An Aesthetic Knowing of Mathematical Identity: Performing stories of Mathematical Identity through filmed drama

A thesis submitted to the University of Manchester for the degree of Doctor of Philosophy (PhD) in the Faculty of Humanities

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Abbreviations and Anachronisms

ABR	Arts Based Research
ABRE	Arts Based Research in Education
BBC	British Broadcasting Corporation
BSED	Behavioural, Social and Emotional Difficulties
ESRC	Economic and Social Research Council
FL	Foundation Learning
GCSE	General Certificate of Secondary Education
HMP	Her Majesty's Prison
JPF	Just Plain Folks
LSIS	Learning Sills and Improvement Service
NEET	Not in Education, Employment or Training
PISA	Programme for international Student Assessment
SEN	Special Educational needs
STEM	Science Technology Engineering and Mathematics
WBL	Work Based Learning

Abstract

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This research is grounded in critical concerns about UK mathematical performance and anxious mathematical identities. More usually these concerns focus mathematics educational policies away from growing academic interest in the role of 'affect' (emotions, attitudes and beliefs) in mathematics education, links between mathematical anxieties and identity, and how mathematical performance can also be how we think, feel, be and 'act' in social contexts. In relation to these critical concerns

The thesis, which includes the film '*Performatics: Performing stories of mathematical identity through filmed drama'* (Performatics), documents the 'identity work' of three postgraduate students (actors), who study mathematical courses, as they developed dramatic scenes framed in terms of their *'shared feelings'* about mathematics. The researcher became immersed in the lives of prospective participants (through science communication and drama) to recruit actors comfortable and committed enough to dedicate eight months to this research, which generated 70 hours of raw footage edited into the final film.

As Arts Based Research (ABR), *'Performatics'* is a whole research process constituting data collection, analysis, discussion and dissemination. Two ABR methods were adopted. Firstly, 'Playbuilding' (Norris, 2000) structured the drama process in order to provoke, compile and construct scenes about experiences with mathematics. Secondly Jean Rouch's observational cinema captured the drama construction process and accounted for the actor's imagination (dream like scenes of past experience) as part of their identity, which is conveyed in the film. In addition, Rouch's approach claims that filmmaking and editing is an inherently rigorous and analytical research process. The ABR is underpinned by principles of *'aesthetic knowing',* which has two meanings here: Firstly, situated in practice, with an in-the-moment, perceiving, feeling, sensing of a situation linked to hermeneutic phenomenological interpretation of human experience (Ricoeur) with identity as dialogic (Bahktin, 1986); mediated by others (including the past and possible/imagined selves). The second is aesthetic knowing through experiences of beauty (Levy, 2015).

'Performatics' supplements knowledge on identity by claiming (i) that there are features of dramatic methodology and film that can be adopted from other fields (observational cinema and theatre studies) to show the intangible, inner aspect of identity. Features that include a wider grasp of emotions and cultural semiotics, and a means to represent past experience in the non-discursive ways that the storyteller may recall them, (ii) In doing so the affective property of story becomes more apparent and (iii) the audience becomes witness to the dynamism of storying in a way not possible in a written text.

DECLARATION

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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Chapter 1.   Finding identity and wisdom through the arts

"The arts make us feel connected to one another and less isolated. Through the arts, we share an emotion and that sharing connects us with each other and we realise we all feel the same emotions. The arts are our last hope. We find our identity and make it easier and more pleasurable to live and they also give us wisdom..."

Arthur Miller – (Arts Council England, 2003, p.6)

1.1 Introduction: The background, justification and focus of the thesis

This thesis is an alternative format, which breaks new ground in undertaking and assessing filmed-drama as valuable for sensing and expressing mathematical identity. The research, a written and film component, *Performatics: Performing stories of mathematical identity through filmed drama'* (Performatics), are a novel and substantive contribution which claim an 'aesthetic knowing' of mathematical identity and a methodological contribution to Arts Based Research (ABR) for education. The film '*Performatics',* documents the 'identity work' of three postgraduate students (actors), who study mathematical courses, as they developed dramatic scenes framed in terms of their *'shared feelings'* about mathematics. The researcher became immersed in the lives of prospective participants (through science communication and drama) to recruit actors comfortable and committed enough to dedicate eight months to this research, which generated 70 hours of raw footage edited into the final film.

As Arts Based Research (ABR), *'Performatics'* is a whole research process constituting data collection, analysis, discussion and dissemination. Two ABR methods were adopted. Firstly, 'Playbuilding' (Norris, 2000) structured the

drama process in order to provoke, compile and construct scenes about experiences with mathematics. Secondly Jean Rouch's observational cinema captured the drama construction process and accounted for the actor's imagination (dream like scenes of past experience) as part of their identity, which is conveyed in the film. In addition, Rouch's approach claims that filmmaking and editing is an inherently rigorous and analytical research process. The written and film thesis intend to contribute methodological approaches to mathematical identity research claiming that there are features of filmed-drama that can show the intangible, inner aspect of identity that maybe include a wider grasp of emotions and cultural semiotics.

In order to frame this contribution to knowledge I provide some background information to contextualise how this research came about. The background section of this chapter explains my interest in mathematical identity as a vocational educator and as a researcher of learner experience. Here I rationalise the ABR approach to sensing anxious mathematical identities and provide an overview of this thesis' contribution to mathematical identity and mathematics education research. The main body of this introductory chapter details the alternative format of the thesis, which is both film and written components. A detailed overview of the structure and content of each thesis chapter then enables the reader to navigate the thesis and identify how the chapters contribute to the overall aim of producing an aesthetic knowing of mathematical identity.

1.2 Background to the study

This study builds on previous research which is concerned with mathematical 'performance' as academic success or ability, with less research directed to mathematical performance as being a certain kind of person – performing a mathematical identity.

The rationale for the study and choice of ABR are situated in relation to perceived issues with mathematical competence or ability where mathematical

'performance' is understood as test or skill performativity. I contextualise the personal, professional and academic resonance of investigating mathematical performance as being a certain kind of person – mathematical identity. A vignette of my personal and professional experience gives some sense of my perspective as a mathematics learner, as a teacher of vocational education, and my earlier research on learner experience, which influenced an ABR approach to mathematical identity in this thesis.

1.2.1 Performing mathematically

Mathematical 'performance' is discussed here in two senses: as demonstrating competence through skill and test performativity, and as performing as a certain kind of person or identity. I claim that a narrow focus on performativity hasn't adequately addressed why an increasing number of students disengage from mathematics or experience anxieties about mathematics. I claim that paying attention to performing identity could be productive in understanding disengagement from and anxiety towards mathematics?

This research is foregrounded by UK national and international concerns about mathematical academic performance and the problem of the dismal mathematics identity. Mathematical performance is usually considered to be the learning of specific and measurable mathematical skills and knowledge graded in school or 'test performance'. Mathematical performance is a focus of Government and employers who perceive the UK population's mathematical performance as inadequate and problematic in terms of UK economic competitiveness (Hodgen and Marks, 2013). This section provides an overview of the international concern with mathematical performance. By examining this concern we encounter 'performativity, as one way in which mathematical identity can be understood.

Mathematical academic performance or 'performativity' is widely understood as a body of mathematical skills and knowledge defined as useful by the

government, albeit advised by academia and industry. This is packaged as a curriculum for learning to be transmitted by teachers to students in a classroom setting. Students 'perform' their level of knowledge by taking a test based on that curriculum. The student's academic performance, as test-competence, is established by the grade they receive for the test. Mathematical academic performance is the subject of both UK national and international concern, backed by an ideology, which could be considered problematic, which equates mathematical competence with positive global economic competitiveness. To this the literature adds that mathematics relates to personal outcomes, due to our encountering mathematics more frequently because of changing technological and workplace practices, where employment is argued to increasingly require a more 'numerate' population (Bynner and Parsons, 1997; Dearden et al. 2000; Machin et al, 2001; Hoyles et al, 2002; Ananiadou et al, 2004; Parsons et al, 2005; Marr et al, 2007; Brown, et al, 2008; Jenkins, et al, 2011; Marsh, 2011; Hodgen and Marks, 2013).

The notion that mathematical academic performance is fundamental to economic and social wellbeing has arguably resulted in mathematics being the focus of attention from various avenues; of which academic research is but one. The labour market drive for, and significant investment in, mathematics consequently subjects mathematics education to particular scrutiny in the form of effectiveness and accountability measures such as UK school league performance tables of GCSE results and the international PISA testing (which tests subjects including mathematics).

Test scores, as indicators of mathematical performance, provide quantitative test data to present an overview of UK mathematical performance (in national and global terms). However, reducing mathematical performance to test data arguably limits our understanding of poor mathematical performance, negative dispositions towards mathematics and anxious mathematical identities. Whilst test performance data may be useful to gain a broad picture of UK mathematical performance in global terms, I suggest that over reliance on

quantitative test data can be problematic as it doesn't provide reasons for mathematical competency or inadequacy. It is not difficult to conjecture that the weight of importance placed on mathematics impacts student relationships with mathematics. Students' mathematical identity is mediated by test grade scores labelling them as more or less able. The discourse of academic performativity does not adequately account for other kinds of performance, such as performing an identity as a certain kind of person –a mathematical person. Equally, pre-occupation with test performativity focuses mathematics educational policies away from growing academic interest in the role of 'affect[1],' emotions, attitudes and beliefs) in mathematics education, links between mathematical anxieties and identity (Heyd-Metzuyanim, 2016), and how mathematical performance can also be how we think, feel, be and 'act' in social contexts; or a mathematical performance that is a socially performed mathematical identity (Zan et al, 2006; Grootenboer and Hemmings, 2007).

A brief overview of mathematical identity in UK and western culture suggest mathematicians as being white, middle class, male geeks. Research into cultural models (Epstein, Mendick & Moreau, 2010) reveals mathematics as logical, dispassionate, difficult, and elitist. In the literature, there is some sense of mathematics as pathological within the dysfunctional body, intimately tied to a medical model of mathematics. As such mathematical identity is increasingly researched through medical and psychological sciences, aiming to determine biological relationships between mathematics and mental states such as creativity (Andreasen, 1987, 2005, 2008, 2014), personality disorders, addiction and mental illness (Nettle, 2005), autism (Baron-Cohen et al, 1998, 2007) and gender and the mathematical brain (Baron-Cohen, 2003). What these studies serve to highlight is the continuing interest in biological and psychological attributes of intelligence and genius and ideas about mathematics, madness, deviance and addiction – a pathologisation of mathematics that situates mathematical ability, and mathematical creativity, within the body. In addition,

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[1] See Mc Leod, and Adams, (1989) and Mc Leod, (1992 and 1994) for studies on affect and the relationship between emotion and cognition in mathematics education.

whilst mathematical identity is increasingly researched, it could be argued that what is being researched is not identity but mathematical activity, and affect towards mathematics. Part of the argument of identity researchers is that social psychological approaches do not actually address identity and that the range of approaches in identity research lacks a conceptual coherence, which has been claimed as problematic to operationalising identity in research (Sfard and Prusak, 2005, Darragh, 2016; Radovic, 2016), a point discussed at greater length in literature review of mathematical identity in section 2.1.1 of Chapter 2.

There is little wonder though that research on mathematical identity stories and dispositions towards mathematics became prominent, given pupils' mass disengagement and dis-identification from mathematics learning, which is viewed by many learners as unimaginative, boring and irrelevant (Coben et al, 2003; Sfard and Prusak 2005; Brown, Brown and Bibby; 2008, Solomon, 2009; Davis et al, 2008; Gerofsky, 2010; Moreau, Mendick and Epstein 2010; Gadanidis, 2012). Where even some teachers experience mathematics anxiety (Gresham, 2010; Hoffman, 2010; Brown and Mcnamara, 2011; Johnson and Vandersandt, 2011). And, rather than voice a 'love of mathematics' (Davis, et al., 2008), students on higher mathematics courses tell stories of alienation from mathematics, valuing the 'exchange' values of mathematics (Williams, 2012). Williams (2012) makes a distinction between 'use' and 'exchange' value of mathematics. The 'exchange' value being the capital worth of mathematical skills and knowledge as quantified in many cases by qualification certificates including GCSE, A' Level and University qualifications. The 'exchange' value of mathematics, therefore, has some capital in realising employment and earning potential as well as a social significance in the division of labour which can arguably reproduce inequality.

The frequency and similarity of dismal stereotypical stories, in the face of different personal experiences, suggests a rehearsed response which is too easily narrated. This rehearsal of stories about mathematical identity, therefore, warrants attention.

This section has highlighted why mathematical 'performance' as competence or test performance cannot be understood in isolation from research which is concerned with the mathematical person and performing as mathematical (or not). The following section further elucidates the personal and professional resonance which developed my thinking to focus on mathematical performance as being a certain kind of mathematical person; mathematical identity.

1.2.2 A rationale for the research: Personal and professional context

How my personal, professional and academic contexts fit within current concerns about mathematical performance are detailed here. I recount the personal and professional context which served as a springboard to studying mathematical identity using ABR. I begin with my own story of experiences with mathematics education, from my teens, twenties and thirties, which tie into my professional life as a Vocational Education teacher of basic skills literacy and numeracy and employability and Careers Advisor. This section ends with a rationale of why mathematical identity was explored through ABR.

On the occasions, I have been asked about my experiences with mathematics, or it has come up in conversation, this is the account I divulge. I have told this story many times and it has become rehearsed, almost like a script. My mathematical identity is thus tied up with a story that has become fossilised over time. I make no claims to a 'truth' of this story, for there are things that I cannot recollect; all I know is these are the parts that I have taken as important, or as saying something about me and my relationship with mathematics, that I feel I can share with others.

