally communicating the results."
The reference to intelligence in the staff's participants is limited.

Table 8 – Personality traits of creative learners

Creativity involves:
Open Minded
Independent
Enthusiastic
Experimental
Deep / Lateral Thinkers
Curious
Imaginative / Innovative
Confident
Motivated
Reflective
Unique
Analytical

The adjacent table has highlighted the ranking of staff's responses at it is noticeable that the majority of themes relate to personality traits (orange) rather than cognitive thinking (blue). This would suggest that the staff participants consider personality to be far more influential than cognitive processing and raises questions of theorists such as Kaufman (2013) who suggested creativity and cognitive skills are linked and that a disservice to both abilities was being made by suggesting they were separate. However, reference to cognitive skills was limited to lateral thinking, imagination, reflection and analysis and these were ranked low in the table. One exception to this rule should be considered. This is the phrase 'open minded' which could be considered limited to those of a certain personality trait, or are staff referring to a cognitive thinking process limited to only those with intelligence?

In conclusion, teachers' beliefs regarding creativity are very positive and they consider creativity as essential for enhancing student learning in schools in academic subjects. They also recognise that creativity is complex and their responses to the question regarding the percentage of students who are highly creative were very inconsistent. Whilst they were generally in agreement with what creativity is, defining it as a divergent

thinking process, that requires problem solving through a design process, they did have differing views on what can and what cannot be defined as ‘highly’ creative. It is clear that staff are using a very broad range of strategies to develop long term goals in the development of creative ability, but inconsistencies in what is defined as highly creative suggests that Kant’s (1790/2016) view, that creativity is a natural phenomenon linked to genius and limited to the eminent few, is not consistently shared.

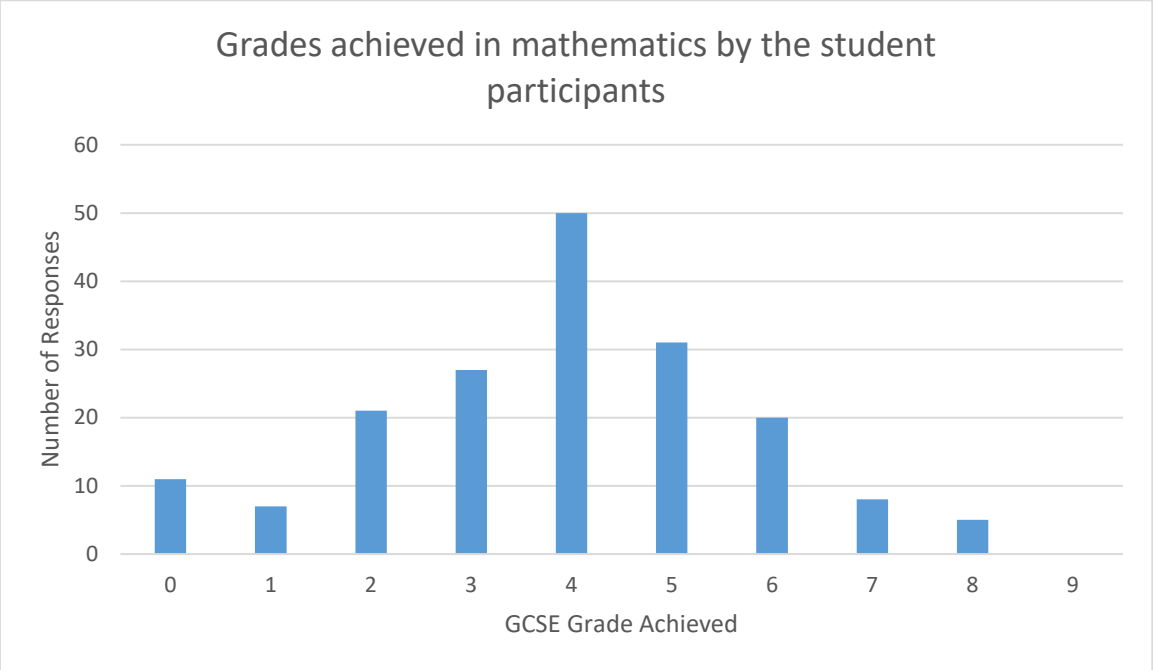
Chapter 5: Findings - Is there an association between the creativity of arts students and performance in mathematics in a specialist arts college?

This chapter will identify the results from the research gathered for research question 2. As stated in the methodology the results will be presented from two approaches. In approach 1 the results will be comparative quantitative data from prior GCSE mathematics performance and creative ability as identified by results of the Guilford test. In approach 2 students' personal characteristics as defined in the student questionnaire will be compared with their mathematical performance to identify potential associations.

Creative ability and Mathematic Performance

GCSE mathematics grades achieved by the student participants

Figure 8



The chart above identifies the GCSE mathematics results from the student participants as a percentage of all participants. The grades were recorded from 9-1 the highest grade being 9 and the lowest grade 1. In the event of a student identifying their grade as a letter from A*-C this was converted into the equivalent number for easier comparisons. For example a grade 4 was considered the equivalent of a grade C. Those students who did not identify a grade and those who have not achieved a grade previously are identified in the 'none' column. From 180 participants 169 had achieved a GCSE grade with 11 recording a grade of none. The greatest percentage of grades achieved was 5, 4 and 3 with the greatest proportion at grade 4 (28%). No students surveyed had achieved a grade 9 and only 7.3% had achieved higher than a grade 6, (the equivalent of a grade A or above in the lettering A*-G system.) 11 students were reported as not achieving a GCSE grade, either because they are yet to achieve, had not previously studied GCSE or did not provide their grade. 66 students who took part in the survey had not achieved a pass grade (4 or above) and therefore had not reached the government benchmark for mathematics GCSE, as a result these students are required to continue to study mathematics whilst in full time education. 114 students had achieved grade 4 or above. However, in addition to the 66 who had not achieved a grade 4 a further 50 had not achieved a grade 5 described by the DFE in its new 9-1 grading system as a 'good pass.' This amounts to 116 learners or 65% of the total participants.

Table 9 – Mathematics GCSE grade count of participants

GCSE Equivalent Grade	Count
9	0
8	5
7	8
6	20
5	31
4	50
3	27
2	21
1	7
None	11

Student Creativity scores as identified by Guilford Test

The Guilford test results identified students' responses to alternative uses for a shoe including their ability to be flexible, fluent, original and elaborate. The results in the following table identify the mean scores achieved. As the test is unique with regards to the choice of object, the time allowed completing the test and the criteria used to assess the results no comparisons can be made to the level of creativity of the students against other external student groups or cohorts. However they can be used to make comparative levels of creativity against students within the College who completed the test. The table identifies the minimum and maximum scores achieved by individual students and the mean score achieved. Individuals scores can be compared with this data, for example, a student scoring 12 in flexibility is above the average of 9.54 but well below the highest achiever who scored 22.

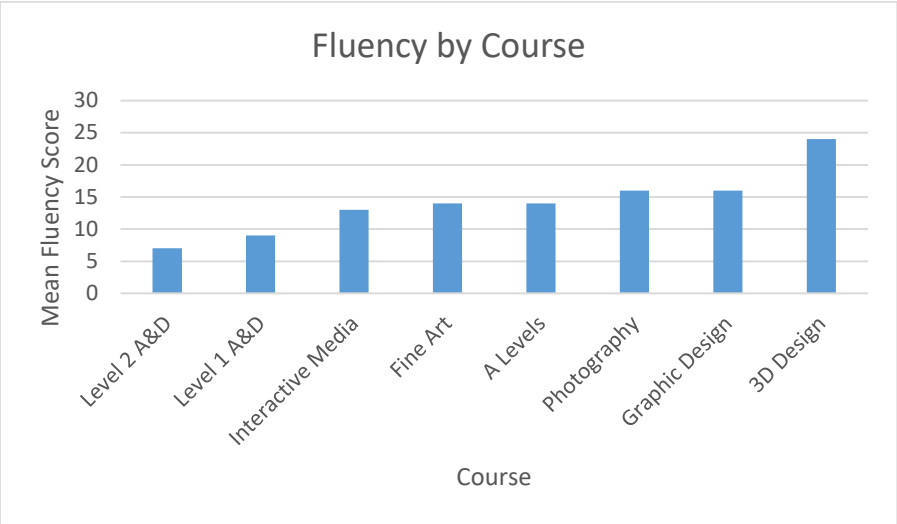
Table 10 – Student creativity scores as identified by the Guilford Test

Field	Minimum	Maximum	Mean	Standard Deviation	Variance	Count
Flexibility	1	22	9.54	4.69	21.98	180
Fluency	1	40	13.15	7.24	52.46	180
Originality	0	1.5	0.56	0.28	0.08	149
Elaboration	0	20	2.87	2.8	7.82	119

Fluency by Course

The fluency score by students was calculated by identifying the amount of answers they gave as alternative uses for a shoe in 10 minutes with one point given for every answer. The following chart looks at the mean fluency score of learners by course and also level. Level 1 and 2 Art and Design courses achieved a fluency mean score of below 10 and level 3 (all other courses stated) achieved a mean score ranging from 13 for Interactive Media to 24 for 3D Design. This suggests that the higher the academic level of the course the greater the creative fluency of the students but also suggests a large disparity between the creative fluency on differing specialist level 3 courses. This was with a standard deviation score of 7.24.

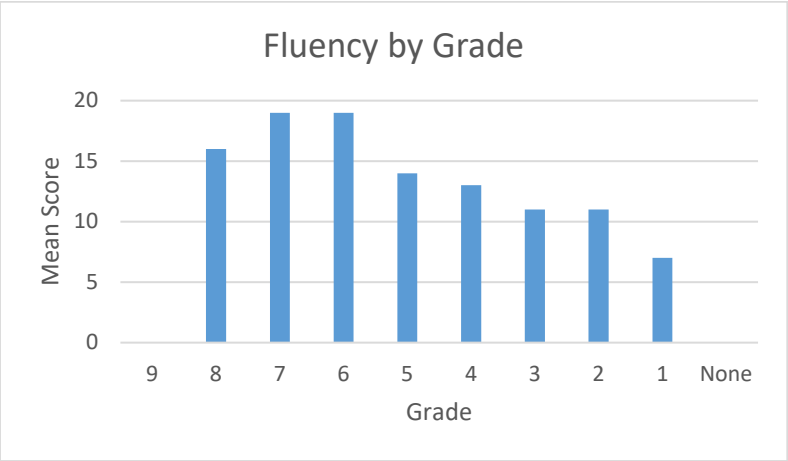
Figure 9



Fluency by Grade

The bar chart below identifies the average fluency score achieved by students categorised by their mathematics GCSE grade. Creative fluency is greater in students with a higher GCSE mathematics grade. The mean scores increases gradually from 8 for those learners who achieved grade 1 to a mean of 18 for those who achieved grade 7. The anomaly in this trend is those students who achieved grade 8 where there is a marginal drop in mean fluency score (down to 16). This could be attributed to the very low sample size of those achieving grade 8 in the survey, which was just 5 students. The mean fluency score for all participants of 13.15 is comparative with students who achieved a grade 4. For those that achieved a grade 5 the mean score is closer to 14 and those that achieved a grade 3 it is 11.