The teen years held few memories of actually studying mathematics, but mathematics was significantly implicated in how this able learner (with 'potential'), disengaged totally from education. I grew up in an area of significant depravation. There was a distinct lack of stories on the estate where I lived (the largest and arguably most deprived council estate in the UK) about the

achievement of past students doing academically well, going to University or entering anything other than manual or low skilled employment. My only vivid memory of my secondary school mathematics classroom was the excitement of workmen in suits sealing off the stationery cupboard for building work - because that was where all the 'good stuff' was; the protractors, the rulers, and the set squares. All I know with certainty is I didn't hate mathematics, I was ambiguous about it.

I sat my GCSE exams in 1992, not long after GCSE's had been introduced. There was a story circulating in the school that no student in the school had yet passed the higher mathematics paper needed to achieve an A-C grade. As far as I can recall, teacher anxiety about pass rates on the higher mathematics paper led to my year group being entered for the intermediate paper, regardless of attainment. I had no idea what this meant or how it would impact on my future possible career choices. I didn't know, for example, that the grade boundary for a 'C' grade on the intermediate paper was higher than it was to get a 'C' grade on the higher paper. I didn't know that a 'C' grade would be the highest grade I could achieve on the intermediate paper. Being entered for the intermediate paper irrevocably damaged my long held ambition to become an astrophysicist. The 'A' grades I achieved in Science were practically useless to me without the accompanying mathematics grade 'B' or above. My grade, my test performance in mathematics, although out of my hands, had decided what sort of person I would be; my learner identity. I disengaged from learning and from then on, up until my late twenties, I experienced a much fractured career path made up of low paid, low skilled jobs and intermittent periods of unemployment.

Disenfranchised from a lack of career direction, I came back to education in my late twenties and studied for a part time degree in the Social Sciences with the Open University. At the same time, I secured an administrative post with the Careers service, which led to a promotion to their vocational education programme as a vocational skills tutor. I held the tutor position for ten years

and in that time I successfully graduated from my degree, achieved a professional qualification in advice and guidance and a teaching certificate.

In my late thirties, I was twenty years on from my secondary school self. I was now teaching basic skills literacy, numeracy and employability across inner city locations of severe depravation in the Northwest of England for a 'Work Based Learning' (WBL) provider. I taught on a programme called 'Foundation Learning' (FL) which was aimed at 16-19 year old NEETS (Not in Employment, Education or Training) Students on the course often experienced family breakdowns, lacked qualifications, experienced SEN/ BSED (special educational needs and behavioural, social and emotional difficulties) and partook in risky behaviour such as substance misuse and crime. I was teaching students with similar social backgrounds to myself, who were also experiencing similar barriers to learning and employment (born of disadvantage and societal attitudes) as I had experienced twenty years previously.

I would have liked to say that over the course of my employment things improved. However, upon leaving vocational education teaching in 2013, the story of my teenage secondary school self was mirrored in the stories my students shared with me about their experiences with education, and particularly their mathematics education. Similarly, their experiences of mathematics at school were a mix of anxiety, poor classroom learning experiences, and a lack of aspiration for the students in the local community, by parents and crucially their teachers. The students experiences often fostered anxiety and negative dispositions towards mathematics, which closed the door to them on many possible career routes and life experiences. The majority of my students progressed to low quality manual or service industry jobs; as I had done before them. Such a lack of access to higher level and skilled technical, manufacturing, mathematical and scientific work was raised in the Wolf review of Vocational Education, with the need for mathematical skills highlighted as a key concern and a recommendation that mathematics be compulsory for those who have yet to achieve a grade C (DfE, 2011). However, what the report

perhaps missed was the personal, emotional suffering that the performance system exposed us all to, where disadvantaged students, and even the ablest students amongst them, disengage from education, and mathematics learning in particular.

From a teaching and pedagogical perspective, FL's remit was to facilitate students into employment by improving their wellbeing in concert with improved academic attainment. There was a specific focus on improving Mathematics and English in what was an almost 'therapeutic' educational programme, which was heavily based on experiential learning. Experiential learning was integral to the weekly timetable and overall course structure and included: work experience placements; an embedded curriculum of Mathematics and English based on real world contexts; arts and performance based learning experiences. Artistic, performance based experiential learning was delivered by course tutors in the centre and also by artists in residence. Additionally, external courses were devised to explore and overcome barriers to learning and employment prospects by tackling subjects important to the learners, and by situating them as integral co-constructors of these artistic endeavours. Opportunities included drama in the classroom as a pedagogical tool (i.e. acting out job interview scenarios), drama productions with local theatres, making films with local filmmakers about their lives and the community, producing their own original music with music producers, photography and drawing and painting. These experiences, whilst educational, were also ways for the students to have a voice and to express their identity. This experience was formative for my approach to this research, as it showed me how the performing arts could help such students express their identity, and suggested such an approach to research might be powerful.

1.2.3 A rationale for the research: A previous study on learner experience

Ways of students having a 'voice' became professionally important for me, and my employer, in finding ways to engage NEET students into education and employment. Ways of having a voice, to express student identity, became the

focus of a practice based research study, which I describe here. The study influenced the direction of this current research.

I became particularly interested in exploring the relationship between learning, emotions and wellbeing and the ways my students could voice their experiences of education; to become experts in their own learning. I was awarded a research grant from the Learning and Skills Council *"Developing the Expert Learner: Active co-production of learning and the impact on mental health and wellbeing"* (LSIS 2012). In my teaching context, I explored the practice of weekly 'learner voice' meetings as a way for students to become experts in their own learning, to improve self-efficacy and wellbeing, and also as a vehicle for the expression of learning experiences (Pickard-Smith, 2012). The project was a mixed methodology of observation, interview, and questionnaire. The purpose was to chart changes in student wellbeing and self-efficacy following their involvement in the learner voice meetings.

The cumulative results from my study and the other LSIS projects were reported at the LSIS National Teaching and Learning Fair (2012)[2]. The standout finding was that having a voice and expressing emotions about their learning experiences was an important priority for the students (Pickard-Smith, 2012, p. 62). HMP Erlestoke's use of drama as a voice in prison education was highlighted at LSIS (2012) as a particularly powerful and productive approach to learner voice.

However, methodological issues with the research design were highlighted in my final report. Students felt their voice was diminished by not being heard in a wider forum, and therefore their ways of having a voice felt insular and

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[2] Details of the learning cafe I presented at LSIS (2012) based on my research, and the work of HMP Earlestoke can be accessed here under 'Learning Cafe' No.3 http://webarchive.nationalarchives.gov.uk/20130802100617/http://www.lsis.org.uk/sites/www.lsis.org.uk/files/T%20and%20L%20learning%20cafe%20information%20FOR%20WEB%20FINAL.pdf

tokenistic. The research wasn't starting from a viewpoint that was meaningful to the students; it didn't begin with their stories of learning experiences and they felt their voices were stifled. When given the chance, however, students valued the opportunity for their learning experiences to be heard more widely; as a powerful means of voicing their identity. Being heard was proposed by the students as a way of being valued.

The LSIS project was germinal for this thesis, focussing my attention on ways of voicing learning experiences of mathematics; conducted so that voices are heard more widely, democratically and also a means for these voices to join the wider conversation on equity in mathematics education. Reflection on HMP Earlestoke's approach to drama as voice and my arts influenced teaching practice, fostered a hypothesis that artistic performance may be a valuable research tool for exploring mathematical identity and performing as a kind of mathematics person. Drama, in particular, was chosen as a means to voice research participant's mathematical identity. Film was chosen to capture the intricacies of constructing and performing a drama and to critically engage a variety of audiences (public, policy and academic) with the research. The choice of suitable research participants would be guided by the literature on mathematical identity and ethical considerations of exploring potentially dismal and anxious experience of mathematics learning through filmed drama.

1.3 Framing the study contribution

In framing what the study is expected to contribute to mathematical identity research I firstly outline two definitions which are important to this thesis: '*Performatics*' and '*aesthetic knowing*'. I then outline the main ABR approach adopted and conclude with the research aim and questions to be addressed in this thesis and a synthesis of the main findings.

1.3.1 Definitions: 'Performatics' and 'aesthetic knowing'

Two definitions are crucial to the understanding of the direction of this thesis: 'aesthetic knowing' as the main claim to a new sense of mathematical identity and *'Performatics'*, which is the film title, indicating the way in which I have come to understand mathematical identity. The definitions of *'Performatics'* and 'aesthetic knowing' are crucial to understanding their use and meaning in this thesis.

'Aesthetic knowing' here has two meanings. The first is situated in practice (Carper, 1978; Galvin and Todres, 2012) with an in-the-moment, perceiving, feeling, sensing of a situation. This is linked to the hermeneutic phenomenological interpretation of human experience (Friesen, et al., 2012), of which Paul Ricoeur's interpretation is employed to interpret identity in practice as dialogic (Bakhtin, 1986); mediated by stories of social others (including the past and possible/imagined future selves). The second is *'aesthetic knowing'* through experiences of beauty (Levy, 2015); this is useful for exploring embodied aspects of mathematical identity, more difficult to capture in purely verbal or written research accounts-such as bodily gestures, memory, inner speech, imagination, thoughts and feelings. Both these aesthetic ways of knowing are brought together to move from practice and the experiential (interviews and observations about mathematical practice) to the presentational and aesthetic (analysing mathematical practice through ABR as a filmed drama). Through the filmed drama the actors become aesthetic objects thus linking situatedness with embodiedness.

There is an additional link between situated and embodied ways of aesthetic knowing. Carper's (1978) aesthetic knowledge was originally a phenomenological understanding of medical caring practices tied to patient/carer wellbeing and emotions and the intimacy of therapeutic relationships and knowledge as embedded in experience and practice. The aesthetic method of drama as research, whilst not primarily a therapeutic endeavour in this thesis, shares with psychodrama and drama therapy (Moreno,

1953 and 1964) the possibility of reflective practice, wherein participants come to an understanding of the self. However, Moreno's drama approach is not central to this study. Rather, I adopt Jean Rouch's filmic psychodrama methods. Rouch was a prolific French anthropological film maker and his career, which began in the early 1940's, spanned some sixty years. Rouch concentrated his filmic work mainly in Africa where he developed what he claimed to be a 'shared anthropology', working with, rather than on his subjects (Henley, 2009), on films such as *'Moi, un noir'* (1958), *'Chronicle of a Summer'* (1960) and *'Jaguar'* (1967). Rouch's films are influenced by the emergence of surrealism and the blurring of the lines between fantasy and reality. Rather than a purely factual observational cinema Rouch purposefully blurred the lines between fiction and documentary through the use of (i) 'ethnofiction' as the acting out of improvisational scene by the research subjects and (ii) 'cinema-verite' (or cinema as truth) as an observational camera approach to unveil the hidden behind and pose the problem of truth and reality (Morin, 1985), casting the filmmaker as a provocateur. Rouch's methods, and my adaptation of them, are described more extensively in the chapter 4 methodology.

'Performatics' implies a scientific knowing of aesthetic performance (Hunter 2007). Hunter proposes 'Performatics' as a verb, a means to scientifically critique and research aesthetic performance, and specifically drama. The thesis film *'Performatics'* is a document of the drama research process and an analytic critique of how the actors performed, through drama, their mathematical identity. This research is a scientific knowing of the dramatic performance of mathematical identity.

However, *'Performatics'* for this thesis is also understood as the coming together of dramatic 'performance' and 'mathematics': 'perfor - matics'.

This duality conveys a sense of the scientific inquiry into the performance of mathematical identity - through performance methodologies.

1.3.2 A synthesis of the thesis contribution to knowledge

Here I synthesise the contribution this thesis will make to mathematical identity and mathematics education research more widely. I address the aim and problems which this thesis tackled and how they were answered with some brief overview of the resulting claims to knowledge and contribution to the field.

The preceding background and rationale for this study guided an exploration of filmed-drama in the mathematical identity literature (Chapter 2), which resulted in the following research aim and problems to be addressed in this thesis.

Aim: To undertake, and assess the value of, filmed-drama for sensing and expressing mathematical identity.

> Problem 1: Develop a theoretical framework of identity as story beyond the written and towards the dramatic/drama.

> Problem 2: Construct an Arts Based Research Methodology

The aim and problems were addressed in an emerging process which began in the thesis' background rationale, expanded on through a review of the literature which defined the thesis problems which were then answered in the subsequent chapters of this thesis which deal with conceptualisations of identity, ABR methodology (including a film component), and the value of ABR to mathematical identity and mathematics education research.

Conceptualised through Paul Ricoeur's phenomenological hermeneutics (interpreting lived experience of narrating the self), Mikhail Bakhtin's dialogism (the self as social in dialogue) and also drawing on Vygotsky's Perezhivanie, identity story is conceived in this thesis as enacted, dramatised, and embodied. Felt emotion and imagination are understood in relation to story conventions (plot and narrative); which powerfully mediate identity. The research as an artistic-academic undertaking is underpinned by ABR principles that artistic

endeavour is inherently analytic, framing film as an academic text. The 'Playbuilding' drama framework of Joe Norris and the surrealist filmic approach of Jean Rouch defined stories of personal experience as provocative, and imagination as central to lived experience where actors look outwards, rather than inwards to the self, to reveal something of their identity in relation to the social.

The written thesis and film thesis '*Performatics: Performing stories of mathematical identity through filmed drama'* (Performatics)', documents the 'identity work' of three post graduate students (actors), who study mathematical courses, as they developed their experiences with mathematics into a drama, which they framed in terms of *'shared feelings'*. The actors' anxious mathematical identity stories, which are performed as tragedy, therapy and anxiety in school settings, jar against fleeting stories of romance for some of the actors, who, outside of the drama, passionately demonstrate their love of mathematics in their everyday lives, and as scholars. ABR unlocked two sites of shared understanding which the actors drew on in the drama. Firstly, 'experiences with mathematics' were interpreted by the actors as past experience and shared feelings of anxiety in the school mathematics classroom. Secondly, their current 'use' of mathematics was understood by the actors in relation to contemporary media and popular images of mathematics and mathematicians.