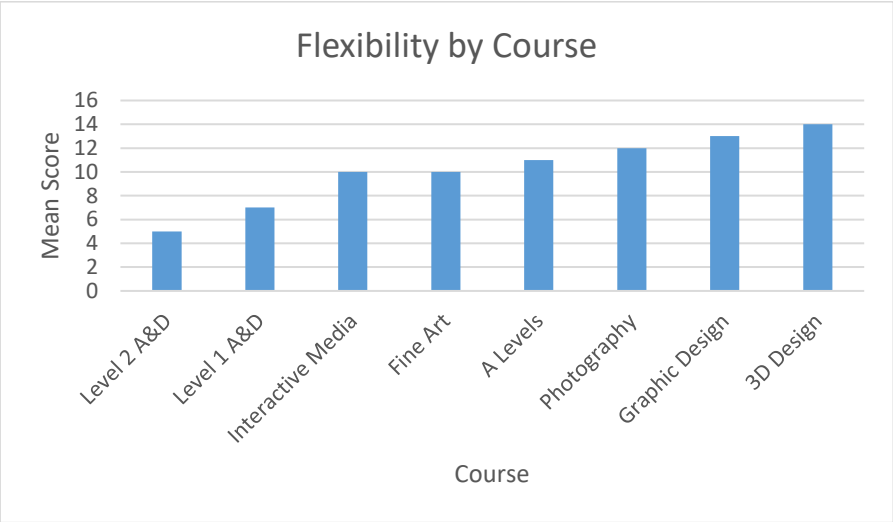
Figure 10 – Fluency by grade



Flexibility by Course

Flexibility was determined by identifying how many different categories were recognised in the respondent's answers to the alternative shoe question. For example, 'use as a cup' and 'use as bowl' would receive only 1 flexibility point as both answers come from the category container for food and drink. Again, similarly to the fluency scores the mean flexibility scores by course and level also follow a similar trend. The mean flexibility of all participants is 9.54. Level 1 and 2 students scored a mean flexibility grade of 5 and 7. The level 3 courses (all other courses identified) scored a mean score of between 10 (for Fine Art) and 14 (for 3D Design.) The mean scores between level 3 courses are closer than when compared to the fluency scores, however, the standard deviation is also less at 4.69 compared to 7.24.

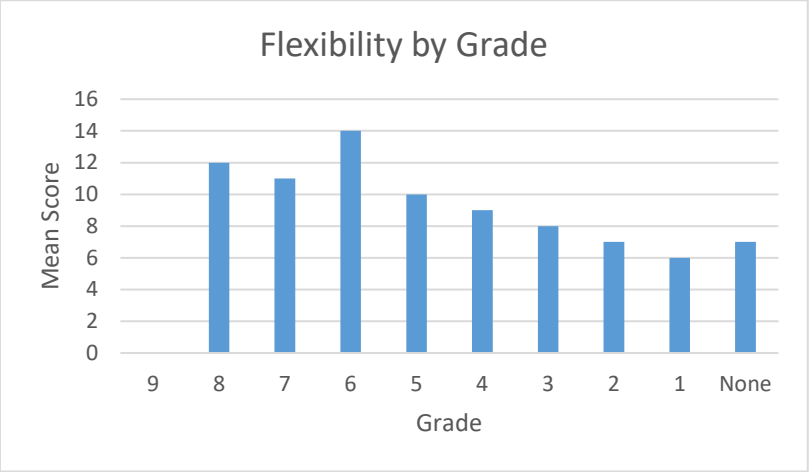
Figure 11 – Flexibility by course



Flexibility by Grade

The flexibility scores of learners followed a similar pattern to fluency when compared to grades achieved. The mean scores for grade 8, 7 and 6 are all above 10 with grade 6 the highest at a mean score of 14. The mean score drops gradually to below 6 for learners who achieved a grade 1. Again, slight anomalies in the trend can be justified by the low sample size in participants who achieved grade 7 and 8 and the lack of reliability in the data for those who responded with grade 'none' or did not provide a response. The mean flexibility score of 9.54 for all participants corresponds to the mean of flexibility of students who achieved between grade 4 and 5.

Figure 12 – Flexibility by grade



Originality by Grade

Figure 13 – Originality by grade

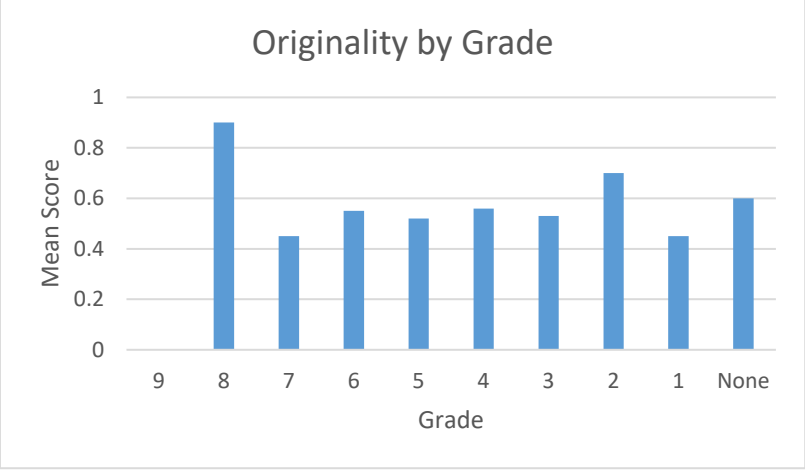
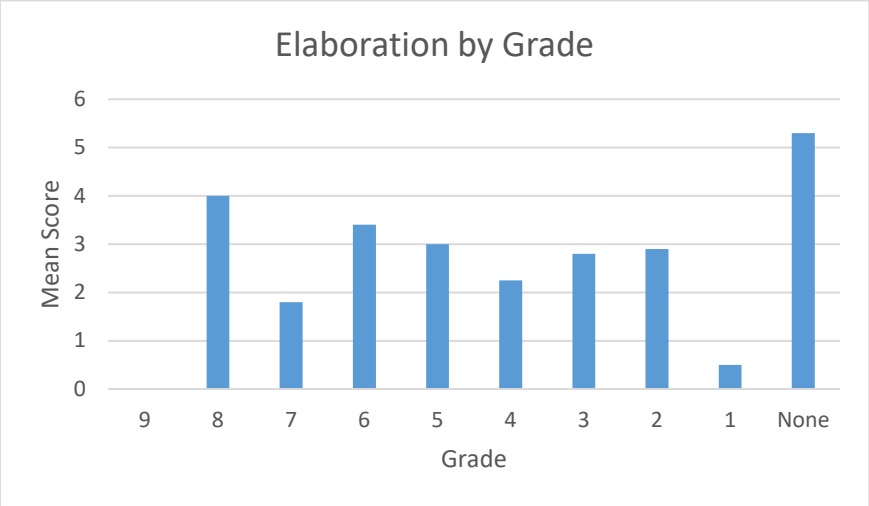


Figure 13 shows the originality scores of students by mathematics GCSE grade achieved. Originality is calculated by awarding points to participants for answers that only a small or very small percentage of participants suggested. To calculate a final originality score this total is divided by their previously calculated fluency score. The chart suggests that there is no significant difference in originality between high achieving mathematics GCSE students and those who have achieved low grades. There was an increase at grade 8 although, again, it should be considered that only 2.8% of participants (5 students) achieved a grade 8 and therefore the sample size was very small. Additionally, students who achieved grade 2 performed very well in originality. As previously identified the grade 2 fluency data was the 2nd lowest group recorded, so this originality score suggests that the grade 2 students identified a limited number, but a more original set, of answers.

Elaboration by Grade

There was no consistent increase in elaboration scores as participants grades increased. The elaboration score was calculated by the level of detail that was provided by a respondent. For example, 'to make ink prints', would receive no elaboration points, but 'to make a picture of the Mona Lisa using ink prints' would receive an elaboration point. Although grade 1 learners elaboration scores were low (below 0.5) the overall range between grade 2 and 8 was only from a mean score of 2 to 4. It should be considered however that an elaboration score does not identify a clear picture of a students' creative process alone. This is because their fluency score (i.e. the amount of answers provided) will have had an impact on the levels of elaboration (i.e. the amount of detail in an answer) in a time constrained process. Never the less, the data does not show a significant relationship between mathematic performance and elaboration.

Figure 14 – Elaboration by grade



Does mathematics performance and creative ability in arts students identify an association?

In this study we have already considered key concerns relating to performance and application of mathematics in particular that students of all ages are not encouraged to solve problems (National Council of Teachers of Mathematics, 1980). The literature review identified that this has resulted in learners who are not made to think hard enough or independently. So, is this data only evidence of a relationship between intelligence of learners and their creative and mathematical performance? Or, is there a cause and effect relationship between the development of creative fluency and flexibility and a learner's performance in mathematical performance. In other words, could it be said that development of skills related to creative flexibility and fluency support the development of mathematic performance by encouraging learners to think harder and more independently?

Throughout this section the research has identified that there does appear to be a association between the creative attributes of flexibility and fluency and performance in GCSE mathematics. There did not appear to be an association between elaboration and originality and mathematical performance.

The data for fluency compared against grade supports this statement with a clear trend in the data showing increased levels of fluency including lower levels of fluency for low-level performers in mathematics and high fluency scores for high-level performers in mathematics. When fluency by course is considered there is a disparity for learners working at level 3 with students on 3D Design far over achieving other courses, for example fine art where fluency is much lower. In one respect this could be considered unexpected as fluency of ideas generation on a conceptual course like fine art might be thought to be higher than the more technically minded 3D students who are future potential architects and design engineers. Or does it represent the greater fluency in technically minded 3D students? Contrary to this argument, however, is the results of the computer based Interactive Media students who achieved the lowest fluency score of all level 3 courses in the study.

Flexibility followed a similar pattern highlighting the same relationship between high mathematics performance and high flexibility scores. Again the level of flexibility corresponded with the level of academic study undertaken with level 1 and 2 learners

achieving lower flexibility scores than those on level 3. Similar to the fluency scores further review of the level 3 flexibility scores shows that the most flexible learners are the 3D learners and the least Fine Art and Interactive Media.

These results may be unsurprising if we consider Kaufman (2013) who argued that closed ended problems solved in tasks associated with high intelligence required the same thought processes as creative tasks associated with the creation and development of ideas with no pre-conceived answer. With regards to the Guilford test carried out by the learners the results support this statement, that is, performance in mathematics improved for more creatively flexible and fluent learners. According to Guildford the test highlights the creative learner's divergent thinking skills where they can think fluently and flexibly towards an undefined solution, in this case alternative usages of a shoe. But this also supports researcher's theory's such as Kaufman (2013) that the thought processes in divergent thinking have a close relationship with those associated with convergent thinking.

Personal Characteristics and Mathematic Performance

This section will look at how students' own evaluation of their personal characteristics link to their prior mathematics performance.

'I like problem solving'

Students were asked to identify how much they agreed with the statement 'I like problem solving.' The results can be seen in the following chart and identifies that the majority of learners agree a little (52%) or agree strongly (13%) with a total of 65% stating that they 'like problem solving'. Only 16% disagreed with this statement including 8.3% who strongly disagreed. The 65% of learners who identified they 'like problem solving' relates to the overall mathematics grade data which highlighted that 64% of participants had achieved a pass grade or equivalent in their GCSE.