Three key claims to the value of ABR and an alternative sense of mathematical identity are proposed in this thesis.

(1) Studies dealing with emotions (e.g., mathematics anxiety), attitudes or beliefs have been detached from mathematical identity research. '*Performatics*' examined the intersection of these related concepts. The actors' expression of emotions, memory and imagination, which were fundamental to their identity story as visual and physiological representations, will be shown as more

authentically performed in the drama than were verbally expressed in personal testimony.

(2) The dynamism of storying was brought to life and captured in the film. 'Negative spaces' of inaction and silences were elucidated as means of resisting being storied by others. Additionally, the tension between story authenticity and tellability was realised through the film.

(3) The body was read as both a sign of identity and for its dramatic intent. What will be shown through '*Performatics*' and in this thesis conclusion is that considering social influences, in concert with the influence of narrative (what makes a good story), can reveal something new about identity (e.g. the identities revealed in the film are (i) visceral, and (ii) reflected, and (iii) socially and dialectically or at least dialogically co constructed and shared though the film drama.

In addition, (Herbel-Eisenmann, et al., 2016) advocate for mathematics education researchers to enter a conversation with the media, who they view as key influencers of public and policy perceptions of mathematics education. Where research on identity has been constrained by the word, the film will be argued as a judicious means to represent the richness of identity data with the potential to enhance the impact of the field of mathematical identity in mathematics education.

1.4. An alternative format thesis: The Film and written content

This section details the alternative format of this thesis which includes a filmed component. I detail the contribution to the word count of the written and film component, how the film is to be read (its purpose within the thesis) and set out the thesis structure by detailing the content and contribution of each chapter to this thesis.

1.4.1 Film component: Access and distribution.

I detail here the alternative format of the thesis, the permissions granted for this thesis, how the film aspect of the thesis has been distributed and how the film can be accessed.

An Alternative format thesis was essential in order to include the filmed data as a substantive contribution to mathematical identity research. The film represents a significant portion of the thesis word count, accounting for a quarter of the work undertaken in the thesis. Permission was granted by The University of Manchester to submit the film alongside a reduced word count thesis of no less than 60 thousand words by using existing guidelines within the faculty from Visual Anthropology. The thesis, as an alternative format, follows some of the usual conventions of a traditional thesis; a literature review, conceptual framework, methodology, presentation of data, analysis and discussion and conclusion. However, only the literature review, conceptual framework, methodology and conclusion are presented in a written format. The film constitutes the presentation of data, data analysis and discussion. There are no discreet written analysis chapters in this thesis. The concluding chapter of this thesis has some limited discussion of the filmed data in order to (i) draw together the thesis as a whole and underline a contribution to sensing mathematical identity and, (ii) as examples of how the film evidences those claims and how highlighted aspects of the film could be appropriated in mathematical identity research and mathematics education research more widely.

The film has been screened and distributed in a number of ways. Over 300[3] people have engaged with the film so far, including the general public, government members, policy advisors, business leaders, educators and academics.

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[3] Film audience has been approximated from conference attendance and watch statistics provided by Facebook, Twitter, Youtube, Livestream and Vimeo.

Film screening to a live audience

- *'Pint of Science'* (2015) - International public engagement with research festival. Public and academic audience. Sell out show.
- '*British Society for Research and Learning in Mathematics'* (2016) – Academic conference.
- *'Festival of Identities'* (2016)[4] – Conference by the Skills Funding Agency and the Learning and Works Institute. Academic, policy, government (Dept BIS) business and educator audience. This session was also live streamed online and a posted by the conference to YouTube and live stream http://livestream.com/L4L/ident
- *'Methods at Manchester'* (2016) – Research methods academic conference.

Film distribution via social media

- Vimeo - *Performatics* is available on Vimeo's online video streaming service on the link provided with this thesis.
- Twitter - via the Vimeo link
- Facebook - https://www.facebook.com/performaticalidentity/?ref=br_rs

Press

- *Anyone Need Math Therapy?*[5] - Union Learn blog https://www.unionlearn.org.uk/blog/anyone-need-maths-therapy#.V67woHJ1Rms.facebook

Journal articles resulting from the film

- Article proposal for a special edition of *The Disorder of Mathematics Education. Challenging the Socio-Political Dimensions of Research.* Accepted.

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[4] The *'Festival of Identities'* commissioned an 'alternative', comic academic presentation. The film of this presentation, which includes *'Performatics'*, comes with an adult content warning for adult themes and strong language
[5] The Union Learn blog article has been shared 52 times. The number of time the article has been read cannot be accounted for but are at least 52.

When to view the thesis film is left to the discretion of the reader. However, Chapter 5 indicates a point in the thesis whereby the film should now have been watched. Chapter 5 also provides a brief overview of the film content and an introduction to the film actors who are acknowledged throughout the thesis: Claire, John, Rob and Maddy the drama facilitator. Chapter 6 makes direct reference to three specific scenes in the film: *'Sum Anxiety'*, *'Tense Identity'* and *'Math Therapy'*. A still screenshot and transcription are provided within the text to accompany each scene. Additionally, a timecode is given with each screen still so that the reader may locate this section of film e.g. Timecode 1m 30s (scroll to 1 minute and 30 seconds into the film). *'Performatics'* the film is accessed via a link to 'Vimeo' (an online film data storage repository). You can click the link, or alternatively, copy and paste the link in your web browser. A hard copy DVD is also provided with this thesis.

Link: https://vimeo.com/147449932

Film clips from other media sources are also used in the literature review in Chapter 2 to exemplify salient points in the literature review. These clips are accessed by clicking the link provided or copying and pasting the link into your web browser.

An alternative format thesis was sought to allow the film to be viewed as integral to the thesis and also so that the film, along with written material from the thesis could be published. The imperative for research to appeal to and reach a wider audience is not only important for the academic community to draw on knowledge about mathematical identity to improve educational outcomes and access but also for educational knowledge to reach practitioners, policy makers and the general public. And importantly, that the participants of research have their voices heard and feel that their contribution has been valued through the sharing of their stories. The film format provides an opportunity to disseminate findings to a wider audience, raising the researchers and Universities profile. Thus the findings of this thesis speak to educational researchers, socio cultural theorists and those outside of education with interest in Arts Based Research,

drama and ethnographic filmmaking. From here on the film will be indicated by its shortened title of *'Performatics'*.

1.4.2 Written component: An overview of the chapters.

I now move on to providing an overview of the written component of the thesis, the overall structure, the chapters included in the thesis and their content. Whilst each chapter is distinct and build on each other, there has been some necessary overlap, specifically in the Chapter 6 discussion, which brings the film into a conversation with the literature, conceptualisation of identity and ABR methodology. The Harvard referencing style has been adopted throughout. Beyond this introduction, this thesis is structured into three 'movements' across chapters 2-6. The content of each chapter is detailed below.

Previews: Contains a literature review on arts based methods in relation to mathematical identity research (Chapter 2), a conceptualisation of identity as a story (Chapter 3), and the Arts Based Research Methodology of filmed drama (Chapter 4).

Main Feature: is guided by a short introduction to the film and the actors (Chapter 5) and suggests watching the film *'Performatics'* now if this has not been watched already.

Review: The value of ABR for mathematical identity, and educational research more widely is discussed in this section, determining the film as an original contribution to knowledge and highlighting salient points from the film with which to make claims for an 'aesthetic knowing' of mathematical identity, and concluding remarks synthesising the thesis contribution to knowledge, limitations and recommendations further study (Chapter 6).

Each of the chapters that follow is now summarised.

Chapter 2 situates *'Performatics'* amongst a niche and un-mapped area of mathematical identity research which frames identity as collective storying and is understood through and arts-based research (film and drama). The chapter

details the review methodology and discusses developments in mathematical identity research, moving from traditional narrative approaches which concentrate on oral storying, re-represented as written text to explore how film and drama are used in relation to mathematical identity research. The chapter purposefully switches between methodological critique and reporting on research findings to understand how performative techniques of film and drama have been used or may be of value to mathematical identity research. Literature is expanded to include film examples, which are argued as academic texts. This chapter identifies a research problem of capturing dialogic identity in practice and builds a case for ABR filmed drama as a unique research endeavour where aesthetic knowing is an alternative way to sense mathematical identity.

Chapter 3 brings together Paul Ricoeur's 'Philosophical anthropology' of phenomenological hermeneutics (interpreting lived experience of narrating the self) and Mikhail Bakhtin's dialogism (the self as social in social dialogue) to disentangle what is meant by identity as a story. The chapter is structured around three main themes related to the film data**:** Firstly, *'Story'* as a means to explore dialogism and the narrative function of the story as critical to mediating identity. Secondly, *'Memory'* as a site of the plural self through time and in relation to the social lives of others discussed in relation to Bakhtin. Finally, *'Imagination'***,** where Holland, Lachiotte, Skinner and Cain's (1998) case for cultural production and heuristic development, as intimately tied to identity, holds a mirror up the body and imagination as intimately tied to reading and mediating mathematical identity. This chapter also makes some distinctions between story, plot and narrative. The overall framing of the chapter is how we can come to know identity through aesthetic knowing as related to narrative.

Chapter 4 outlines the Arts Based Research design applied in this study as a combined method/methodology chapter. The methodology is discussed alongside the research methods used. The chapter is punctuated by images, film clips and objects from the research (tables, excerpts from the research diary), to exemplify the methods in action and discuss the kinds of data to be elicited. The methodological direction is guided by mathematical identity as dialogic and therefore dialogic research methods of drama and film are

discussed for their implications of attending to dialogic identity from data gathering to presentation and analysis. The methodology discusses how aesthetic knowing is a rigorous research design. Within the discussion, how drama and film are useful as research tools and the types of data they may elicit is presented. The methodology is also concerned with capturing aspects of anxious mathematical identity. The discussion is centred on psycho-socio drama from a surrealist perspective. Utilising the methodology of filmmaker Jean Rouch, who views dreams and the imagination and an interplay between fact and fiction as part of the actors experience, an ethnofiction approach to observational cinema is adopted where the film uses drama techniques alongside observational cinema to include dream scenes, or aspects of the actors and film productions processes to bring together fact and fiction as part of the lived experience of the film. The Playbuilding technique of Joe Norris, where the drama is conceived of as a research method, is used to structure the drama scenes. This chapter also details the time-consuming and demanding process of participant recruitment and retention, particularly in view of the open-ended nature of the project, and the lack of immediate reference points within the local academy. The extent of investment by the participants is portrayed, and reflection on the demands on the researchers, physical and psychological wellbeing is outlined. The chapter concludes with discussion on the ethical approach to non-anonymisation and data storage.

Chapter 5 is represented by the film *'Performatics'* as the thesis substantive contribution to mathematical identity research. *'Performatics'* constitutes data gathering, representation, dissemination, analysis and discussion of mathematical identity. Arts Based Research principles claim that aesthetic cultural artefacts (like film) can constitute rigorous research (see Chapter 4 methodological discussion). The research effort involved in the film is equivalent to a minimum contribution of a quarter of the work of a 'whole thesis' and therefore counts towards the final word count. There are limitations to using film in research (see Chapter 4 and Chapter 6 for further discussion of limitations). The research participants are credited in this short chapter for their substantial efforts in contributing to the research over the period of 8 months, which resulted in gathering approximately seventy hours of filmed data. In

order to value their significant contribution, in constructing and directing the drama as a drama group, with little intervention from the researcher, the participants are credited as 'actors'. Whilst a short introduction to how the actors became involved in the filming we come to know the actors through the film. The film is an analysis of the actors' identity and represents some theoretical ideas about identity - specifically dialogism (as collective storying) and phenomenological hermeneutics (understanding the development of human experience). It was fundamental to the research design that theorisation of identity occurred through the filmmaking process. Explicit discussion of theory within the film would have gone beyond the film's purpose and its observational research approach (i.e. of coming to know the actors through the film). The theory is implicit in the film through the ABR approach adopted in the research.

Chapter 6 advances mathematical identity research by putting the research film *'Performatics'* into discussion with the literature, conceptualisation of identity and the methodology to consider its value to the research field, highlighting how the filmed drama (i) expressed emotions, memory and imagination as fundamental to identity, (ii) exemplified the tense dynamism of storying, and (iii), read the body as both a sign of identity and for its dramatic intent. The chapter concludes by returning to the problem of why dismal mathematics anxiety stories persist. I synthesise how the thesis has addressed the aim of the research: to sense and express mathematical identity through ABR. I attend to how the problems which required addressing to achieve this aim (conceptualising identity as a story and constructing an ABR) were achieved. Thereafter, the ways in which ABR, as filmed-drama, could be adopted in future research are suggested. Finally, limitations of the study are discussed and how these limitations may also be opportunities for future research.

PREVIEWS

Chapter 2.   Situating 'Art Based Research' (ABR) methods of 'filmed-drama' in mathematical identity research: A literature review.

2.1 Introduction

This review situates the research film '*Performatics*' within a niche area of research (including traditional written academic texts, drama, and film/observational cinema), which understands mathematical identity as collective storying. The intention of the review is to ascertain the state of the art in order to expand on current research and fill gaps in our understanding of mathematical identity. The aim is to break new ground by exploring filmed-drama as a means to elucidate alternative ways of knowing about, sensing, and expressing mathematical identity (in relation to anxious mathematical identities). In doing so mathematics education research is newly positioned so that it may influence/enrich storylines about mathematics, which impact policy and practice.