Figure 15

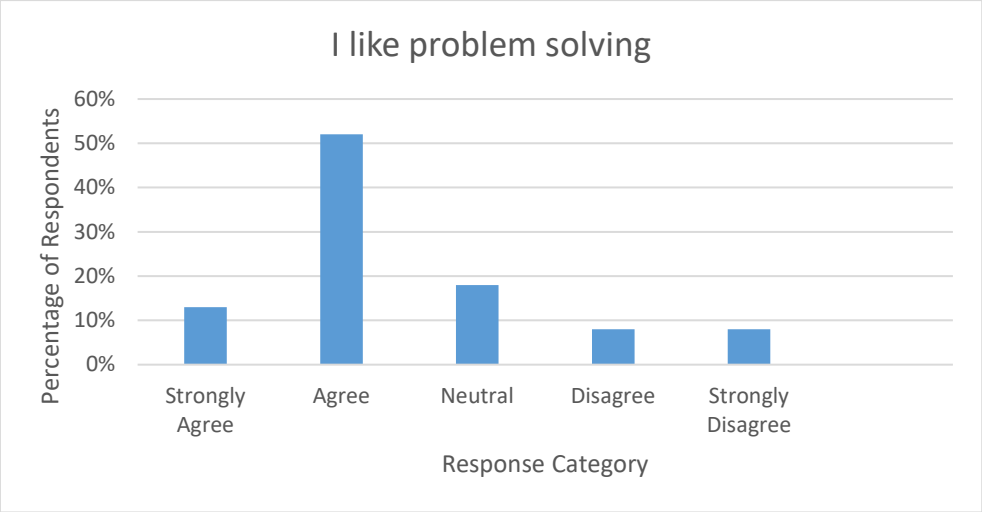


Figure 15a

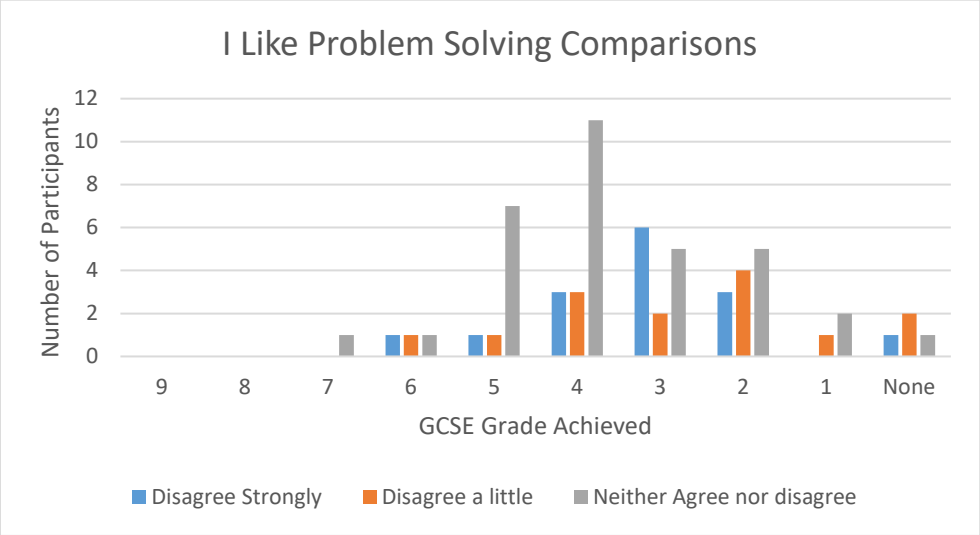
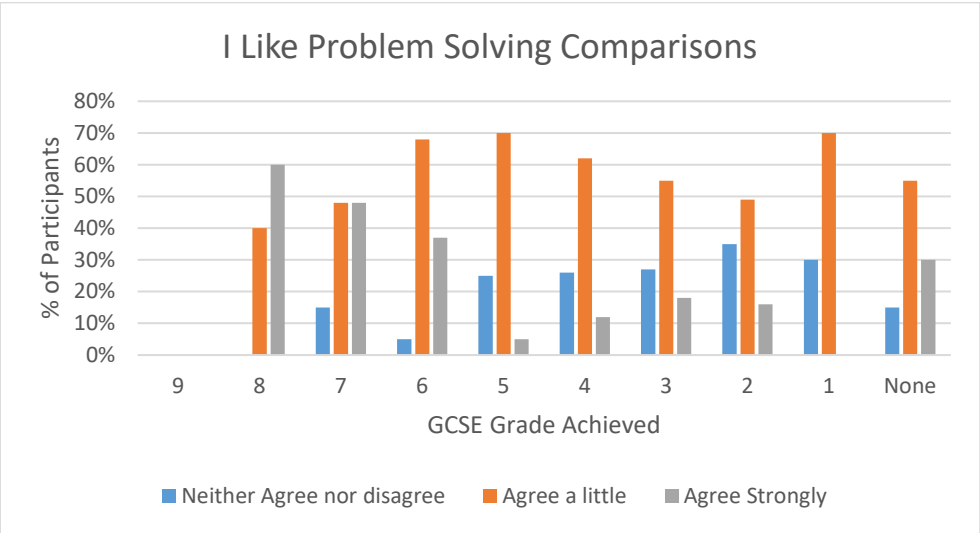


Figure 15b



Further analysis of the data regarding the statement 'I like problem solving' can be seen in figure 15a and 15b. This highlights that those learners who stated they did not 'like problem solving' were predominantly achieving at a grade below level 5 and as the grade got higher so did their 'liking' of problem solving. With regards to the participants who agreed strongly to liking problem solving the grey bars in figure 15b indicates that this was limited to predominately those students who achieved grade 6, 7 and 8.

Passing GCSE mathematics is important to my future career

Figure 16 identifies the participants' views on the importance of mathematics to their future careers. The results show that students recognise how important GCSE mathematics is to their future careers with 44% strongly agreeing and 32% agreeing a little. Therefore the majority of students (76%) agree it is important. 17% of students were undecided and 7% of students disagree a little or strongly. This is a total of 24% of students who do not consider mathematics to be important to their future careers. This corresponds to 43 learners in total

Figure 16

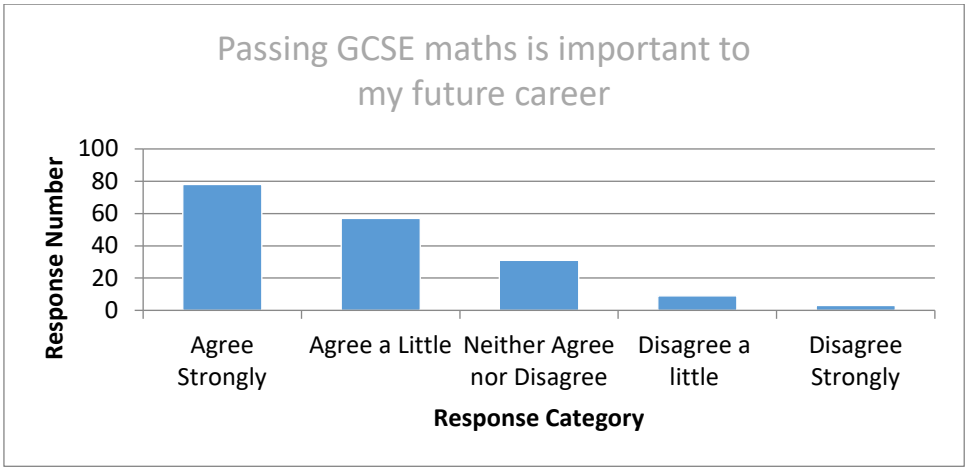


Figure 17a shows how students responded by grade. It shows that students who achieved grades 1,2,3,4 and 5 in general did not strongly agree. Those that achieved grade 6, 7 and 8 generally strongly agreed or agreed a little with 60% of those who achieved a grade 8 strongly agreeing. Of those participants that disagreed strongly or a little the majority achieved a grade 2 or 3 with over 20% of grade 3 participants strongly disagreeing.

17b identifies participant's responses by course to the importance of mathematics to their future careers. The chart shows similarities in responses on the whole with some minor

differences. Level 2 learners have the most learners who disagree strongly or disagree a little. From the level 3 courses 3D Design stands out highlighting their majority response of 'strongly agree.' Fine Art and Interactive Media participants were the leading level 3 courses to strongly disagree although the difference was not significant.

Figure 17a

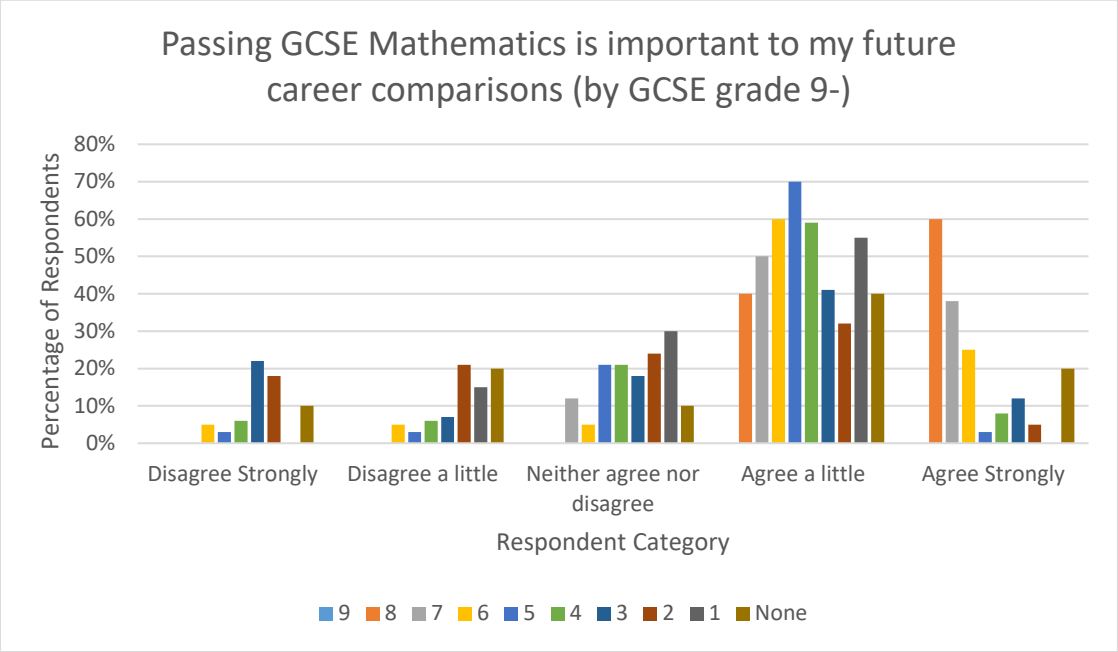
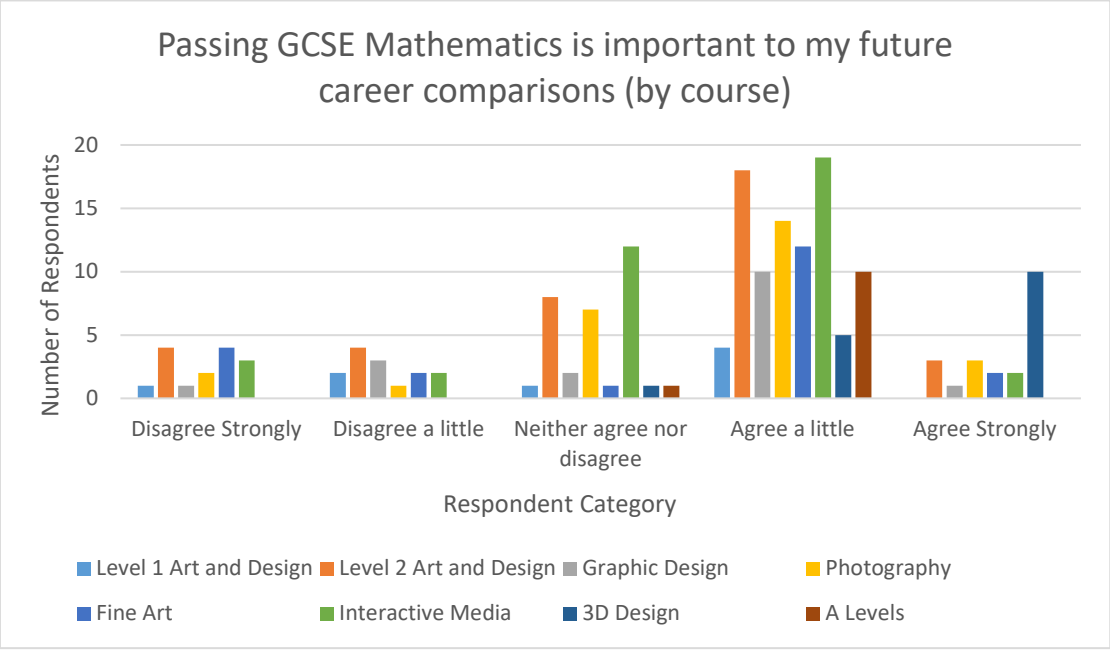


Figure 17b



'I don't give up easily in mathematics' all participants' responses

I don't give up easily in mathematics identifies students' resilience to achieve. The

following chart identifies that the majority of learners believe that they do not give up easily with 52% agreeing a little and 13% strongly agreeing. This is a total of 65% of all participants. This corresponds with the 65% of learners who identified they 'like problem solving' and the 64% of participants who achieved a pass grade or equivalent in their GCSE mathematics.