Firstly, this introduction identifies a continuum of research approaches identified in the literature review and the mathematical identities of concern (anxious identities, the professional mathematician, and just-plain-folks). Then (in section 2.1.1), two recent literature reviews on mathematical identity are discussed (alongside other scholarship) in order to understand what is already known about mathematical identity. Scoping the field in this way defined the review focus on performing identity as a story and provided the grounding to develop an 'aesthetic knowing' of mathematical identity. The introduction concludes with the methodology of the literature review and a précis of the literature (including films) consulted in the discussion. The main discussion is then structured around 'story', 'drama' and 'film'; purposefully interlinking methodological critiques with reporting on research findings in order to understand how identity story is approached and conceptualised in research,

and to ascertain how film and drama are currently or could possibly be productive for mathematical identity research. In the conclusion, the literature is synthesised in order to answer the questions which guided the review so as to identify the research aim and problems to be addressed in this thesis.

Overall, in charting the field of mathematical identity as a story, I identified that the research is broadly working along a continuum of approaches (see Fig. 1.).

Figure 1. Continuum of identity research approaches

More or less		
Presentational	◄───►	Representational
Written	◄───►	Aesthetic
Factual	◄───►	Fictional
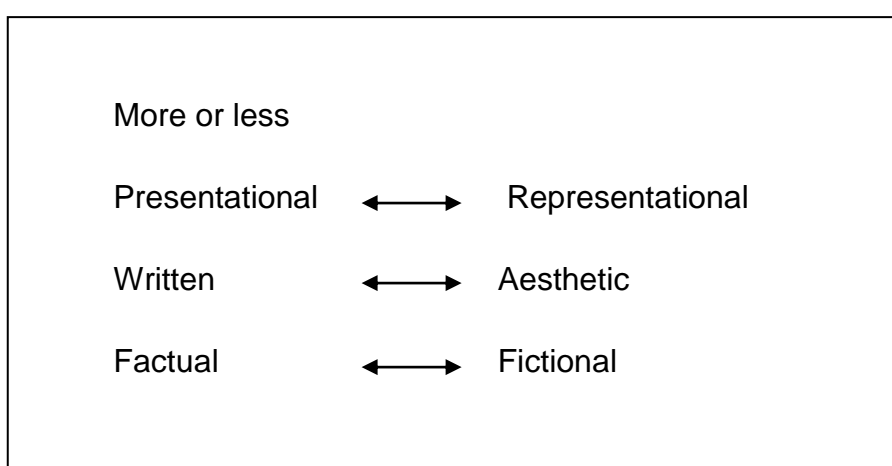
In addition two different, but inter-related, senses of story were also defined: *'oral'* (what we say) and *'embodied/enacted'* (incorporating how we think, feel and act). In a sense it can be argued that oral storytelling, by an individual (e.g. in interview), is some sort of hybrid of these two in practice, and it is interesting to consider also that the terminology of the stage/drama *"sneaks its way into much writing about identity, even when the identity definition does not specifically understand identity in this way"* (Darragh, 2016). Problematically, the academic texts, across the research spectrum, reduced both senses of story to written narrative and privilege oral storying. For example, both interviews (oral story) and observations (embodied/enacted story) are reduced to written texts. Similarly, representational/aesthetic academic approaches also took a written form as fictionalised or experimental texts. Moreover, the potential

of the imagination as a productive site for exploring and understanding identity hasn't been fully realised. These issues are problematic for (a) accounting for identity storying 'in action' and (b) adequately representing or exploring the embodied/enacted sense of storying. In contrast, the more representational dramatic/filmic offerings more usefully accounted for both senses of storying, captured storying 'in action', and also hinted at the potential of drama and film to explore imagination as fundamental to identity story.

Additionally, two main types of 'mathematician' are encountered in the literature: 'professional mathematician' (mad, eccentric genius etc), the stuff of stereotypes, and told of in the popular media, and the 'Just plain folks' (JPF), who are mathematically competent or incompetent. It is important to make a distinction between these two groups, and the attitudes and identities related to them because research suggests these mathematical identities are quite different cultural objects, even though they 'interact' in mathematical identity. These identities are read as real people, with real experiences, but are also symbolic of wider cultural ideas about mathematics and what it means to be mathematical; manifesting mathematical competence by having a certain kind of identity. What does it mean then to be more, or less, mathematically adept? Can you find confirmation of competence, not necessarily in the activity of doing mathematics, but through the cultural context – can the culture define the identity? Throughout the literature review, discussion necessarily turns to the cultural confirmation of these two interlinked mathematical identities, which are understood in their relation to the other.

This section has identified the broad range of approaches to mathematical identity research in the literature, the ways in which story are approached (as oral and embodied) and the two main types of mathematicians (professional and JPF) who may be subject to experiencing anxious mathematical identity.

2.1.1 Review Rationale: What is already known, or claimed, about mathematical identity

This section provides a rationale for the performative focus of the literature review and thesis. Firstly the literature is grounded in significant concerns about anxious mathematical identities. Secondly, and more substantially, the field of mathematical identity research is described in terms of ontological perspectives of mathematical identity as a dialogic, psychological, social and cultural phenomenon. Whilst drawing on scholars from the field, I attend more heavily to two recent literature reviews on mathematical identity by Radovic (2016) and Darragh (2016) in order to give a breadth of understanding about what is already claimed, or known, about mathematical identity, and particularly in light of some critique of a lack of conceptual coherence in mathematical identity research. This breadth crystallised a gap, pertaining to literature of a more performative persuasion, which were claimed to account for the various approaches in research and therefore offer a conceptual coherence. Performative approaches are then explored in more depth in the review discussion from section 2.2 onwards.

This thesis is situated amongst significant, continued concern with mathematical identity and negative stories about mathematics. This review, therefore, is concerned with how subjects are positioned in relation to anxious identities with respect to two main mathematical identities of 'professional mathematician' and 'Just plain-folks'. Studies of mathematics anxiety are well researched[6] from psychological and cognitive perspectives which predominantly favour quantitative or experimental research designs. The identity research group at the International Conference on Mathematics Education (ICME) have recently critiqued current approaches to mathematics anxiety as somewhat disconnected from the identity literature (Kaiser, 2016, p.25). The Identity ICME

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[6] See Dowker et al. (2016) for a review of 60 years of mathematics anxiety research. They report a great deal of quantitative research on social influences of anxiety, including gender stereotypes and recommend more investigation on other influences such as parents and teachers.

group cite recommendations from an earlier Psychology of Mathematics Education (IGPME) conference that researchers pursue study at the *"intersections between identity and other affect-related constructs"* (Frade et al. 2010). This concern is shared by the current British Academy commissioned systematic review of mathematics anxiety research. The British Academy review is grounded in previous research with an ontological perspective of the psychological, social and cultural as critical to understanding the phenomenon.

> "Despite the large amount of literature related to mathematics anxiety and the underlying concerns around numeracy and confidence with numbers, there has been to date a limited understanding of the evidence beyond the different research communities that dealt with the topic and its implications. Previous research also suggests that the focus on anxiety needs to be tempered by other closely related variables and constructs (such as dispositions, efficacy, and identity). To identify the implications for policy and practice, the phenomenon needs to be understood from the outset as both a psychological and a sociological, cultural phenomenon"

> (Pampaka et al., 2016)

Pampaka et al (2016) support an inter-relation between anxiety and identity and suggest that a wider perspective could aid our understanding of the phenomena of anxious mathematical identities. I draw on two recent systematic reviews of mathematical identity research (Radovic, 2015, and more extensively, Darragh, 2016) to ascertain what perspectives are adopted in, or suggested as useful to, mathematical identity research.

Firstly, Sfard and Prusak (2005) critiqued a lack of conceptual consensus, whereby identity is rarely defined or explained in the literature. They illuminate how identity can be variously described in the literature as cultural productions, beliefs, attitudes, practices, and, for Sfard and Prusak -stories.

Problematically, for Radovic (2016) this breadth of identity research was claimed as 'overcrowded' and still subject to Sfard and Prusak's critique of a lack of coherence in the mathematical identity literature. In a systematic review of mathematical identity research, Radovic considered why this lack of coherence might be the case. Radovic identified two *'turns'* in mathematical identity research. Firstly, the *'affective turn'* of the 1970's which explored an individual's beliefs, emotions and attitudes (Fennema and Sherman, 1977); and the more recent claim that identity is an affective variable (Hannula, 2012). Secondly, the *'social turn'* of the 1980's identified social activity as mediating identity. Whilst some scholars were identified as claiming that identity can bridge the gap between these individual and social perspectives *"thus constituting a missing link (e.g. Boaler 1999a; Sfard and Prusak, 2005)"* (Radovic, 2016, p.120). In mapping the field in this way Radovic was also able to define five main categories of identity conceptualisation:

> "identity as individual attributes; identity as narratives; identity as a relationship with specific practices; identity as ways of acting; and constraints and affordances of local practices".

> (Radovic, 2016, P.120)

Broadly these identities are ways of thinking, being and doing in social, cultural contexts. Radovic suggests that mathematical identity research may find a solution to conceptual coherence by looking outside of the field.

Not too dissimilar from Radovic's classifications are the '*participative, narrative, discursive, psychoanalytic and performative identities'* classified in Darragh's (2016)[7] review of mathematical identity research. Darragh charted the last two decades of mathematical identity research, identifying that USA and UK scholars were abundant in the literature and that most scholar's adopted a qualitative approach. Darragh's analysis of the field maps the differences,

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[7] Darragh (2016) analysed how mathematical identity research uses the concept of identity in empirical and theoretical research. She reports the authors drew from identity work from outside the field of mathematics and even outside education and overall there was general support for the notion that identity is poorly defined in mathematical identity literature.

similarities and overlaps between approaches, which are synthesised here in order to understand the state of the art and how it is moving forwards.

For Darragh, participative identity is exampled by those researchers drawing on social theories of learning who claim identity is mediated through participating and engaging in social groups. Darragh exemplifies Solomon's (2007b) use of Wenger's (1998) Communities of practice to explore female undergraduate mathematical identity, Holland et al.'s (1998) Figured worlds to explore the positioning of fragile mathematical identities, (Solomon, Lawson, & Croft, 2011) and Bakhtin's dialogism to understand the individual in relation to the social storing of identity (Solomon, 2012). Figured Worlds also offer 'figures' as mediating, cultural resources in understanding identity as narrative (Williams, 2011), and contemplating how a particular context (e.g. the mathematics classroom) positions identities through cultural norms and rules (Boaler and Greeno, 2000). I suggest that Boaler and Greeno's approach is particularly useful to considering the role of environmental context in mediating mathematical identity.

Already we can appreciate the overlap between approaches as Darragh draws our attention to the common ground participative approaches share with narrative/discursive approaches, which draw on the proposition that identity is something told, (e.g. Andersson, 2011; Bishop, 2012; Heyd-Metzuyanim, 2013; McCulloch, Marshall, DeCuir-Gunby, & Caldwell, 2013). Most notably, Sfard and Prusak's (2005) identity storying (the stories you and other tell of yourself) as an identity in practice; as identity work. Darragh notes that some post-structuralist narrative/discursive approaches contemplate a relationship between individual and other (societal) stories of mathematical identity; for example, the media's role in mediating mathematical identity (Mendick, 2005; Epstein, Mendick, & Moreau, 2010). Darragh also claims evidence of an overlap in that some post structural analysis is also apparent in psychoanalytic views of identity, which aim to gain a deep analysis of personal experience in relation to social, and historical, narratives about mathematics, which shape subjectivities

towards mathematics; such as Walshaw's (2013) concern with gendered identifications. We could arguably add social class, e.g. what it means to be 'disadvantaged' (Zevenbergen, 2001), and race, e.g. what it means to be black and do mathematics (Martin, 2012) to research which explores subjectivities.

 In addition, as has been argued by Roth and Walshaw (2015), in drawing on Vygotsky's 'Perezhivanie' (lived experience) to explore the case of mathematics anxiety, is that the affective properties of these social, historical, narratives cannot be divorced from cognition. That is cognition and lived experience are both necessarily emotive and therefore how one thinks and feels are connected. For mathematics education research this perspective is productive for thinking about subjectivities towards mathematics and how affect might influence one's identity, and cognitive function, dependent upon one's experience with mathematics.

A useful example of a psychosocial approach, which draws on both social science and psychoanalysis, is Brown et al.'s (2008), paper *"I would rather die",* which investigated subjectivities of 16 year old students and their reasons for not continuing mathematical studies. The student's emotional experience was languaged as difficultly, frustration, struggle and hate. This psychoanalytic approach revealed the formation of 'subjectivities', and the personal, psychic, 'investment' one makes in taking up a position over another. Elsewhere, Bibby (2002) had earlier reported how mathematics is often experienced as intensely emotional, reporting how the absolutist/product conception of mathematics provides opportunities for shameful reactions to criticism of mathematical ability by others. These subjectivities are not dissimilar to the narrative/discursive identity or the participative 'identity work' of storying oneself against the social stories of others. However, what Bibby and colleagues argue is that the depth of the psychoanalytic approach, and attention to behaviours, language, and what cannot easily be articulated, facilitates a deep exploration of the feelings towards experiences with mathematics. For example, more recently, Bibby (2007) had identified fragile and febrile emotional states of children in the

mathematics classroom, which were not heard or noticed by the teachers. Bibby contends that a psychoanalytic approach offers a means to attend to what the discursive cannot capture by paying attention to

> "the gaps and contradictions in discourse that make visible the limits of what can be articulated. This attention enables us to foreground behaviours and 'throw-away' comments made in-action"

> (Bibby et al, 2007, p.1)

This premise of emotionally experienced mathematics, often difficult to articulate, or sense, takes us to Darragh's final category of performative identity research, which draws on scholars such as Butler (1988, 1997), who conceives performed, historical and stylised acts of identity, and Goffman's (1963) socially performed identity. Darragh contends that much research is now drawing on these performative approaches (E.g. Chronaki, 2011; de Freitas, 2008; Gutiérrez, 2013; Neumayer-Depiper, 2013).