Figure 18

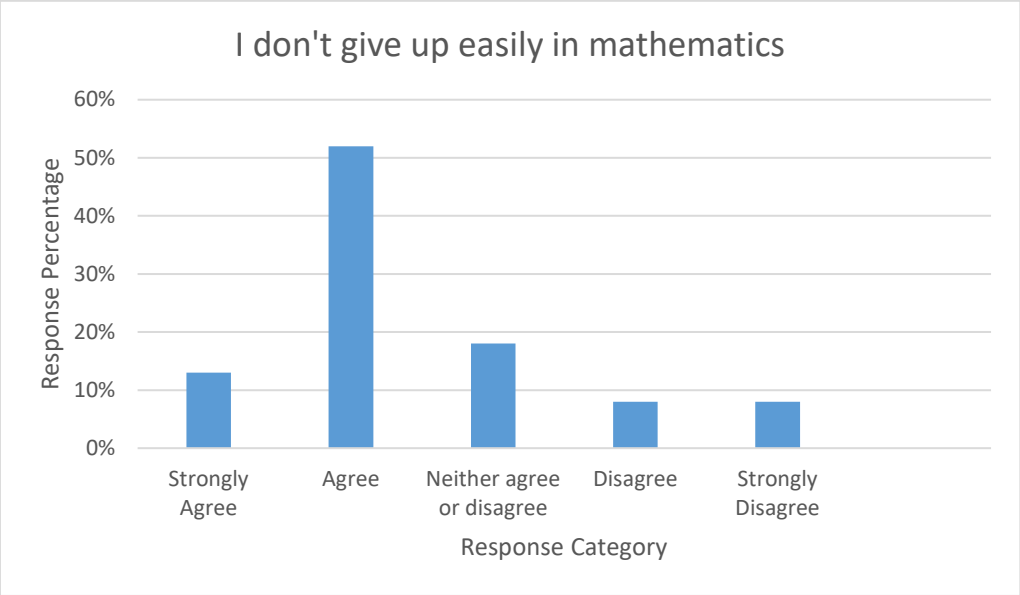
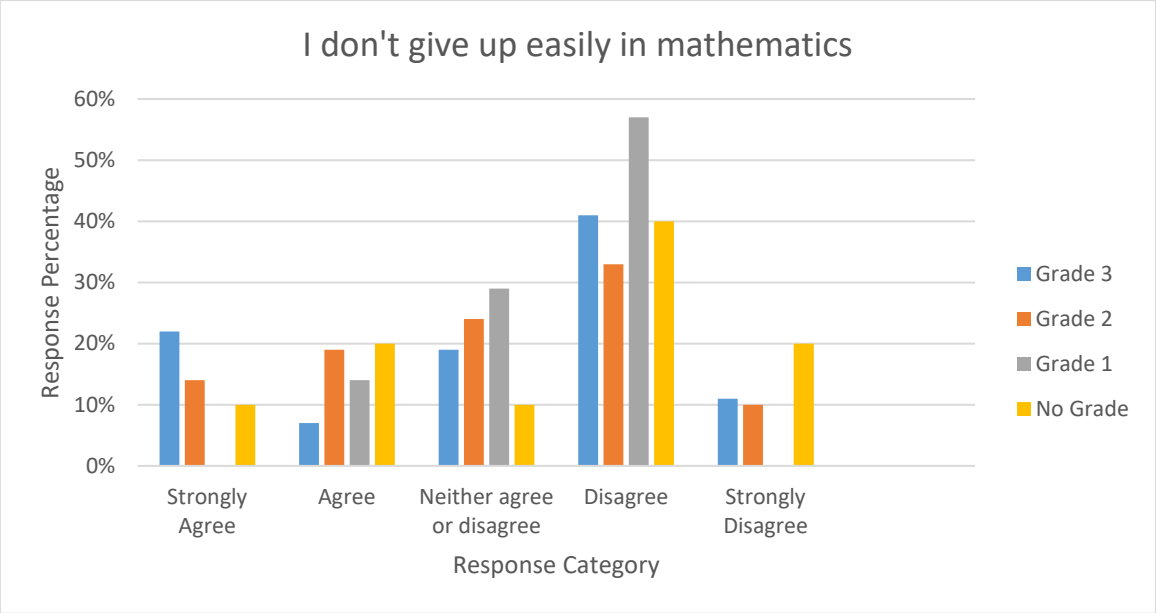


Figure 19 identifies the results for participants' responses to 'giving up easily in mathematics' by grades 3, 2, 1 and none. For students who achieved grade 3, 1 grade below a pass, the percentage of students agreeing a little or strongly agreeing decreased to 52% when compared to all participants of 65%. For grade 2 this decreased further to 42% and for grade 1 was 57%. Although these numbers are not a significant drop it does show that learners who achieved a grade lower than a pass grade of 4 believe they are more likely to give up and are less resilient in their study of mathematics.

Figure 19



Participants' resilience and performance in mathematics

The following table shows the percentage of participants who disagreed strongly with statements that question their resilience. The table shows that there is not a significant difference between the results of learners who achieved below a grade 4 and the results of all participants. In fact there is a variance of less than 3% in all statements. Equally those that agreed strongly to the statements were again similar in variance between the results of all participants and those who achieved below grade 4 in GCSE mathematics. One exception was the statement 'I prefer class work that is challenging so I can learn new things' where there was a 6% variance in those that strongly agreed identifying that more participants who failed to achieve a grade 4 wanted to be stretched and challenged than those who achieved a pass grade or higher. Another exception was the statement 'I try to understand things even when they don't make sense' where there was a more than 6% variance between below grade 4 and grade 4 and higher. Those learners who achieved a grade 4 or higher were more likely to 'try to understand what the teacher is saying even if it doesn't make sense. Although the variance is not very significant they do perceive themselves to be more resilient in this statement.

Table 11 – Resilience and performance in mathematics (disagree strongly)

Question	Disagree strongly	
	< grade 4	All
I don't give up easily in maths	13.33%	15.65%
I prefer class work that is challenging so I can learn new things	2.78%	4.35%
I often choose topics I will learn something new from even if they require more work	1.68%	0.88%
I have an uneasy upset feeling when I take a test	7.78%	6.09%
My study skills are usually excellent when compared with others	11.11%	13.04%
When work is hard I either give up or only study the easy parts	19.44%	18.26%
I try to understand what the teacher is saying even if it doesn't make sense	1.69%	0.87%
I work on extra questions even when I don't have to	12.92%	11.50%
I work hard to get a good grade even if I don't like the class	1.67%	1.74%

Table 12 – Resilience and performance in mathematics (agree strongly)

Question	Agree strongly	
	< grade 4	All
I don't give up easily in maths	16.11%	14.78%
I prefer class work that is challenging so I can learn new things	16.11%	10.43%
I often choose topics I will learn something new from even if they require more work	19.55%	18.42%
I have an uneasy upset feeling when I take a test	29.44%	32.17%
My study skills are usually excellent when compared with others	2.78%	1.74%
When work is hard I either give up or only study the easy parts	7.78%	10.43%
I try to understand what the teacher is saying even if it doesn't make sense	26.97%	33.04%
I work on extra questions even when I don't have to	7.30%	5.31%
I work hard to get a good grade even if I don't like the class	40.56%	39.13%

Results from the table above includes 'I work hard to get good grades even if I do not like the class' which was agreed with strongly by 39% of participants. 32% strongly agreed or that they have an uneasy upset feeling when they take a test.

Do personality traits have an impact on mathematical performance?

Much of the literature review highlighted the importance of the ability to solve problems in both the learning of creative and mathematical concepts. In particular, it suggested that the ability to solve problems and investigate requires learners to be fluent in their thinking and flexible in their approach to problem solving and investigation (Guilford, 1967). However, personal characteristics, cognitive ability, life experiences and social context were also seen as important factors in the creative process (Cropley, 2011).

Defining students' views on 'problem solving' helps identify relationships between 'creative' problem solving and 'mathematical' problem solving and if there is an association between 'liking' problem solving and creative and mathematical performance. The literature review highlighted that the ability to solve problems was key to effective mathematics performance. Haylock (1985) stated that educators need to give students the opportunity to develop their creative exploration whilst expanding their knowledge and

this will encourage the development of mathematical creativity. Furthermore, it is suggested that not doing so results in the development of learners who do not diverge from a systematic approach to problem solving and only develop their abilities within their own knowledge limitations.

Overall the study highlighted that students like problem solving with 65% of student participants agreeing. However, of those that strongly disagreed to liking problem solving they were predominately below the pass grade in mathematics of grade 4 and this figure peaked at grade 3. Also, those students that strongly agreed to liking problem solving were predominately grade 6 or above peaking at grade 8 (the highest grade achieved by this group of learners). This is clear evidence within this group of learners that if they like problem solving they are more likely to achieve. Or, which may be the situation, that if they are achieving they are more likely to enjoy their experience.

The majority of learners agreed that mathematics was important to their future careers with 76% agreeing and although a small percentage of learners disagreed the data shows that those who did not think that it is important are predominantly in the grouping of learners who did not achieve a pass grade of 4 and those that agreed strongly were the high achievers.

Students who stated they did not give up in mathematics easily, in other words are not resilient, are far less represented in students who achieve below a grade 4. The percentage of the whole group of student participants is 66%, this decreases for those at grade 3 with 51% and grade 2 with 41%. Although, the grade 1 students responses were 57% (still lower than the overall cohort.) This is significant evidence that whilst in general students see themselves as resilient the lower performers perceive themselves as far less resilient.

This supports the findings of the White Paper ‘All Our Futures: Creativity, Culture and Education’ a report to the Secretary of State for Education and Employment and the Secretary of State for Culture, Media and Sport (1999) referenced in the literature review, which suggested that the answer is in the development of creative potential, that learners who find their creative abilities can see dramatic improvement in their confidences and this impacts on their achievement in all aspects of their academic and social lives. The report calls for creative development, as a key component to education and those educators need to be trained and supported to create a pedagogical approach that provides opportunity for innovation and risk taking.

In conclusion regarding personality traits and performance in mathematics there is a clear relationship in arts students in this cohort. Students are less likely to perform in mathematics if they report that they do not like problem solving, do not see it as important to their future careers or if they state that they are inclined to give up easily.