Mathematical identity has been variously identified so far in this section as a cultural production, as practices, acts, beliefs, emotions, subjectivities and performances. It has been claimed that the multiple approaches have led to an overcrowding of the field.   However, others have suggested these overlaps and connections are necessary and that identity is the connecting factor

> "We see identity as a unifying concept that can bring together multiple and interrelated elements that all stakeholders (including teachers and students) bring to a learning environment. These elements include beliefs, attitudes,emotions, cognitive capacity and life histories. Although these respective elements have individually provided a central focus of numerous studies in mathematics education, the concept of identity potentially connects these elements"

> (Grootenboer et al, 2006, p.612)

To accommodate conceptual coherence it has been suggested that mathematical identity research adopts alternative approaches (Darragh, 2016; Pampaka et al, 2016; Radovic, 2016). However, Darragh finds the alternative already evident; as performative identity research. Darragh concludes that performative identity can bring together the varying, yet often overlapping, approaches to mathematical identity research in order to provide the necessary coherence for operationalising identity in research, whereby

> *"Perceiving identity as an act, a performance that may or may not be recognised as desired, is a useful future direction for research. It is in this direction that the study of identity has much to offer.*

> (Darragh, 2016 p.29)

Mathematical identity research has begun extending into new research communities, to uncover new understandings about mathematical identity through the literary/narrative arts, the rise in prominence of Bakhtin's dialogism, and a call to Arts Based Research (ABR) which moves knowing about mathematical identity into aesthetic practices. Dialogism is gaining prominence as an analytic perspective on mathematical identity.

> "The significance of Bakhtin to sociocultural theories of education seems to have grown more prominent recently. It is still relatively under-used in mathematics education with some exceptions. Bakhtin's work has been developed and synthesised with Vygotskyan perspectives in mathematics education with reference to Engestrom's original work by authors such as Roth and Lee (2007) and Williams and Wake (2007). More recently, work on identity and narrative from Bakhtinian-Vygotskyan influences has become better known and used in mathematics education, largely because of the insights it affords into mathematical identity, human agency and "world-making" (see Braathe & Solomon, 2015; Solomon, 2012; Solomon et al., 2016; Williams, 2011)."

> (Brown, et al., 2016, p. 292)

Developments in dialogic research include the ways data texts are interrogated or put in dialogue with the voices of others; explicit and implicit voices in the subject's narrative (Solomon, 2016), researcher voice (Povey et al, 2006) and public audience (Boylan and Povey, 2009; Povey, et al., 2016). For Brown et al, these public images of mathematicians, as cultural resources, are contradictory and in tension.

> "public images of mathematics pull in a number of directions that produce alternative conceptions of mathematics. These disparities of vision result in much variety in how mathematics is materialised in everyday activity. They also point more fundamentally to the uncertain ontology of mathematics itself and its evolution according to the demands made of it.
>
> (Brown et al, 2016, p. 294)

The implication of public images as cultural resources to mediate identity speaks to the fields of cultural, dramaturgical and media studies and provides the potential to consider how various voices and, therefore identities, interact dialogically. Thusly texts concerned with cultural and media perspectives of mathematical identity are of critical concern to this review. Additionally, Rosiek (2013) highlighted an impasse in qualitative research and declared an under-utilisation of and limited literature on creative methodologies in mathematical identity research, calling for arts based methods which could provide new possibilities for data collection, analysis and representation.

During the research process, the call to ABR for mathematical education research was growing. Increasingly, education researchers were advocating performative practices in order to: validate how ABR could be rigorous research (Cahnmann-Taylor, and Siegesmund, 2007); sense the mathematical body differently through the camera as scientific inquiry (De Freitas, 2016); understand mathematical identity as performed (Darragh, 2016); and raising the profile and influence of mathematics education research (Herbel-Eisenmann et al., 2016). Herbel-Eisenmann et al. (2016) comment that mathematics educational research is not strongly positioned to influence the storylines of

policy, practice, and public notions about mathematics and mathematicians. For them, key influencers are outside of academia, communicating through policy and the media. Their solution is for mathematics education researchers to engage these key influencers by disseminating their work to broader audiences, which, in their estimation, will require alternative forms of communication, including social and mixed media. Herbel-Eisenmann et al. [8], provide some examples of successful public scholarship which is already having an impact and advocate for these practices to be more widely adopted in mathematics education.

Overall, the developments in mathematical identity research herald an opportune moment to scope a niche area of mathematical identity research concerned with: bringing together identity and affect (mathematics anxiety), disentangling what is meant by identity story, and engaging with the media as a means to elevate the influence of the field, policy, practice and public perceptions on mathematics education. I suggest approaches from the dramaturgical and film research communities may address these concerns. To this purpose, this review intends to scope the more performative literature in more depth and to include filmic and online social media resources as useful sources of data.

This section has outlined the most recent reviews of the state of the art, which have mapped approaches to mathematical identity research as psychological, social and cultural. It has been claimed that identity has been approached in varying ways, which has led to a sense of a lack of conceptual coherence. However, further reviewing the field has identified much consensus and overlap,

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[8] The National Council of Teachers of Mathematics Research Committee reported in the *Journal for Research in Mathematics Education* (2016), Vo.l 47, No.2, 102-117 commentated that key influences on mathematics education were outside the academic domain and instead identified policy makers and the media as influential. Engagement with media was viewed as key to raising the profile of the field. Two key examples cited included Jo Boaler's blog (see http://joboaler.com/blog/) and Samuel Otten's Math Ed Podcast (see http://mathed.podomatic.com/).

culminating in a suggestion that a performative approach could usefully bring together the varying approaches in order to offer a coherent account of identity for mathematical identity research. This literature review will, therefore, focus in on ways the field is, and might possibly, move towards a performative approach and is guided by the following questions:

(i) How is mathematical identity, as story, approached and conceptualised in the literature?

(ii) What is the current use and potential of filmed-drama to sense mathematical identity story differently?

2.1.2 Literature review method

A systematic review was considered and ultimately rejected as being less likely than a traditional narrative approach to access the unconventional arts based and performance literature (including films) which may not be accessible from key word searches due to search protocols. Reviewing an emerging field presented an opportunity to include a wider breadth of literature to investigate how the performative arts (film, theatre, TV) have been incorporated in mathematical identity research and how they mediate mathematical identity. Film clips are included in the literature as an academic text. Film and drama were hypothesised as less likely to be captured in a key word search because film doesn't always follow academic conventions of providing key word tags and are more likely, than academic sources, to have titles which are esoteric, metaphorical or plays on words, which may not clearly indicate their relevance.

This review looks for ways in which performance and identity intersect. For this review, literature with a narrative and performance persuasion was sourced. Whilst books were excluded from Darragh's (2016) systematic review, *'Mathematical Relationships in Education: Identities and Participation'* (Black, Mendick, & Solomon, 2009) was noted as a 'demonstrably significant' work. The significance of this review is the book's chapters which frame experimental

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texts as early explorations into ABR, and those chapters which deal with emotions, mathematics anxiety and anxious or tense identities.

Whilst there was no data range restriction for this review most literature were produced in the last 10 years, indicating narrative, and particularly texts with a performance approach, are emerging in the field if mathematics education and mathematical identity. 131 texts on mathematical identity, which were published before 2013 were examined in more depth. After the completion of the research, a further 15 texts published between 2013 and 2016 were added to the review in order to position this thesis amongst contemporary debate. The more traditional academic texts included in the review were sourced from journal articles, books, book chapters, conference papers and PhD thesis. The scoping focused my interest on literature which said something about UK mathematical identity, and I draw on these heavily in the review for their salience to exploring the mathematical identity of British born students. Key UK academic authors include Mark Boylan, Laura Black, Heather Mendick, Hillary Povey, Yvette Solomon and Julian Williams. However, Canadian scholars, Susan Gerofsky and George Gadanidis are key authors utilising arts based drama and filmic approaches to mathematical identity and their work is critical to the review.

The literature review conducted in four stages.

> **Stage one:** Initial search terms in scholarly repositories and Academic Journals including Scopus, PsychInfo, Google Scholar, Mendeley, Elsevier, and University of Manchester Library, journals focusing on Mathematics and Education in general and on Drama and Film in education.
>
> Search terms: Mathematics, identity, performance, home, school, classroom and workplace, dialogism/dialogic.
>
> **Stage two**: Emerging themes from initial literature were added to the search

New terms: Anthropology, visual anthropology, story, narrative, film mental health, madness, anxiety, gender

Stage three: Snowballing

References contained in the literature from the initial searches were followed up for their potential usefulness and salience to the review.

Stage four: Informal content search of film repositories such as film festivals, YouTube, Vimeo, Journal of Video Ethnography and BBC films.

Stage five: Update the literature with academic sources from 2013 onwards

2.2. A 'collective storying' of mathematical identity

In order to expand our understanding of mathematical identity, it is crucial to trace current approaches to identity as a story. This section starts to make sense of the field and we see an emerging continuum of mathematical identity research along with a spectrum of presentational (factual, written) research accounts which move towards more representational (fictionalised, and/or aesthetic) accounts.

The literature consulted take a socio-psychological perspective of identity and are concerned with how mathematical identity relates to mathematical learning, often accounting for anxious mathematical identities. There is often little distinction amongst the accounts of mathematical identity between narrative and story by researchers and so these terms are used interchangeably in this chapter to reflect their approaches. I outline the recent developments in narrative approaches, from the more traditional transformation of the interview and observational data into narrative transcripts to more experimental and literary approaches with the emergence of dramatic texts as research, highlighting the findings which are elucidated as a result.

Whilst mathematical identity research was relatively late to the use of story in research (Rosiek, 2013), stories of 'doing' mathematical identity research are increasingly adopting narrative approaches in order to understand mathematical identity as socio-culturally constructed (Darragh, 2016). For example, Williams et al (2009) argue these narrative identities, 'ways of talking', or 'repertoire', provide ways of relating experiences of mathematics in educational contexts. Those experiences, they argue, shape dispositions towards mathematics as a subject. More usually, these stories begin as interviews or observations, which are then transcribed as narratives and the reader sees the interpretation through the transcript. For example, in interview, female students have been transcribed and analysed as narratives, which elucidate tensions from: a curriculum that is alienating to them (Boaler, 1997); possessing a female body and being mathematical (Mendick, 2005, Solomon, 2012, 2016a), and a resistance and re-figuring of female mathematical identity against positions which are *just stories'* (Solomon et al, 2007). These stories are also implicated in students' affective dispositions towards mathematics.

Black et al (2009) show how an increasing test, assessment, and selection culture is increasing negative emotional states around mathematics. Negatively associated emotions contribute to a negative feedback loop whereby student's expectations of the task ahead gives rise to negative emotions which then hamper test and/or mathematical performance, thus reinforcing the negative experience (Hembre, 1990; Bull, 2009). This anxiety is also evident for high ability students, particularly girls, who, because of particular cultural ideas about the type of people who are able mathematicians already hold negative beliefs about their mathematical ability (Solomon, 2007a; Solomon, Lawson and Croft, 2011). Moreover, whilst much research addresses female mathematical identity, boys are also subject to similar anxieties borne from a cool/mathematics dichotomy and the geek identity of being a 'mathematician', both of which may alienate from mathematics (Lucey et al. 2003, Mendick et al., 2010). Boylan and Povey (2009) claim that narrative inquiry assists our understanding of the perseverance of anxious mathematical identity by attending to emotional and psychological states that come with identifying with,

and performing as, mathematical (or not) and how these states can be discursively expressed as

> "anxiety, fear, hope, despair, envy, resentment, disappointment, anger and shame...fundamental to and constitutive of the mathematical life world of learners"

> (Boylan and Povey, 2009, p. 48)

However, if we are to follow the socio-cultural perspective that a person's identity is mediated through a relationship between social others and culture, then it also follows that the stories they tell of their experiences, and indeed the feelings they feel, will also be mediated by the same social and cultural constructs. Whilst Bruner (1987) advocates narrative inquiry as a means to understand identity, where life is narrative, he also cautions that self-biography is unstable, meshing with others cultural understanding; which necessarily includes emotions.

From this point in the discussion moves on to Arts Based Research approaches and how they might be useful to exploring emotions and more embodied ways of being. Attention is paid to how Arts Based Research approaches can be considered as data collection, analysis, and discussion and research presentation –a whole research process. In doing so the discussion purposefully makes connections between methodology, method and theoretical approaches to ascertain the usefulness of such approaches to mathematical identity research. The following examples evidence how the approaches adopted work more or less successfully in eliciting identity data and facilitating analysis of dialogic identity as a practice of collective storying.

Solomon, (2016) builds on Bakhtin's analysis of parody to illustrate, manage and recount authoritative voices speaking to and through the subject as a parody, or *'skaz'* speech in an almost theatrical style. The subject, 'Beverley',

variously voices the players implicated in the mediating of her mathematical identity around discourses of ability.

> I got home […] dad was very silent and very still – that's how he deals with things he's a bit of a hedgehog (intake of breath) *"turmoil, emotional turmoil, oh I can't I don't know if I can I cope with my disappointment or my anger or my joy or my sadness or my happiness or I'll just curl up and make everyone stay away so I don't have to deal with it"* (dramatic voice of father) ... and mum said "*you have three choices, Beverly, because you're not re-sitting them*" (pompous, formal mother)
>
> (Solomon, 2016, p.6)

Parody speech was not initiated by Solomon in the interaction with Beverley but rather Beverley's natural inclination towards *'not speaking straight'* presented an opportunity to analyse the multiplicity of stories Beverley navigates in her attempts to resist stories of failure whilst highlighting her struggle to find an internally persuasive discourse. Solomon concludes the notion of 'multiplicity' *"is thus fundamental to becoming, being and persisting as 'able' in mathematics"* (Solomon, 2016, p.8). I contend Solomon's purpose is productive in that the various voices become apparent but that the documenting of this dramatic parody in written form becomes thick with punctuation which is necessary for the transcription to account for the complexity of the conversation. To have heard or had a visual reference would help the reading of the data to account for the other non-verbal cues that necessarily accompany speaking as another – how were those voices voiced? There is potential here to draw out and give even more room to how Beverley perceives these voices, which are imaginative representations of important characters in her identity story.