The results of the focus group

The focus group was designed to provide evidence for research question 2 including qualitative data from a range of pre-determined questions. These are defined in the methodology. For Question 1 'is there an association between creativity and mathematics performance?' staff responses to this question were not conclusive. Some staff responses stated that they believed creative students can do mathematics, and another response highlighted that they had observed their most creative students and often they are the best mathematicians'. However, another view that was supported by several of the group was that creatively minded students sometimes struggle with mathematics work, although others dismissed this stating it is non-creative students that struggle with mathematics. Staff did not have any significant evidence to prove this ether way and could not totally agree with Haylock (1985) who believes that educators need to give students the opportunity to develop their creative exploration whilst expanding their knowledge to encourage the development of mathematical creativity. Responses to question 2 'what do you understand about convergent and divergent learning?' re-iterated this with all staff generally agreeing that they recognised their learners as divergent thinkers and that learners who were studying mathematics used convergent thinking skills. When asked if these skills can be overlapped responses suggested that some learners are good at both divergent and convergent thinking although it was suggested that sometimes learners arrive at the same answers in mathematics but arrive at it in a different way. This was suggested a flaw in convergent thinking and mathematical teaching methods that did not support learners to find their own way but instead have an approach prescribed to them. This was said to be the challenge for divergent thinkers who do not like to conform to one way of thinking and are far more interested in the exploration than the outcome or answer. In this respect they agree with Haylock (1985) who suggested that not learners who do not diverge from a systematic approach to problem solving will only develop their abilities within their own knowledge limitations. Question 3 'Do you think creative sessions can develop fluency and flexibility?' was firmly agreed and it was believed that the cognitive skill development associated with the Guilford test was easy to deliver and would have benefits to students'

cognitive abilities and confidences when applied to mathematics. Question 4 ‘Do you think this can support performance in mathematics and how can it be achieved?’ There was general agreement that creativity can support mathematics, however it was highlighted that often students are developing mathematics skills in their creative sessions without realising and that the issue for staff is to better develop strategies to promote mathematics in engaging activities that change their perceptions of the subject.

In Conclusion, is there an association between the creativity of arts students and performance in mathematics in a specialist arts College?

This section has explored the association between the mathematics performance of learners, their creative ability and their personal character traits. On review the data suggests that there is a association. This could be seen in the Guilford test where the creative attributes of learners corresponded closely with their mathematical performance. The Guilford test was effective in making this association, however, this method alone was not enough to suggest the association between creativity and mathematical performance as these were not the only variables in the results. Cropley, (2000) in his review ‘Are Creativity Tests Worth Using’ suggests that whilst creativity tests measure divergent thinking and other aspects of cognitive ability such as making connections and developing ideas through the thought process, the Guilford test alone does not measure a full recommendation of someone’s ability to be creative. It does not, for example, recognise a person’s motivation or their willingness to take risks. Within this study this has been addressed with a research tool that has effectively measured aspects of the student participants’ personality traits alongside the Guilford test to also support understanding of personal traits as a key component of creativity when making comparisons with mathematical performance. It is clear from the results that these are significant and that opportunities exist in a creative curriculum to develop the creative skills of fluency and flexibility along with personality traits of confidence building, self-purpose and resilience.

Chapter 6: Findings - What are staff's attitudes in a specialist arts College towards mathematics in the curriculum?

As identified in the methodology this section will identify staff's attitudes regarding creativity in the curriculum in a specialist arts College, their top five characteristics that best describe a student who is good at mathematics and the strategies and characteristics used in the classroom to promote mathematics. The responses to the questions will be used to measure their attitudes as recognised through their behaviours towards mathematics.

Characteristics of Students 'who are good at mathematics'

The response to Q9 which was 'List the top five characteristics that you feel best describe a student who is good at mathematics' can be seen in the following table. Each response has been categorised with the following results. Out of 25 staff participants to the questionnaire 12 (48%) suggested that logic was in their top five characteristics. This was the most frequently suggested attribute just ahead of 'methodical thinker' that had a response count of 10 (40%).

Problem Solving was listed by 7 participants (28%). Creativity was also stated by 7 (28%), however, it should be considered that the questionnaire completed by staff was asking questions about the relationship between creativity and mathematics and whilst it should be acknowledged that they made this statement it may have been influenced by previous questions in the survey.

Other significant responses included resilient with a count of 6 (24%). Confident, motivated and diligent all received a response count of 5 (25%). Intelligent, contextualises and organised all had 4 responses (16%).

Categories with very limited response included flexibility, fluency, playful and naturally gifted that were all mentioned by only 1 participant.

Table 13 – Characteristics of students 'who are good at mathematics'

Characteristic	Count
Logical	12
Methodical Thinker	10
Problem Solver	7
Creative	7
Resilient	6
Confident	5
Motivated	5
Diligent	5
Intelligent	4
Contextualises	4
Organised	4
Visualiser	2
Curious	2
Perfectionist	2
Introvert	2

Within the lists of responses to question 9 there was also a range of statements. This included 1 participant who asked the question 'Is there any particular characteristic that tells you someone is mathematical?' Another suggested that all subjects require the same characteristics stating them as 'open-mindedness, confidence, passion, willingness to learn and explore life experience and interest in the world.' One other participant questioned if the survey was hoping to discover what characteristics it required to be good at mathematics or to pass mathematics examinations.

Strategies and Activities to support Mathematics in the Art and Design Curriculum

The responses to Q10 on the staff questionnaire 'list the strategies and activities you use to promote mathematics' has been analysed using thematic analysis and a range of themes have been identified.

Table 14 – Strategies and activities to support mathematics in the art and design Curriculum

Theme	Count	Percentage
Development of cognitive skill	**54**	63%
Development of mathematical concept	**15**	18%
Confidence and Resilience Building	**9**	12%
Relating to career progression	**3**	4%
Contextualising mathematics	**3**	4%

Blue = Activity Based Orange = Strategy Based

The majority of activities listed can be categorised within the theme ‘development of cognitive skills.’ Within this theme strategies and activities were very wide ranging with many responses identifying tasks related to measurement, proportion and scale. For example ‘Spatial Design - gives the student an opportunity to develop skills to work out an area, to work to scale, this can include addition, multiplication and division in the construction of scale models.’ Other answers included activities to explore volume for example ‘Product Design - offers an opportunity to develop skills in volume (container project to hold 1 litre of juice).’ Outside of 3D design examples of activities including opportunities for students to develop their cognitive abilities related to fractions and ratios, for example in Photography ‘Apertures - fractions, which I use cake/pizza to describe shutter speeds - fractions again ISO sensitivity numbers. Temperatures with chemicals. Timing of exposures in the darkroom (can be related to fractions again).’ In addition ‘Liquid measurements and ratios of chemicals.’ In Fine Art activities relating to cognitive development were described as ‘volume and ratio: mixing media, sculpture area and perimeter: canvas stretching: perspective/scale proportion life drawing: measured drawing, scale, proportion’

The second theme established is related to ‘contextualising mathematics.’ For example one participant stated a strategy as ‘explain the relevance and contextualise 'traditional' mathematics topics.’ This was followed up with a range of activities related to the world of architecture. Another textiles teacher responded similarly by defining their approach to mathematics activities as ‘promoting students use of numeracy in drawing by highlighting mathematical terms.’

Another theme can be defined as ‘relating to career progression.’ One participant referred to a mathematics strategy as ‘discussions on work relating to project - value to own career progression.’ Another participant made a similar response with the strategy ‘Discuss benefits of good mathematics skills in students' futures, careers etc.’

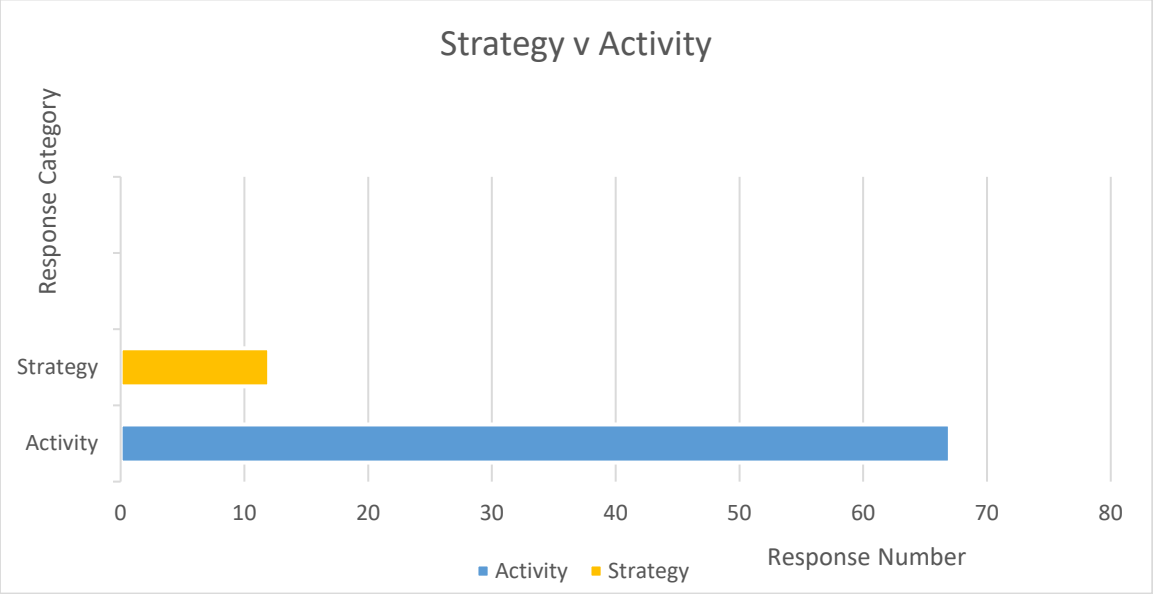
Only one response included references to confidence building and the development of student resilience. They ‘encourage students to believe in themselves - reduce the effects of mathematics anxiety by scaffolding work and dissolving false beliefs of inability.’ Although another participant stated the importance of ‘making it fun and inclusive to everyone.’

The theme ‘development of mathematical concept’ included a range of responses. Predominantly this was linked to the golden ratio for example ‘Introduce them to the

Golden Ratio and allow this awareness to influence solving through composition.' Other examples of the development of mathematical concepts included 'Ergonomics plays an integral part of mathematics in the curriculum given specific dimensions to work to and adhering to them as a 'standard' requirement when planning a space.'

Similar to the question reviewed in Chapter 4, where definitions were identified the question asked the staff what strategies and activities they used to promote mathematics. Figure 20 looks at how staff participants responded to the question identifying how many strategies were identified to promote mathematics and how many activities were used. In total there were 84 responses provided by the 25 participants. This is a mean of 3.36 responses per participant.

Figure 20



Of the 25 participants there was mix between those that highlighted strategies and activities and those that suggested strategies and activities together. The following table highlights that 68% of staff participants identified only activities, 4% only strategies and 38% a combination of both strategies and activities.

Table 15 – Strategy v Activity to promote maths

Participants	Count	Percentage
Identified Activities only	17	68%
Identified Strategies only	1	4%
Identified Strategies and Activities	7	38%

Comparing staff identified characteristics of a good student mathematician and their teaching strategies and activities

Q9 and Q10 of the staff questionnaire highlighted staff's beliefs related to what makes a student a good mathematician and the strategies and activities staff use to promote mathematics. The tables below shows the top ten characteristics against the activities that naturally support development in these areas. For example the strategy 'relating to career progression' could be linked to the characteristic 'motivation'. Another example 'development of cognitive skill' could be linked with the characteristic 'intelligence'.