Drawing on socio-drama approaches, and the 'stepping into the experience of another, Boylan and Povey, (2009) have written what they call an 'extended monologue' of their subject's (Louise) experiences with mathematics. The monologue is chosen by the researcher as indicative of a salient point they wish

to highlight and is only interrupted by intermittent researcher analysis. The method purposefully engaged the audience to highlight the lesser considered emotional and psychological states that come with identifying with, and performing as, mathematical. Similarly, Di Martino and Zan (2010) engaged their research subjects in the writing of their own extended monologues to 'diagnose' anxious mathematical experiences. The narrative offered a way for them to consider the story plot for a more holistic sense of the story, which was then systematically analysed for key phrases and words. These texts could be considered performative and dramatic. Indeed, literary texts possess a quality of painting pictures in the readers' mind, which can be powerfully moving. An additional aspect to capturing the emotive aspect of mathematical identity would be to see how these emotive stories are also bodily told by the author and what new understanding could be uncovered through a deeper exploration of embodied aspects of identity.

In the *'Storying of Joanne'* , Povey et al., (2006) adopt Heron and Reason's (2006) *'co-operative inquiry'* to better understand the storying process, in a movement from experiential knowing (the interview, observations of the research subjects and social activity) to a presentational aesthetic knowing (the literary formulation of the data). In their experimental paper, Povey et al. Position the various narratives of the subject (Joanne's) alongside transcribed narratives of the researcher and lecturer (notes and emails). This interplay between the various actors in Joanne's story is an account of the collective re-storying of Joanne's experiences with mathematics. Evidently, Joanne's identity is a product of the interaction between herself, researcher and lecturer. Making the researcher's thoughts and processes more transparent affords the audience an 'insiders' perspective of the crafting of 'Joanne', adding to the research rigour by making the researcher's analytic thought process accountable to the audience/reader. I suggest such co-operative inquiry is a productive means to account for the activity of crafting an identity in practice amongst the voices of others and is an approach that warrants further attention.

Nardi's book *'Amongst Mathematicians'* also re-stories original data; in this case around the *"problem, characters, settings, actions and resolution"* (Ollerenshaw and Cresewell, 2002, p .330 in Nardi, 2016, p.4). Analysed were themes, patterns and causal links. Subsequently, the re-storying affords the researcher opportunity to also re-contextualise the story of the research in a more coherent and ordered format from the original tellers, which may be chronologically disordered or missing contextual detail that would assist the reader/audience to make more sense of the narrative (Nardi, 2008, p.19). Nardi's interest was the pedagogical experiences of University mathematicians (who interestingly were all male). The mathematicians were presented with teaching resources and student work as provocations for discussion. Nardi's dialogic format re-storied the raw data as fictionalised dialogues between a mathematician and mathematics researcher, arranged as 'episodes' around the data themes. The narrative framing of 'Amongst Mathematician's' makes it, referentially at least, an insightful expose of identity as voiced through the mathematician's sense of being mathematical, albeit through the lens of a fictional dialogue.

> "I recall how simple and beautiful and illustrative was my first encounter with the proof for the sum of the first n integers. I recall feeling moved. I recall thinking hey, this is something new and it's called mathematics!"

> (Nardi, 2008, p. 98)

Narrative brings an emotional quality and allows space for the subject to drive the narrative towards their own intention. However, this also means that some subjects worthy of intellectual pursuit, in this instance the discussion on affect for example, whilst touched upon were not sufficiently covered for the researcher to make any claims in this respect. Nardi attends to such necessary deficiencies which result from sometimes overwhelmingly rich data

> "There are so many things that the dialogues between M and RME are not about; so many angles and issues on the learning and teaching of undergraduate mathematics that have been left out – some might say glaringly so. Take Affect: there are some references to building student

confidence but M and RME hardly pursue affective matters to the extent these matters certainly merit."

(Nardi, 2008, p.293)

What fictional re-storying can offer is a space to present multiple perspectives in a finite space of an academic text whilst still offering the complexity, depth and breadth of experiences of the various participants.

De Freitas (2004) also re-stories data, in this case, a fictional 'political text'; an outlet for otherwise unknowable dissenting inner voices to be made evident as an alternative reading of mathematical identity. What these texts have in common is the dramatic sense which the narrative provokes through the reading.

"...perhaps research through telling stories can be a form of literary endeavour (Clough, 2002) where we have, precisely, a responsibility to craft our text? "

(Povey and Angier, 2016, p.461)

Stories as data may only be convincing because they follow comfortable and satisfying narrative styles (Stronach and Maclure, 1997). It has also been countered that lives are not lived as neatly packaged stores (Strawson, 2004 and Mackenzie and Atkins, 2008). Critical questioning of this approach is, therefore, useful to determining the value and scope of narrative research.

Williams et al (2009) questioned their own narrative approach by drawing on work from their project, *'Opening doors to mathematically-demanding programmes in Higher Education'.* The project explored student transitions between high school, college and University. The purpose of this analysis was to demonstrate and evaluate the projects discursive psychology and narrative approaches to understanding and explaining the production of mathematical

identity in practice through a post-hoc analysis of four of the project's papers[9]. Data consulted related to student biographical interviews and classroom observations. Their appraisal argued that analysis of mathematical identity is assisted by a 'boundary object' as a shared story; a cultural model of mathematics which brings together the activities of practicing mathematics and storying the self, showing how a cultural model arising from mathematical classroom practice can be instrumental for students narrative identity work. Their approach successfully demonstrated how biographical interviews could be considered activities like any other, which take a particular form in a given moment between actors –the key point being these actors brought experiences with them as they came into the interview activity. In this storying process, the activity was critically questioned

> "Quite apart from the essential post hoc storying of the student's accounts, as interviewers do we not co-construct the narrative with the student in ways that we find 'satisfying'? Can we convincingly draw conclusions for identity and classroom practice based on these narratives alone?"

> (Williams et al, 2008. p.64)

This re-storying could be considered reductionist and the focus on the story might impact data validity. That the students changed their stories between interviews did not threaten validity but rather spoke to the dynamic of storying the self amongst others and it was this development of identity which was of interest where the interview was a site of enacting identity in practice. It was also concluded that the explanatory power and complexity of narratives came with a price. Finding the physical 'space' within the word count of a written account (article or chapter) was problematic (Williams, et al, 2008, p.28). Additionally, there is artificiality about the interview scenario and the re-storying. Williams et al.'s study reflected that difficulties with maximising observational

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[9] Papers drawn by Willams et al (2009) in their critique: Black, Davis, Hernandez-Martinez, Pampaka, Wake, & Williams, date -under review; Hernandez-Martinez, Black, Williams, Davis, Pampaka, & Wake, 2008; Williams, 2007; Williams, Black, Hernandez-Martinez, Davis, Hutcheson, Nicholson, & Wake, 2007.

data in their narrative framework resulted in a shallow treatment of identity in practice (identity work). Whilst overall, Williams et al concluded narrative as useful for exploring identity contradictions (how one narrates themselves differently in different conditions) their reflections identified a gap for an ethnographic approach to researching mathematical identity in practice and

> "the need for discursive and narrative methodologies to be complemented by ethnographic-style case studies of social practice in order to produce 'explanations' of trajectories of identity"

> (Williams et al, 2008, p.2)

Evidently, the literary arts, as productive for exploring stories of mathematical identity, provide insight into the dialogic storying of identity making but are constrained somewhat by the complexity of narrative and questions arise as to how to how to capture data, analyse and present it?

In summary, my interpretation, and how I envisage using ABR to contribute to my research is to use the dramatic texts as a springboard to move beyond written text to more dramatic-ethnographic methodologies to evidence aspects of identity (such as imagination, inner speech, emotions) more difficult to express in purely textual accounts. In the process of the research, we come to learn something new about the subject of mathematical identity. Identity as a story has been approached from more traditional presentational (factual-written accounts) along a continuum to more representational (fictional and/or aesthetic). Crucially, whilst emotional states can be verbally expressed, they are most often 'felt'. Whilst there are attempts to capture embodied aspects of identity such as thoughts, feelings and emotions, these studies reduce the data to written accounts. Whilst primacy is given to oral storying it is questionable how far discursive expression can adequately express these states which are embodied. There is potential to develop these approaches and access the research subject's imagination as an underdeveloped resource in mathematical identity research.

2.3. Dramatic mathematics

Now I move on to the potential ABR approaches and firstly, how drama is approached in relation to mathematical identity research. Drama, as pedagogical practice (drama-pedagogy), is discussed for its potential as an important outlet for students' expression of mathematical identity. Drama-theatre questions depictions of mathematics and mathematicians in Theatre, exploring how these performances might mediate the mathematical identity of the audience and wider society.

Performance literature for mathematical identity was limited to mostly international studies. For drama pedagogy, Sengun's (2010) literature review of drama as pedagogic activity in mathematics education concluded there were limited scholarly studies on this topic (17 in total). The date range for the review is not made explicit but the most recent article included in the review is dated 2009. Sengun concluded that there are not enough studies of creative drama practices in mathematics classrooms and that studies conducted were quantitative and concerned with drama as a means to improve academic attainment. Sengun concluded the quantitative data was inadequate to examine human behaviour and classroom practice, particularly how the drama worked in the classroom. Rather than cover Sengun's work, I concentrate on studies from 2008 onwards, to capture studies Sengun did not and to explore those of a qualitative persuasion. These examples are limited and so I rely heavily on three key international, academic contributors who are mathematics educators and researchers: Gerofsky, Gadanidis and Caglayan. Drama practitioner Patrice Baldwin is included as a UK contributor to mathematics drama pedagogy. All contributors advocate performance and drama as pedagogical tools and powerful expressions of mathematical identity in practice.

2.3.1 *"Make us go to story land"*: Drama in the mathematics classroom

'Make us go to story land' scopes the landscape of drama in the mathematics classroom, beginning with an overview of drama pedagogy literature. Thereafter

four examples from Patrice Baldwin, Susan Gerofsky, Gunhan Caglayan and George Gadanidis specifically focus on drama in the maths classroom in order to ascertain how drama has been used in mathematics education, in mathematics education research, and to scope the value of drama for researching mathematical identity.

The literature on dramatic performance as pedagogy in education is plentiful: See Fleming's (2010) review of the arts in UK education and Davis et al (2015) for sociocultural approaches to drama in education. In comparison, literature on Drama as pedagogy in mathematics classrooms is scarce. Davis et al.'s (2015) Vygotskyan framing of drama pedagogy contains no examples of mathematics drama pedagogy, whilst Sharma's (2016) international perspective of drama pedagogy only references drama in mathematics in relation to possibilities for drama framed by the UK Mathematics National Curriculum. Most mathematics drama literature is concentrated on international sources[10].

The literature on drama in the UK mathematics classroom was limited. Indeed guidance for including drama in the UK National Curriculum does not currently include mathematics (Arts Council England, 2003). Fleming et al.'s (2004) positive impact of drama pedagogy in improving primary school children's mathematical performance is of note. Other UK sources included a proposal for a study using dramatic discussion with adult learners of mathematics (Griffiths, 2012)[11] and an ongoing, and as yet unpublished project entitled *'Embodying mathematics'*, developing drama and movement in the mathematics classroom (Boylan et al, 2015)[12]. Similarly, Back and Lee (2005) drew on Kieran Egan's

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[10] Examples of international studies using drama pedagogy: Duatepe-Paksu and Ubuz, (2009); Chaviaris & Kafoussi, (2010); Gadanidis, (2010) and Gerofsky (2006, 2010, 2011).

[11] Griffiths (2012) detailed an exploratory study using 'dialogue scenes' to teach mathematics to adults. The study was part of a CPD package for trainee teachers.

[12] Embodying Mathematics is collaboration between Sheffield Hallam University and Complicite Drama Company. Their movement based mathematics curriculum is inspired by Complicite's maths/drama workshops, which were based on their Olivier award winning theatrical production *'A Disappearing Number'*.

(1989) premise that stories engage children in learning to develop dramatic storytelling as pedagogy in the primary mathematics classroom, claiming that the story brings a physicality and emotionality to the learning environment. Evidenced in the student feedback was the student's eagerness to suggest further mathematics stories which they were eager to explore. [13]. Whilst elsewhere, Lee and Pound (2011) provide useful examples of ways to teach mathematics creatively; from the use of story to performing music[14].

Dramatist, Patrice Baldwin's book *'With Drama in mind: Real Leaning in Imagined Worlds'* (2012) discusses the benefits of drama pedagogy, exampling her work in Primary mathematics classrooms. Baldwin's work is also based on Kieran Egan's (1985) premise of teaching as storytelling; that stories help make meaning. Further, Baldwin builds on Gardner's (1983) concept of 'multiple intelligence', positioning drama as multi-intelligent learning. Baldwin's work in Primary mathematics is evidenced in Clip No 1 which is provided below.

Clip No 1: Maths through Drama at Key Stage 1

https://www.youtube.com/watch?v=o0u16p4wyoE

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[13] A brief write up of Back and Lee's (2005) dramatic stories as mathematics pedagogy is available on the nrich website, which can be accessed here https://nrich.maths.org/2433
[14] Pound and Lee's (2011) book *'Teaching Mathematics Creatively'* details how creativity can be conceived in the primary mathematics classroom, in relation to the national curriculum, and suggests some ways in which creativity can be manifest in pedagogy, through the use of classroom examples.