Table 16 – Characteristics v strategy and activity

Characteristic
Logical
Methodical Thinker
Problem Solver
Creative
Resilient
Confident
Motivated
Diligent
Intelligent
Contextualises

Theme	Count	Percentage
Development of cognitive skill	**54**	63%
Development of mathematical concept	**15**	18%
Confidence and Resilience Building	**9**	12%
Relating to career progression	**3**	4%
Contextualising mathematics	**3**	4%

Blue = Activity Based Orange = Strategy Based

The comparison shows that 50% of the total characteristics (i.e. 5 out of 10) were character and personality based such as resilience, confidence and motivated. Although, only 20% of the strategies and activities cited by staff participants were strategies to support the development of personality based characteristics. Development of cognitive skill and mathematical concepts made up over 80% of the activities identified. This relates directly with the staff's suggestions of what they perceive to be the top 3 characteristics in a student who is good at mathematics. They all related it to cognitive ability or the development of thought related processes such as problem solving.

Many of the mathematics activities developing cognitive skill and development of mathematical concepts were based within creative exercises. For example, producing canvases to be painted, or mixing quantities of chemicals for photography development. In this respect it could be said that 100% of activities 'contextualised mathematics' as they took place in an art and design session. In one instance a participant highlighted creativity as important, however no participant offered a strategy to develop 'creativity' to promote mathematics.

Teachers' perceptions of a creative student compared with their perceptions of a good mathematics student

The following table comparison highlights the differences and similarities between the staff participants' responses to the characteristics of a creative student and the characteristics of a student good at mathematics. Similarities include the inclusion of confident and motivated in both tables although not high on the lists. The blue and yellow shading identifies that there are both cognitive skills and personality traits highlighted although for the 'good mathematics' learner the cognitive skills are ranked higher. Intelligence is ranked relatively low for 'good mathematics students' and does not appear at all in the top ten of the 'creative' learner.

Table 17 – Characteristics of creative student v good mathematician

Characteristics of a student who is creative (top 11)	Characteristics of student good at mathematics (top 11)
Open Minded	Logical
Independent	Methodical Thinker
Experimental	Problem Solver
Deep / Lateral Thinkers	Creative
Curious	Resilient
Imaginative / Innovative	Confident
Confident	Motivated
Motivated	Diligent
Reflective	Intelligent
Unique	Contextualises
Analytical	Organised

Blue = bias towards cognitive skill yellow = bias towards personality trait

The statement ‘The college where I teach places emphasis on fostering student creativity in non-art and design subjects’ where 19 out of 24 respondents agreed or strongly agreed, implies there is already evidence of the potential of creativity in the delivery of mathematics within the context of the College. Furthermore, of the respondents who were from non-art and design based subjects the Mathematics teacher selected agree and the English and Psychology teachers selected strongly agree identifying that there is already an ethos of creative pedagogy in all subject areas in the College. Although it should be said that non-art and design based sample sizes were very small.

Review of the data - What are staff’s attitudes in a specialist arts college towards mathematics in the curriculum?

Staff attitudes relating to a good mathematics students identified that they believe them to be logical, methodical thinkers who are good at problem solving. They are resilient, confident, motivated, and diligent and can contextualise mathematics in the world. Similarities exist with findings in the literature review it was highlighted that Ofsted suggest students need to develop conceptual understanding whilst being fluent at the fundamentals of mathematics, being able to reason mathematically and solve problems if they are going to improve in mathematics. It could be said that the attributes of logic, methodical thinking and problem solving link directly with Ofsted’s view.

When compared with staff participants’ views of creative learners there is a difference. It is clear that they identify the good mathematics student as having skills related to cognitive ability and thinking with greater importance although they don’t dismiss other personality traits that support these attributes such as being motivated and confident. In their attitudes of the creative student, which the most significant characteristics relate to personality traits of being open minded, independent and experimental they again do not dismiss the cognitive abilities associated with lateral thinking, imagination and innovation. Pedagogical approaches to teaching mathematics are in keeping with many of those identified in the literature review. It was highlighted that 80% of teaching in mathematics in the creative curriculum was activity based linked to cognitive ability and development of mathematical concepts and of these 100% were contextualised and linked to art and design based exercises. In the literature review it was identified that Ofsted believe that too often teaching is focussed on how to complete tasks without fully understanding why, resulting in learners that progress to the next stage of their learning without the necessary foundations on which to build their knowledge. In addition, Orton et al. (2004) suggest that teachers have traditionally become effective at teacher led delivery and at supporting

learners in the consolidation of skill development through practising and routine building. This is not the case in the teaching of mathematics in this study, although it should be highlighted that mathematics is not the key aim of the delivery in the art and design sessions. However, Orton et al. (2004, recognise that learning mathematics should incorporate some development of the skills it requires to be a mathematician including problem solving and investigation. In the better examples of strategies and activities highlighted by staff participants there is evidence of this taking place, for example the activity that used ergonomics when designing a solution for a space. Other approaches that do not support Orton et al, where the activity can be described more as routine building include activities such as those involved in working out screen resolutions for digital files or measuring techniques to create glazes. These activities are good examples of practicing cognitive skill through repetition and contextualisation but they do not stretch learners to achieve Ofsted's wish that pedagogical approaches to mathematics should develop learners who are good problem solvers who have skills to work independently and are made to think harder.

Never the less, there are many examples where mathematics is being applied to creative contexts as advocated by the National Council of Teachers of Mathematics (NCTM) who said 'problem solving' is key to the development of mathematics skills in schools. By linking mathematics delivery to everyday activities we are investing in the development of the economy.

Chapter 7: Conclusion

In this study the aim has been to identify the perceptions of creativity and mathematics in a Post 16 arts college. As a senior manager in a specialist art College the researcher is faced with many challenges created by government education policy to develop mathematics performance in all students studying 16-19 programmes of study. The scale of this challenge was unclear, however mathematics performance in the college was inconsistent and below the high standards of the creative arts provision. One key issue was uncertainty around perceptions of mathematics in the creative curriculum of staff, although there was evidence of poor attendance and poor attitudes of students. In recent years teaching observations highlighted some positive attitudes of staff to embedding of mathematics in the creative curriculum. However, other staff had highlighted concerns expressing a belief that creative students 'can't do mathematics' often using this as an excuse for poor performance. This study aimed to raise these questions in an attempt to identify true perceptions and build a foundation of knowledge from which to develop mathematics provision both in the creative curriculum and in mathematics sessions more effectively, and in the future maximise student potential in the subject and improve attainment in this area.

There were weaknesses in the study. For example, the staff questionnaire had limited participation due to the small scale of the College. The balance between art and design subject specialists and non-art and design based was also not fully resolved with only 3 staff participants taking place from a non-art and design background meaning their views were not from a significant enough sample to be considered noteworthy. In addition the Guilford test was carried out without rigorous controls from the researcher. The varied results identified from these tests could easily be a reflection of the lack of consistency in the methodology of completion, where groups of learners may have been provided with more ambiguous or clearer guidance, despite the researcher's best efforts to brief the supervisors of the task. In addition further research into the effectiveness of the Guilford test in other studies would have supported the analysis of the findings. Understanding if other researchers had found limitations in the results of the test would have provided more reliable interpretation of the data.

Initially the study aimed to identify what staff's perceptions of creativity were and link these to common theories of creativity. The findings regarding staff's views on creativity were very positive. They believe creativity can be taught and generally agree that it

should be delivered in regular classrooms in schools to support academic performance. This links with Sir Ken Robinson's assertions that the current educational system is designed for the Industrial Revolution and not suitable for the modern World (Robinson, 2011) and that current teaching practices are linked with carrying out activity without the appropriate level of divergent thinking required for life in the modern world. The College staff's views are, however, contrary to current government policy as identified in the study including the introduction of the EBacc in schools, the greater emphasis on mathematics and English testing, and increased funding for STEM related subjects. In addition, Nicky Morgan's comments that arts and humanities subjects will not give young people the skills that they need to pursue a career ("Your Life" campaign, 2014).

The complexity of creativity was highlighted in the very broad range of responses to the essential features of creativity. Simonton (2000) recognised 4 key themes in creativity research as being cognitive processes, personal characteristics life span development and social context. The staff's responses to the essential features of creativity broadly agreed with these themes with the most frequently referenced themes being related to divergent thinking and personal traits. Whilst life span development was referenced it was less frequent and social context was rarely considered essential. This may be due to the wide range of social backgrounds of students at the College signifying that social background is not essential to being creative.

Alternative approaches to teaching are supported as was their attitudes to creativity as a pedagogical concept. This was highlighted in the staff's responses to the strategies and activities they use to promote creativity. The literature review highlighted creative pedagogical approaches used throughout history including the Reggio Emilia approach and the 2006 reforms provided by the Cambridge Primary Review and the staff's responses clearly supported alternative teaching methodology when teaching creativity. It is very clear that the majority of staff employ a broad range of strategies to develop long term creativity goals and a significant amount of these are focussed on developing personality traits to support their creative learning for example resilience, motivation and independence. However there was also a broad range of strategies developed to support cognitive development although these were related primarily to providing time to think and reflect through group work and discussion rather than the skill development of complex theories. This supports staff attitudes regarding creativity where they identified divergent thinking within a creative process as key components. It is also significant that staff make more emphasis on personality traits than cognitive skill development with the exception of being 'open minded' which was the leading feature of creativity highlighted. It could be

said that this epitomises the staff's views, as being open minded requires cognitive ability to think laterally and have a personality trait that includes a positive response to often complex or far-reaching ideas.

The second key aspect of the study involved identifying if there is an association between the creativity of arts students and performance in mathematics in a specialist arts college. The conclusion was that there is an association. Identifying students' creative ability, according to the Guilford test (1967) and comparing it to their mathematics performance established this. There was a clear association between students' creative flexibility and fluency although more original students or elaborative students did not have a superior mathematical performance. However, it was deemed that it was not enough to provide a conclusive association as it was considered, and supported by some staff in the focus group, that students who are perceived to be more intelligent are often the most creative students. Therefore, as this study cannot conclusively attribute increased creative flexibility and fluency as the reason of improved mathematics performance the researcher suggests caution is exercised when considering causation. In addition to the creativity test it was also important to identify associations between personality traits and mathematical performance. From this aspect of the survey there is strong evidence to suggest that the most confident learners, who recognise mathematics as important to their future careers and are more resilient are more likely to achieve a higher mathematical performance. Equally those learners that did not identify with these as their personal characteristics were more likely to fail to achieve a pass grade. This provides some evidence that students do not succeed because they are not stretched or have not developed the learning skills to achieve. Ofsted highlighted a range of findings from inspections during 2015, key concerns relating to achievement included application of mathematics and that students of all ages were not encouraged to solve problems, resulting in learners who are not made to think hard enough or independently.

Finally the study aimed to identify staff's attitudes in a specialist arts college towards mathematics in the curriculum. Initially this was to look at staff's perceptions of students who are good at mathematics where they recognised them to be logical and methodical thinkers, resilient, confident, motivated and diligent. When compared with their views of the creative learner there are some noticeable differences. For example creative students are perceived to have personality traits that support creativity including being independent, unique, open minded with far less importance on cognitive ability. In the learners who are good at mathematics they perceive the cognitive skills to be far more important, however, they do emphasise personal traits also in particular resilience,

motivation and diligence. In the staff survey one member of staff stated that they believe that the same attributes are relevant for any effective learning in any subject. This study seems to support this argument, however, there are noticeable differences in the importance of these attributes in the staff's views with staff suggesting that in mathematical study cognitive development is more important and in creativity the balance is more focussed towards personality traits.