Baldwin's work elucidates how drama is used as a developmental space to think differently about mathematics as a form of metacognition, helping students to conceptualise and think about their mathematical learning. Students chant the magical incantation *"make us go to story land"* to enter a different mathematics space and perform mathematics in character. Drama pedagogy assists learning through the humanising aspect of doing mathematics socially, working with someone (a chef in the case of the class drama) to solve a problem and in this way, the drama is 'logical-mathematical' (Baldwin, 2012, p. 59). Baldwin recounts how in this imaginary, intrapersonal space the student as actor access their imagination, thoughts, feelings and emotions in a process of self discovery, linked with developing a sense of self which inspires

> "reflection and contemplation (partly through ritual) on the human condition and identity. Drama clarifies life situations, and then supports the imagination, to rise above the boundaries of them, supporting growth and imagination"

> (Baldwin, 2012, p.60)

In doing drama the students' identity is represented and transformed. Whilst the premise of the research is to develop mathematical thinking this invariably entails a developmental potential for mathematical identity; understood as the students' dispositions towards mathematics, in light of their intellectual engagement with the subject in drama.

Filming the drama also allows the audience to engage with the concept of using drama in the mathematics classroom, to witness some benefits drama pedagogy might have on student cognition. However, the film also says something about mathematics and being mathematical, where 'story' makes a *"dry subject more exciting"* (class teacher). There is an implication that the *'magic'* which makes mathematics fun and interesting is the drama and the positioning of 'fun drama'/'dry mathematics' illuminates the reinforcing of negative stories about mathematics.

Similarly, Gerofsky employs the drama pedagogy *'mantle of the expert'* (Heathcote and Herbert 1985) where group improvisation is performed by students, without an audience, for their own learning purposes. Through drama Gerofsky's students are transformed into mathematicians and transported to a fictionalised, military occupied Chile.

> "I wanted to know how my students felt about trying to solve mathematical problems in hot, cramped, crowded conditions, with inadequate light and not enough pencils and papers to go around … The reaction has always been the same: it was far more exciting to be working on mathematics in the 'caves', under adverse and uncomfortable conditions. Students reported that there was a sense of urgency and importance in these circumstances that they had never felt when solving problems in their university math courses. Why? "Because it really mattered here." This is a very interesting response because we were all quite aware that it didn't really matter to anyone. We were involved in the drama 'as if' it were true – as if there were really a military coup and a resistance movement, and as if we were hiding in caves in the night."

> (Gerofsky, 2011, p.7)

The drama concretised the mathematics and completing the task was consequential to escaping the prison. It mattered. Even in the students' imagination, because they had taken on the role of another. Performing 'as-if' they were themselves, but no longer themselves. The students had suspended belief, been taken to story land. In the fictional space, the completion of the mathematical task was crucial to their 'as-if' character. The performance of storying oneself in drama became a powerful means for the students' enactment of mathematics as they take on the role of 'another'. Moreover, Gerofsky illuminated how mathematics that 'mattered' is voiced as important to the students and has developed their mathematical identity as being positive towards mathematics in this context.

Like Gerofsky, Boylan (2009) employs drama as a means to step into the role of another by drawing on psychodrama and psychotherapy and the technique of creative action methods (Fox, 1987; Moreno, 1993; Sternberg & Garcia, 2000). In this case, teachers (university lecturers) engage with dramatic monologues of student experiences with mathematics. Through a series of enactments, the teachers dramatically replay the student experience. The intention here is to exposed teachers to the emotional experience of being a mathematics student. Through teacher feedback on the session, Boylan reports that emotional and cognitive empathy was evident in the teacher feedback responses.

> "It really made me realise how it feels to be one of the students in the class who doesn't understand the maths, as I have never felt like this before.
>
> In "the teacher is like", I liked the switch to get us to do the simile that we did not agree with. The sessions made me aware of how much one needs to think about the different views people have on teaching styles."
>
> (Boylan, 2009, p.9)

Boylan concludes that the drama opened a space for the teachers to explore student emotion in relation to alienation and oppression in mathematics education.

In comparison to 'reality' role play, Caglayan (2016) tasked students to construct dramatic scenes as a way to make sense of particular mathematical problems or concepts but in an esoteric/abstract rather than realistic way.

> **ACT ONE: YOU ARE MY SQUARE, YOU ARE MY IMAGE.**
>
> **Student A:** [to Student B] You are my square . . . when I look in the mirror; I don't see myself at all. All I see is you; you are my image in the mirror.

Student B: [to Student A] I am your square and I belong to you. You are my pre-image in this mirror. [The mirror (Student M) comes forward facing the audience]

Student M: 2 cannot see itself through me because I am the one who creates all images. 2's image is 4 through me; I am the squaring function. . .

[Student M then takes her original position in between Student B and Student A, facing Student A] [Hand in hand, Student A and Student B walk forward and show themselves to the audience. They are paired in a particular order. The student facing the mirror, Student A, is on the left, and his "image," Student B, on the right. The mirror then claims possession

(Caglayan, 2016, p.236)

The students perform temporary mathematical identities by taking on the role of the other, which is a mathematical concept. The students become the 'mathematics' in order to understand the concepts. However, as a presentation of research, Caglayan's paper doesn't do justice to the drama and in becoming a text it loses the essence of the performance. The reading of the performance text is complex when taking account the dialogue, stage directions and movement (or the extra-discursive aspects of the performance).

Gadanidis proposes performance as an almost political response to the anxiety of *'Why can't I be a mathematician?'* (2012). For Gadanidis, drama performance is a social leveller; a means to have a wider conversation and appreciation about who and what can be mathematical. Identity is dialogic and drama a dialogic process which invites a prospective social audience into the performance. Gadanidis proposes drama as a powerful means of 'self-enactment', and 'self-authoring' and therefore an expression of identity, arguing that students learn and become mathematicians in a narrative process (2008, 2012). Like Baldwin, Gadanidis filmed student's dramatic mathematical performances (see Clip No 2, *'Parallel lines'* aka *'Flatlands'*)

Clip No 2: Flatlines

http://www.edu.uwo.ca/mathscene/T/flatland.html

In an associated paper Gadanidis (2008) builds on performance theorist Daniel, J. Boorstin's (1990) work on voyeurism and the visceral eye to describe how the filming of 'Flatland' enables a watching audience to have a 'visceral' experience, through the visual beauty of the film the oral storytelling and even humour engage the audience with the emotions in practising mathematics so as to relate their own experiences to the performance. Gadanidis is careful to acknowledge potential criticism of his methods.

> "Is the vicarious experience important for mathematics education? McKee (1997) suggests that there is a danger: "Flawed and false storytelling" might "substitute spectacle for substance, trickery for truth" (p. 13). However, our goal here is not to suggest the need for spectacle, but rather that a spectacular - a visceral - experience can be used to complement a good performance."
>
> (Gadanidis, 2008, p.49)

Elsewhere, Gadanidis[15] contributes to performance mathematics through online, rather than traditional academic, platforms. The recording of these performances and the relative freedom and possibilities of performance arts has been claimed by Gadanidis as a way to shift identity.

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[15] Examples of George Gandanidis performance mathematics of drama, poetry, song and art can be accessed at the following web pages 'Research ideas' http://researchideas.ca/mathperformance.html and 'Maths Scene' http://www.edu.uwo.ca/mathscene/index.html.

> "calling ourselves performance mathematicians creates a shift of identity that impacts on mathematics education, by helping us view mathematics not as confined to classroom activity or to the work of professional mathematicians, but as something that is shared with the wider world."

(Gadanidis, 2008, p.50)

Similarly, for Gerofsky performance is a developmental space for making new meanings about mathematics, which in turn is developmental for identity because new ways of being mathematical arise. Performance offers a democratic possibility to make new meaning and images of mathematics.

> "As our everyday society becomes a culture of collaborative makers and players rather than passive consumers and audiences, the Modernist separations (high from low culture, mathematics and science from arts and humanities, expert performers from reverent audiences) can no longer hold. As performance (both live and digital) becomes a predominant mode of being and communication for everyone, performance takes on a far more democratic, empowering and playful character. If everyone can take on the roles of actor, spectator, producer and critic in quick succession, then everyone is involved, actively and in-depth."

(Gerofsky, 2010, p.8)

In summation, this literature has elucidated how drama in the classroom is a potent means for students to perform their mathematical identity and to politically address mathematical (in) equality. The potential for drama performance (particularly in filmed formats) to story identity is an emerging and potentially useful tool for researching mathematical identity and this is the gap the thesis can address.

2.3.2 Theatre and the mathematician

The discussion moves to the relationship between theatre and mathematics. Whilst it is suggested that dramatic performances are powerful means to develop other, more positive mathematical identities, students still draw on wider cultural ideas to mediate and inform their performance. Questioned here is how images of mathematicians, as resources to mediate mathematical identity, can be traced to theatrical representations of mathematics and mathematicians and how theatre and mathematics are both concerned with the big life questions which shape experience and who we are. In developing an understanding of how theatre relates to the mathematical identity we can then conceptualise how theatrical approaches might be useful for mathematical identity research.

Mathematics and particularly mathematics in school has a particularly enduring cultural image; mathematics "*may be loved or hated, understood or misunderstood, but everybody has some mental image of it."* (Furinghetti, 1993, p.34). For the UK and western counterparts the dominant image of mathematics is a 'geeky' subject and for genius types which are predominantly white, middle aged, middle class men (Boaler, 2000; Sfard and Prusak 2005; Solomon, 2009; Black 2010; Gadanidis, 2012; Moreau, Mendick and Epstein 2012).

Early mathematical studies on images of mathematicians are traced back to Mead and Metraux's (1957) investigation of American student's overwhelmingly negative drawings of images of scientists. Thereafter the Draw a Scientist Test (DAST) was conceived to explore stereotypes of scientists (Chambers, 1983; Finson, et al., 1995; Huber and Burton, 1995). These studies influenced mathematical identity research exploring images of mathematicians through online questionnaires (Rock and Shaw, 2000) and children's drawings of mathematicians (Picker and Berry, 2000). The mathematician studies concluded that the pupils knew very little about mathematicians work and rely on stereotypical images of mathematicians to guide who mathematicians are.

The particularly enduring stereotypical image of a mathematician as the mad genius, consumed by their subject, has long since been ingrained in public consciousness. Increasingly, medical and psychological science seeks to explore biological relationships between mathematics and mental states such as creativity (Andreasen, 2014), personality disorders, addiction and mental illness (Nettle, 2005), autism (Baron-Cohen et al, 1998, 2007) and gender and the mathematical brain (Baron -Cohen 2003).

What these studies serve to highlight is the continuing interest in biological and psychological attributes of creativity, intelligence and genius and ideas about mathematics, madness, deviance and addiction, which are an intoxicating mix for theatrical drama. Abbot's (2015) recent tracing of a century of mathematics in theatre found that too often mathematics was portrayed in the theatre for the dramatic elements such as the mathematicians struggle against the problem and often against personal difficulties and how these images have advanced our understanding of what mathematics is and what mathematicians are like. Mathematician, writer and filmmaker, playwright and novelist Apostolos Doxiadis explores mathematicians of historical note, investigating the relationship between mathematics and narrative though Bruner's viewpoint of narrative as a mode of thought (Doxiadis, 2003, 2015). Through narrative, Doxiadis addresses the seeming fascination with the dichotomy of mathematics and madness in his play '*Seventeen nights*'[16] (Doxiadis, 2004). Doxiadis depicts how the life and identity of mathematician Kurt Gödel descend into madness as he is consumed by finishing his incomplete mathematical proof.

> "common theatrical wisdom has it that "drama is conflict" and a
> mathematician knows that there is no stronger conflict than paradox, the
> co-existence of two opposing views... "the new Aristotle", died (from

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[16] Seventeen nights is the finished product of the working title play *'Incompleteness, a play and a theorem'*, which was first staged in a workshop production in Athens, June 24-28, 2003. The first presentation of its finished form was given at the Aurora Theatre Company, Berkeley, California, in a rehearsed reading, on May 24, 2004. To learn more about the play, visit www.apostolosdoxiadis.com

malnutrition) trying to protect himself from dying (by poison) – not a very logical situation, you will agree.

(Doxiadis, 2003, p.4.).

Doxiadis intimates that conflict, as drama, is entertaining and therefore stories of paradox and dichotomy are particularly compelling, tellable and therefore durable. Additionally, the paradox between rational man and madness becomes apparent whereby mathematics regarded as emotionless also provokes such human emotion as to make men mad.

In the prologue to his review of theatre and mathematics, Abbott intimates how theatre can humanise mathematics by attending to these big life emotions which revolve around the obsession of mathematics; amongst others. The prologue begins with a scene from Tom Stoppard's mathematical play 'Arcadia'. Arcadia was updated two months into production after Andrew Wiles published his proof of Fermat's Last Theorem (FLT). Arcadia's opening scene was adapted to contrast the very human experience of procreation and pleasure to the birth of a Theorem.

> **Thomasina:** If you do not teach me the true meaning of things, who will?
>
> **Septimus:** Ah. Yes, I am ashamed. Carnal embrace is sexual congress, which is the insertion of the male genital organ into the female genital organ for purposes of procreation and pleasure. Fermat's last theorem, by contrast, asserts that when x, y, and z are whole numbers raised to the power of n, the sum of the first two can never equal the third when n is greater than 2.
>
> **Thomasina:** Eurghhh!
>
> **Septimus:** Nevertheless, that is the theorem.
>
> (Thomas Stoppard, 1993, in Abbott, 2015, p.365)

Mathematics, sex and comedy humanise mathematics as relatable to big human ideas, experiences and emotions. Abbott concludes that Arcadia

heralded a *'seismic'* change in the way mathematics intersected with popular culture and the arts particularly. Writing on *'A Disappearing number',* by Complicite Drama Company, Abbott writes of a synergy between mathematics and big life stories.