The survey identified that staff have a very positive attitude towards mathematics in the curriculum evidenced in the very broad range of activities that they use to promote mathematics in their art and design sessions. However, the study also highlighted that many more opportunities exist. The results of the study recognised that whilst the majority of teaching strategies incorporated to promote creativity were focussed on long-term goal development in mathematics the staff focussed more on the delivery of activities that often developed cognitive skills or promoted mathematical concepts. Opportunities were missed to use strategies to develop personality traits associated with successful mathematic performance. For example staff's use of strategies to promote the importance of mathematics to future career progression, or to develop confidences and resilience or simply to make the subject fun to motivate learners are underdeveloped. In consideration of Bloom (1985) who suggests that mathematical talent is developed throughout 3 stages of the learning process where at stage 1 the student falls in love with mathematics, the second stage is where students develop the values and key concepts associated with creative mathematics and the third stage is where learners become successful in their field, might never reach stage 1 of this process. This could most likely be said for students who are not fully engaged from their experiences in mathematics at school and who do not receive effective strategies that promote mathematics through the development of personality traits in college, but are instead learning values and concepts before they are engaged with the full potential of mathematics to themselves and their futures.

Although not a key aim of the study, what this study has failed to answer is can creativity make learners better mathematicians? There was evidence of a clear association between the mathematical performance of students and their creative fluency and flexibility. Staff are very positive towards creative learners and have very clear ideas regarding what makes learners creative and good mathematicians and in many aspects these attributes overlap. They utilise a broad range of strategies to develop long-term creativity goals of learners and, despite strategies being under developed in the promotion of mathematics, activities that embed mathematics in the creative curriculum

are broad ranging to support cognitive development associated with mathematical skills and concepts. However it is the potential of the development of creative fluency and flexibility that remains unanswered. Staff clearly have the ability to deliver strategies to develop these cognitive attributes for example through continuous application of activities such as the Guilford test that promote lateral and open minded thinking in the development of cognitive processes. However, to understand if the development of these creative attributes can have a noticeable impact on mathematical performance it would need further studies including a structured programme of research over a considerable period of time to identify any measurable change in performance. An interesting approach would be to consider the theory of little ‘c’ and Big ‘C’ creativity. In this study there was clear evidence to suggest that staff develop activities towards the development of little ‘c’ creativity and use creative strategies to support the longer-term goal of Big ‘C’. How can this be translated to develop little ‘m’ mathematics and Big ‘M’ mathematics?

Appendix 1 – Staff Questionnaire

(Staff Survey) Creativity in the Classroom

Start of Block: Please answer all questions

Q1 On what course do you currently do most of your teaching?

- O Level 1 Art and Design
- O Level 2 Art and Design
- O Level 3 Art and Design
- O Graphic Design
- O Photography
- O Fashion
- O Textiles / Design Crafts
- O Fine Art
- O Interactive Media
- O 3D Design
- O Access to Higher Education
- O A Levels
- O Mathematics
- O English

Q2 Consider the following statements identifying one answer to each question.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
Creativity can be taught	O	O	O	O	O	O
Student creativity can be taught in the school classroom	O	O	O	O	O	O
All teachers should have knowledge about creativity	O	O	O	O	O	O
Creativity is essential for enhancing student learning in schools in academic subjects	O	O	O	O	O	O
A regular classroom teacher is responsible for helping students develop creativity	O	O	O	O	O	O
The College where I teach places emphasis on fostering student creativity	O	O	O	O	O	O
I employ many methods in my classroom to foster creativity	O	O	O	O	O	O

The College where I teach places emphasis on fostering student creativity in non art and design subjects	o	o	o	o	o	o

Q3 When you see or hear the word creativity, what comes to mind?

_____

_____

_____

_____

_____

Q4 Discuss what you believe to be the essential features of creativity.

_____

_____

_____

_____

_____

Q5 Should creativity be enhanced and taught in 'non art and design' classrooms? Why?

_____

_____

_____

_____

_____

Q6 What percentage of your students do you consider to be highly creative?

_____

_____

_____

_____

_____

Q7 List the top five characteristics that you feel best describe the creative student.

_____

_____

_____

_____

_____

Q8 List activities and strategies you use in the classroom to support creativity

_____

_____

_____

_____

_____

Q9 List the top five characteristics that you feel best describe a student who is good at mathematics.

_____

_____

_____

_____

_____

Q10 List the strategies and activities you use in the classroom to promote mathematics.

_____

_____

_____

_____

_____

End of Block: Please answer all questions

Appendix 2 – Student Questionnaire

Start of Block: Please answer all questions

Q1 Please give your full name

_____

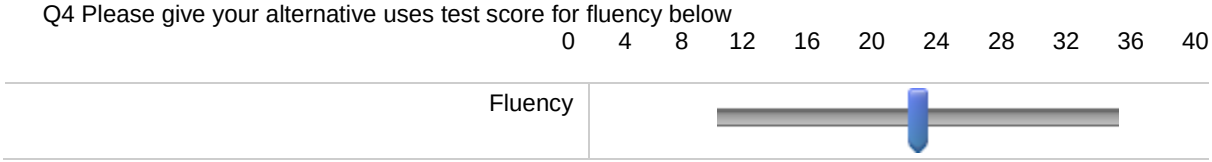
Q2 On what course do you currently study?

- O Level 1 Art and Design
- O Level 2 Art and Design
- O Level 3 Art and Design
- O Graphic Design
- O Photography
- O Fashion
- O Textiles / Design Crafts
- O Fine Art
- O Interactive Media
- O 3D Design
- O Access to Higher Education
- O A Levels
- O Foundation (Level 3)

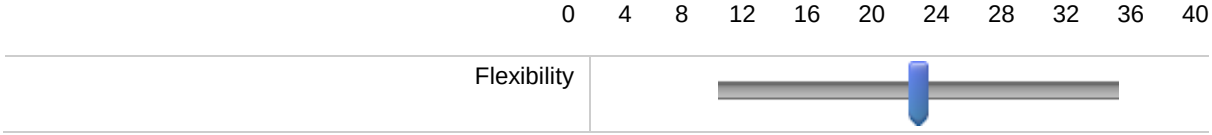
Q3 What is your highest Mathematics GCSE grade achieved?

- O 9
- O 8
- O 7
- O 6
- O 5
- O 4
- O 3
- O 2
- O 1
- O None

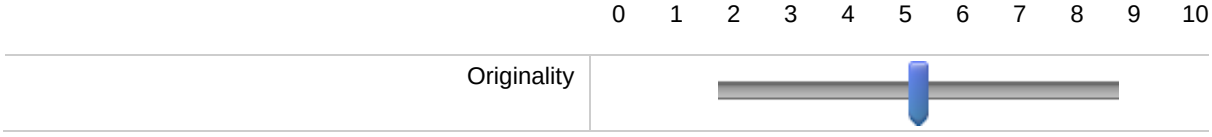
Q4 Please give your alternative uses test score for fluency below



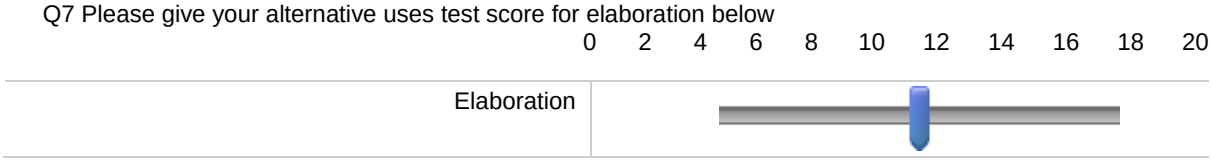
Q5 Please give your alternative uses test score for flexibility below



Q6 Please give your alternative uses test score for originality below



Q7 Please give your alternative uses test score for elaboration below



	Disagree strongly	Disagree a little	Neither agree nor disagree	Agree a little	Agree strongly
I like problem solving	O	O	O	O	O
I don't give up easily in mathematics	O	O	O	O	O
I think my creative ability can help me in mathematics	O	O	O	O	O
I prefer class work that is challenging so I can learn new things	O	O	O	O	O
It is important for me to learn what is being taught in mathematics	O	O	O	O	O
I am certain I can understand the ideas being taught in mathematics	O	O	O	O	O
I often choose topics I will learn something new from even if they require more work	O	O	O	O	O
I have an uneasy upset feeling when I take a test	O	O	O	O	O
I think what I am learning in mathematics is useful for me to know	O	O	O	O	O
My study skills are usually excellent when compared with others	O	O	O	O	O
I worry a great deal about tests	O	O	O	O	O

Passing my GCSE mathematics is important to my future career	O	O	O	O	O
In mathematics, I ask myself questions to make sure I know the material I have been studying	O	O	O	O	O
When work is hard I either give up or only study the easy parts	O	O	O	O	O
I try to understand what the teacher is saying even if it doesn't make sense	O	O	O	O	O
When I study for a test I try to remember as many facts as I can	O	O	O	O	O
I work on extra questions even when I don't have to	O	O	O	O	O
I often find I have been studying and don't know what it is all about	O	O	O	O	O
I work hard to get a good grade even if I don't like the class	O	O	O	O	O

End of Block: Please answer all questions

Appendix 3 – Staff Consent

The Perceptions of Creativity and Mathematics in Post 16 Arts Education

Dear Colleague,

The College is currently carrying out a research project to learn more about the perceptions of creativity and mathematics in Post 16 arts education. We are writing to ask if you are able to take part in the study.

What would this mean for the College?
We are very interested in your views on mathematics education in a specialist creative arts College. As part of this study we are keen to understand how your teaching in your Creative subjects helps or hinders students' understanding and learning in mathematics. This will include you completing a short survey and possibly taking part in a focus group discussion exploring how your students learn and what teaching strategies you use.

The aim of the study is to better understand the relationship between arts education and the study of mathematics. The information will be used to develop the art and design provision in the College and the teaching of mathematics to better support students' skill and academic development.

Anonymity
The data that you provide will be stored by code number. Any information that identifies you will be stored separately from the data.

Storing and using your data
Data will be stored in secure filing cabinets and on a password protected computer. The data will be kept for two years in an anonymised format. The data may be used for future analysis and shared for research or training purposes, but participants will not be identified individually. If you do not want your data to be included in any information shared as a result of this research, please do not sign this consent form.

You are free to withdraw from the study at any time during data collection and up to 3 weeks after the data is collected, by contacting me.

You will be given the opportunity to comment on a written record of any focus groups you attend.

Information about confidentiality
The data that we collect may be used in *anonymous* format in different ways. Please indicate on the consent form attached with a ☑ if you are happy for this anonymised data to be used in the ways listed.

Please note: If we gather information that raises concern about your safety or the safety of others, or about other concerns as perceived by the researcher, the researcher may pass on this information to another person.

We hope that you will agree to take part. If you have any questions about the project/study that you would like to ask before giving consent or after the data collection, please feel free to contact John Waddington by email (john.waddington@ccad.ac.uk) or by telephone on 01642 856156, or the Chair of Ethics Committee via email education-research-administrator@york.ac.uk

If you are happy to participate, please complete the form attached. The online survey can be found on the College VLE at…

Please keep this information sheet for your own records.

Thank you for taking the time to read this information.

Yours sincerely,

John Waddington
Head of Further Education

The Perceptions of Creativity and Mathematics in Post 16 Arts Education

Consent Form Please initial each box if you are happy to take part in this research.

I confirm that I have read and understood the information given to me about the above named research project and I understand that this will involve me taking part as described above. ☐

I understand that the purpose of the research is to better understand the relationship between arts education and the study of mathematics. ☐

I understand that data will be stored securely in a locked filing cabinet or on a password protected computer and only John Waddington will have access to any identifiable data. I understand that my identity will be protected by use of a code ☐

I understand that my data will not be identifiable and the data may be used in…. ☐

in publications that are mainly read by university / college academics ☐

in presentations that are mainly attended by university / college academics ☐

in publications that are mainly read by the public ☐

in presentations that are mainly attended by the public ☐

freely available online ☐

I understand that data will be kept for 2 years after which it will be destroyed. ☐

I understand that data could be used for future analysis or other purposes [e.g. other research and teaching purposes] ☐

I understand that I can withdraw my data at any point during data collection and up to 3 weeks after data is collected. ☐

I understand that I will be given the opportunity to comment on a written record of my responses in any focus groups I attend. ☐

Name (Please Print): Date:

Signed:

Appendix 4 – Student Consent

The Perceptions of Creativity and Mathematics in Post 16 Arts Education

Dear Student,

The College is currently carrying out a research project to learn more about the impact an arts education has on a students' ability to study mathematics. We are writing to ask if you are able to take part in the study.

What would this mean for the College?
We are very interested in how you learn. As part of this study we are keen to understand how your learning in your Creative subjects helps or hinders your understanding and learning in mathematics. This will include you completing a short survey and possibly taking part in a focus group discussion exploring how you learn and what teaching strategies suit you.

The aim of the study is to better understand the relationship between arts education and the study of mathematics. The information will be used to develop the art and design provision in the College and the teaching of mathematics to better support students' skills and academic development.

Anonymity
The data that you provide will be stored by code number. Any information that identifies you will be stored separately from the data.

Storing and using your data
Data will be stored in secure filing cabinets and on a password protected computer. The data will be kept for two years in an anonymised format. The data may be used for future analysis and shared for research or training purposes, but participants will not be identified individually. If you do not want your data to be included in any information shared as a result of this research, please do not sign this consent form.

You are free to withdraw from the study at any time during data collection and up to 3 weeks after the data is collected, by contacting me.

You will be given the opportunity to comment on a written record of any focus groups you attend.

Information about confidentiality
The data that we collect may be used in *anonymous* format in different ways. Please indicate on the consent form attached with a ☑ if you are happy for this anonymised data to be used in the ways listed.

Please note: If we gather information that raises concerns about your safety or the safety of others, or about other concerns as perceived by the researcher, the researcher may pass on this information to another person.

We hope that you will agree to take part. If you have any questions about the project/study that you would like to ask before giving consent or after the data collection, please feel free to contact John Waddington by email (john.waddington@ccad.ac.uk) or by telephone on 01642 856156, or the Chair of Ethics Committee via email education-research-administrator@york.ac.uk

If you are happy to participate, please complete the form attached. The online survey can be found on the College VLE at…

Please keep this information sheet for your own records.

Thank you for taking the time to read this information.

Yours sincerely,

John Waddington
Head of Further Education

The Perceptions of Creativity and Mathematics in Post 16 Arts Education

Consent Form

Please initial each box if you are happy to take part in this research.

I confirm that I have read and understood the information given to me about the above named research project and I understand that this will involve me taking part as described above. ☐

I understand that the purpose of the research is to better understand the relationship between arts education and the study of mathematics. ☐

I understand that data will be stored securely in a locked filing cabinet or on a password protected computer and only John Waddington will have access to any identifiable data. I understand that my identity will be protected by use of a code ☐

I understand that my data will not be identifiable and the data may be used in…. ☐

in publications that are mainly read by university / college academics ☐

in presentations that are mainly attended by university / college academics ☐

in publications that are mainly read by the public ☐

in presentations that are mainly attended by the public ☐

freely available online ☐

I understand that data will be kept for 2 years after which it will be destroyed. ☐

I understand that data could be used for future analysis or other purposes [e.g. other research and teaching purposes] ☐

I understand that I can withdraw my data at any point during data collection and up to 3 weeks after data is collected. ☐

I understand that I will be given the opportunity to comment on a written record of my responses in any focus groups I attend. ☐

Name (Please Print): Date:

Signed:

References

Andres, R. (2003), *Research Questions*. Bloomsbury Publishing

Abell, S. K., & Lederman, N. G. (Eds.). (2007). *Handbook of Research on Science Education* (Vol. 1). Psychology Press.

Alexander, R., Doddington, C., Gray, J., Hargreaves, L. Kershner, R. (2012). *The Cambridge Primary Review Research Surveys.* Hoboken: Taylor and Francis.

Amabile, T.M. (1996). *Creativity in context: Update to The Social Psychology of Creativity.* Boulder, CO: Westview

Banaji, S., Burn, A., Buckingham, D. (2010). *The rhetorics of creativity: a literature review.* Newcastle: Creativity, Culture and Education

Bell, J. (2005). *Doing Your Research Project.* Open University Press. Retrieved 21 April 2017, from <http://www.myilibrary.com?ID=94698>

BERA (2011). *Ethical Guidelines for Educational Research.* British Educational Research Association. London

Busse, T., Dahme, G., Wagner, H., & Wieczerkowski, W. (1986). Teacher perceptions of highly gifted students in the United States and West Germany. *Gifted Child Quarterly*, 30(2), 55-60.

Boyatzis, R.E. (1998) *Transforming qualitative information: thematic analysis and code development.* Sage.

Braun, V. Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology, 3(2),* 77-101

Cohen, L., Manion, L., Morrison, K, & Morrison, R.B. (2007) *Research methods in education.* Routledge

Csikszentmihalyi, M. (1996). *Creativity: Flow and the psychology of discovery and invention.* New York: HarperCollins.

Cropley, A.J. (2000) Defining and Measuring Creativity: Are Creativity Tests Worth Using? *Roeper Review, 23 (2)*, 72-79

Cropley, A.J. (2001). *Creativity in Education & Learning.* Routledge

Denscombe, M. (2014). *The Good Research Guide.* (S.I.): McGraw-Hill Education.

Department for Business, Innovation & Skills and Department for Education. (2011) *Review of vocational education: the Wolf report*

Department for Digital, Culture, Media & Sport. (2016) *UK economic growth and Media and creative industries*

Dippo, C. (2013). *Evaluating the Alternative Uses Test of Creativity. Proceedings of the National Conference On Undergraduate Research* (NCUR) 2013 University of Wisconsin La Crosse, WI

Edwards, C., Gandini, L. and Forman, G. (1998). *The Hundred Languages of Children: the Reggio Emilia Approach – Advanced Reflections.* 2nd Edition. Greenwich, CT: Ablex Publishing.

Fleith, D. (2000). Teacher and student perceptions of creativity in the classroom environment. *Roeper Review, 22(3,)* 148-53.

Fleming, M. (2010). *Arts in education and creativity: a literature review.* Newcastle: Creativity, Culture and Education

Fryer, M., & Collings, J. (1991). British teachers' views of creativity. *Journal of Creative Behaviour, 25(1)*, 75-81.

Gardner, H. (1993). *Creating minds*. New York: BasicBooks.

Glenada, A. Walshaw, M. (2009). Characteristics of Effective Teaching of Mathematics: A View from the West. *Journal of Mathematics Education*. Massey University, New Zealand

HESA (2014), Experts in UK higher education data and analysis https://www.hesa.ac.uk/data-and-analysis

Hudson, L. (1968). *Contrary imaginations*. London: Methuen

Hunsaker, S. (1994). Creativity as a characteristic of giftedness: teachers see it, then they don't. *Roeper Review*, 17(1) 11-15.

Hyman,L., Lamb, J., Bulmer, M. (2006). *The Use of Pre-Existing Survey Questions: Implications for Data Quality.* European Conference on Quality in Survey Statistics
Kant, I. (2016). *Critique of Judgement*. Jester House Publishing.

Kaufman, S.B. (2013). Opening up openness to experience: A four-factor model and relations to creative achievement in the arts and sciences**.** *Journal of Creative Behaviour*, 47, 233-255.

Leikin, M. Tovli, E. Malykh, S. (2010) Bilingualism and Creative Abilities in Early Childhood. *English Linguistics Research*, 3(2).

Marsh, J. (2010) *Childhood, culture and creativity: A literature review*. Newcastle: Creativity, Culture and Education

Morgan, D. (1997) *Focus Groups as Qualitative Research*. 2nd ed., Thousand Oaks, Calif. ; London : SAGE

Morgan, N. (2014) *Speech: Nicky Morgan speaks at launch of Your Life campaign* School and college qualifications and curriculum and Young people Department for Education and The Rt. Hon Nicky Morgan https://www.gov.uk/government/speeches/nicky-morgan-speaks-at-launch-of-your-life-campaign

National Advisory Committee on Creative and Cultural Education. (1999). *All Our Futures:* Creativity, Culture and Education. London: HMSO

National Council of Teachers of Mathematics. (1980). An Agenda for Action: Recommendations for School Mathematics of the 1980s.

Newby, P. (2014) *Research Methods for Education*, second edition. Routledge

Odom, S.L., Fleming, K., Diamond, K., Lieber, J., Hanson,M., Butera, G., Horn, E., Palmer, S., Marquis, J. (2010) Examining Different Forms of Implementation and in Early Childhood Curriculum Research *Early Child Research Quarterly*. 25(3): 314–328.

Ofsted. (2016) Further Education and Skills Inspection Handbook https://www.gov.uk/government/publications/further-education-and-skills-inspection-handbook

Patchett, R., & Gauthier, Y. (1991). Parent and teacher perceptions of giftedness and a program for the gifted. *B. C. Journal of Special Education*, 15(1), 25-38.

Petty, R., & Cacioppo, J., & Goldman, R. (1981). Personal involvement as a determinant of argument-based persuasion. *Journal of Personality and Social Psychology,* 41(5), 847-855.

Programme for International Student Assessment (PISA). (2016). *PISA 2015 Results (Volume I): Excellence and Equity in Education*. OECD.

RCU Market Research Service, www.rcu.co.uk

Rich, G. J. (2009) Big C, little c, Big M, little m. *American Psychologist*, 64, 155– 156.

Robinson, K. (2011). *Out of Our Minds: Learning to be Creative.* John Wiley & Sons

Robinson, K., Aronica, L. (2015) *Creative Schools: Revolutionizing Education from the Ground Up. Uk:* Penguin

Roulston, K. (2001) Data analysis and 'theorizing as ideology'. *Qualitative Research 1*, 279_/302.

Schleicher, A. (2016). In *Global Education and Skills Forum 2016*. Dubai.

Sierwald, W. (1989). Creative giftedness—identifying, developing and fostering the creatively gifted]. Munich.

Silvia, Paul. (2015). Intelligence and Creativity Are Pretty Similar After All. *Educational Psychology Review.*

Simonton, D.K. (2000). Creativity: Cognitive, Personal, Developmental, and Social Aspects *American Psychology.* 55(1):151-8.

Simonton, D. K. (1999). *Genius, Creativity, and Leadership: Historiometric Inquiries*. Lincoln, Nebraska: iUniverse.com Publishers.

Singer, P., & Feinstein, A. (1993). Graphical display of categorical data. *Journal of Clinical Epidemiology*, 46(3), 231-236.

Stevenson, D. (2015). Enriching Britain: Culture Creativity and Growth. *Cultural Trends, 24*(2), 205-208

TES. (2016) *Colleges face 'testing' times over GCSE resits* https://www.tes.com/news/further-education/breaking-news/colleges-face-testing-times-over-gcse-resits

Torrance, E. (1965) Scientific Views of Creativity and Factors Affecting Its Growth Source: *Daedalus, Vol. 94, No. 3, Creativity and Learning* (Summer, 1965), pp. 663-681

Vygotsky, L.S. (1930). Imagination and creativity in the adolescent. *Child psychology.*
The collected works of L.S. Vygotsky, ed. D.B. Elkonin, vol. 4, Moscow, USSR

Wetcher-Hendricks, D. (2011). *Analyzing Quantitative Data*. John Wiley & Sons, Incorporated.