> "mathematics is employed to explore themes of love, grief, creativity and permanence, all of which transcend disciplinary boundaries as well as cultural ones. This is the power of art to expose similarities between disparate objects, to find patterns amid apparent chaos, to derive abstract general truths from special cases. That all of these characteristics describe the business of mathematics just as well is hardly a coincidence."
>
> (Abbott, 2015, p.378)

Mathematics and theatre are claimed as both being concerned with the big life questions, those life questions that shape human experience and therefore identity. Complicite were keenly aware of this connection between the drama movement, the mathematics and the human questions. Complicite went on to use A Disappearing Number as a foundation for school based drama workshops as drama pedagogy in the mathematics classroom. However, as yet, there is no academic evaluation as to the success and outcomes of that project. As indicated earlier, Complicite, are keenly aware of the potential of drama for education and are currently in partnership with Sheffield Hallam University, engaged in an academic inquiry of drama/movement based mathematics pedagogy. The drama activities in the project aim to *"support pupils' attitudes to mathematics, mindsets and thinking skills through a strand called 'Being a Mathematician'"* (Boylan and Povey, 2015, p2). Complicite will evaluate a drama-based, whole class approach to maths to see if it improves children's attainment.

However, despite the utility of drama in education, and as a means to humanise mathematics, we must be reminded that theatre is also a spectacle.

"I feel for once that I stumbled onto a really good narrative idea. Arcadia has got a classical kind of story and, whether we are writing about science or French maids, this whole thing is about storytelling first and foremost"

(Tom Stoppard, 1993; quoted in Abbott, 2015, p. 366)

Once again these 'classical' stories speak to how human experience is often told in the form of storytelling. How much wider society is driven like the playwright where the *'whole thing is about storytelling first and foremost'* is an important question for the storying process of mathematical identity. What we have learnt here is that theatre can come to shape what we know about mathematics and mathematicians, but theatre can also challenge those perceptions and provide alternative senses of what mathematics is, and what it means to be mathematical. Whilst theatre is theatrical, the mind is also keenly focussed on the role theatricality and drama have in designing the kind of mathematical identity stories one might tell.

2.3.3 The potential for drama as research

The previous section has been concerned with how drama can be a way to explore mathematical identity. Here I provide an overview of the literature; firstly as drama as pedagogy, and then theatrically as a way to understand depictions of mathematicians on stage and how those depictions might relate to social stories about mathematics. Some claims are then made as to how drama may be usefully applied in mathematical identity research.

Firstly, the literature consulted more usually adopted drama as pedagogy (i.e. in practice in school). The drama was a means to improve student understanding of mathematics and also as a way to 'make mathematics fun'. However, these performances are also claimed by the authors as an important means for students to voice their mathematical identity. Filmed classroom drama, which

was shared online in social platforms and accessible beyond the classroom, are advocated by Gadanidis, as a way to connect the mathematical learning of the students to the wider world, there is something, he says, about voicing mathematical activity to an audience, which empowers the student as a way to 'shift' their identity. Similarly, Gerofsky claims that performance takes on a democratic, yet playful character and there is something powerful in performance where the students can imagine their mathematical selves anew. Performance, shared through digital media, has for both Gadanidis and Gerofsky, the potential to engage a wider social audience in a visceral experience intended to provoke thinking about mathematical experiences. This filmed-drama I suggest is a process which could, therefore, be equally developmental for researching mathematical identity specifically.

Abbot's (2015) tracing of mathematics in theatre elucidated how both mathematics and theatre are concerned with big life questions and human experience (birth -of a theorem sex, madness and death), thus saying something about humanity, and therefore identity. Abbot argues how, through theatre, and the relationship between mathematics and life questions, mathematics is made human. Theatre and mathematics share the same concern of the big life questions so they also shape identity. The theatre is a window into viewing the bi-directional relationship between art and life. Both Abbot and Doxiadis explicitly referenced how mathematical identity stories, which resonate with the innate tellability of dramatic, salacious, provocative stories driven by spectacle, become resources which can be drawn on in knowing about mathematics and mathematicians and therefore mediate mathematical identity. One could critique that theatre differs from academic research because theatre focuses on telling a good story. However, I suggest there is an opportunity for academic research to consider how the tellability of a story might be implicated in the mediation of mathematical identity. For this thesis, theatre speaks convincingly to mathematical identity research as a potential resource with which to develop our understanding of whom and what is mathematical. None of the literature discussed used drama as a specific

research tool to explore mathematical identity, highlighting a gap in current mathematical identity research which can be addressed by the use of drama/theatre as a research method in this thesis.

2.4. Filmic Mathematics

Mathematics in film covers how TV, cinema and ethnographic film relate to mathematical identity research. Film is presented as comparable to journal articles or other esteemed academic works such as research funding body or policy documents. The academic ethnographic film may be commissioned (BBC films) much like policy research might be commissioned by a funding body or government agency or peer reviewed at film festivals. Like academic journals film festivals are also of varying quality but those festivals with an academic intention follow the same principles as reviewing written journal articles where films are peer reviewed by filmmaker academics. This section addresses the use of film in mathematical identity research and approaches film in three ways: Firstly, the discussion focuses on how film is used as data to be read and how this film data might mediate mathematical identity as a cultural resource. This section draws on literature which read the body as part of the mathematical identity to account for the embodied aspects of self. I critique the methodology but also report on the research findings to explore what film data read as a cultural object is saying about mathematical identity and how narrative conventions, apparent in film, might be implicit in the ways we story identity. Secondly, film as a means to represent mathematics and mathematical research via British Broadcasting Corporation (BBC) anthropological films and anthropological/observational cinema examines how researchers have begun to use film as a means of research, as data collection, analysis, discussion and presentation.

By reading film as research we broaden the medium by which mathematical identity research is conducted and written. By considering film as academic texts in their own right we open up the possibility to write mathematical identity

narrative in film, marrying the traditional narrative discursive and embodied aspects of identity. In addition, the recent work of Elizabeth De Freitas (2016), and her tracing of the scientific camera, usefully situates the research film '*Performatics*' amongst a history of camera use in educational research

2.4.1 Film and the mathematician

This section discusses the mathematician in film, how those images are depicted, how mathematics and mathematicians are understood through film, and how film might mediate mathematical identity. I draw on studies exploring images of mathematicians which detail the interplay between the 'professional mathematician' identity and the 'just plain-folks'. Particular attention is paid to the body, which is read as a sign which mediates and also tells stories of mathematical identity. We come to understand how film is read as a cultural object and the potential of film to both reify and disrupt what is understood about being mathematical. The potential being to write mathematical identity research in film so as to tap into the power of this medium to contribute research knowledge to a wider (and also non-academic) audience, to broaden the appeal of the research and make it more accessible, whilst still retaining academic principles.

In contemporary culture, students may draw on media images of mathematicians because mathematicians in everyday life are claimed as essentially invisible (Picker and Berry, 2000; Whitelegg et al, 2008). TV and media are implicated as a resource that students conceivably draw on when imagining images of scientists and mathematicians; however, there is a scarcity of studies on how popular cultural and media images are implicated in mediating mathematical identity. Moreau, Mendick and Epstein's (2007) ESRC funded project *'Mathematical images and identities: education, entertainment, social justice'* is one such study. The study methodology saw students participate in focus groups where they watched film clips about mathematicians and then discussed what they had watched. The objective was to elicit student responses to the films to explore their discursive constructs of mathematicians,

and the identity work the students undertook in response. Their findings indicated how students had an appreciation of stereotypical images of mathematicians but utilised them nonetheless due to a lack of other resources available to them (Moreau et al, 2010). The focus was on what was said and not how they said it. How the students used those stories as they interacted in the discussion with each other and during the film was not part of the research. Filming the discussion might have evidenced the dynamics of the storying process and how the students engaged with each other, the researchers and the film in a dynamic process of storying mathematical identity which may have offered some further insight into the dialogic process of storying self in response to the polyphony of voices.

In addition, a further element was added to the project to explore emerging themes around popular mathematical images and gender identities (Mendick and Moreau (2007). Whilst Mendick (2006) asserts that doing mathematics is doing masculinity, she also underlines how there are many masculinities, some of which are in tension with being mathematical and geek or boffin identities[17]. The male body as an object can symbolise intellect but it is often depicted in media as fragile and feminine and socially inept (Mendick et al, 2010). Additionally, it is claimed this vision of a traditional, masculine identity can impact upon boys' learner identities as they negotiate the tensions between perceived feminisation of academic success and/or 'studiousness' (Renold, 2001, p.369), and guard against geek identities (Lucey et al, 2003, p.52). These peculiarities of mathematical masculinity often manifest in media and social discourse as mental illness, personality disorders and the like (Csicsery, 1993; Doxiadis, 2003; Gadanidis, 2010; Mendick et al, 2010). The mentally ill male mathematician, as a real person and fictional character, is profuse amongst the genre of mathematical films.

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[17] Pomeroy (2015) reports on three cases where tensions were evident between 'hard' masculine identities, such as the athlete, and the difficulties connecting these masculinities to mathematics. This dichotomy between physical masculinity and mathematics can be considered akin to the female attractiveness/mathematics dichotomy.

> "John Nash in 'A Beautiful Mind' presents symptoms of schizophrenia, paranoia, and some form of social anxiety disorder, as do the mathematicians in Pi and Enigma. There are also some suggestions of mental health issues in relation to Charlie Eppes and Will Hunting...... In some cases, there are direct links made with Aspergers and autism, notably in 'The Curious Incident of the Dog' in the Night-time and Rainman"

(Mendick et al, 2010 p.4)

Mendick et al argue that madness is a means to locate mathematics in the body and explain it as a natural ability, of and for men, but go further by claiming that through the media mathematicians lives as read through mathematics.

> "mathematicians' lives are read as if everything in their life, personality, practices and beliefs is subjugated to their mathematical self and leads to them becoming great mathematicians. This not only suggests that mathematics takes over their life, but also their identity"

(Mendick et al, 2010 p.5)

Like theatre previously, mathematicians in film are portrayed as addicted to mathematics, tying into the earlier psychological studies of the prevalence of mental disorders, including addiction as more prevalent for academic 'creatives' (including the scientists).

In comparison, the profusion of male mathematicians visible in the media, female mathematicians are relatively invisible. The female body is often read as a sign of someone who is not mathematical. The landscape of the workplace and home as gendered describes a femininity concerned with homemaking and childrearing (Harris, 1987; Gerofsky, 2010). The constructed female domestic sphere is considered un-mathematical. Equally, much research reports how girls and women struggle to equate this traditional femininity and particularly feminine attractiveness with intelligence (Walkerdine, 1990; Renold, 2001;

Herzig & Bowitch, 2006; Solomon, 2009; Allen and Mendick, 2013; Archer et al, 2013). It is often the case that women and girls wanting to be feminine or attractive disengage from mathematics which is viewed as unattractive, nerdy or geeky. Women or girls who retain an interest in mathematics might either underplay their femininity or credit their intelligence to male influences like a 'male brain' (Solomon, 2009). This 'passing' or acting as another subverts the self as "*they are compelled to assume the identity of the 'Other'—in exchange for academic success*" (Fordham, 1993, cited in Holland et al, 1998, p. 132).

The media has become an unlikely ally for women and girls, addressing the attraction/mathematics dichotomy by depicting female mathematicians as highly attractive, even sexualised (Paasonen et al., 2007; Mendick et al, 2009). This sexualisation of women in media and popular culture is epitomised by the TV quiz show format whose attractive female co-host's 'sex appeal' is a viewable and therefore saleable commodity. The mathematics based TV quiz show *'Countdown'* is presented by Mendick et al as indicative of a format which sexualizes women mathematicians.

> "One important reservation is the way that these women are all classically attractive and conventionally feminine. This applies equally to the adult women mathematicians. Carol Vorderman through the hostess role on Countdown, her diet, exercise products and a range of sexually provocative publicity material reminds us that she is a body as well as a mind"
>
> (Mendick et al, 2009, p.10)

Mendick et al suggest that providing attractive viewing content brings additional problems which reinforce the feminism/intelligence dichotomy where the sexualised female body becomes the object of interest rather than intelligence or mathematical ability. They also conjectured that the objectification of conventional female beauty as hyper-feminised may be unhelpful in mediating mathematical identity for those who don't conform to this standard (Mendick et al, 2010; Betz and Sekaquaptew, 2012). What have been traded are

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unattractive mathematicians for the *'hyper-feminised'* or sexualised female mathematician. It is evident that mathematical identity for women is still fraught with tension.

So far the discussion has centred on how mathematical bodies are gendered and that both men and women are equally undone by these media representations. The body as a sign is well used by the media and these images are then available as resources to mediate mathematical identity. The media is a powerful site for production of such images but also key into the public mood to provide attractive viewing content. As attractive viewing content becomes increasingly important media images of mathematicians reflect this development. However, more recently 'Geek Chic' has positioned studiousness and academic success as attractive and desirable (Du Sautoy, 2011, Mendick et al, 2012, Vakharia, 2012). It has become socially acceptable and desirable to be academically successful. But whilst 'Geek Chic' subverts the dichotomy of attraction and mathematics it still holds on to those stereotypical conceptions that mathematicians, both male and female, dress unfashionably, and are socially awkward. What we learn from reading media images as cultural artefacts and charting the mathematical body, read as a sign, is that what is 'fashionable', somewhat dictates how mathematicians are regarded.

This historical development of the mathematician, documented in and propagated by the popular media indicates how one's mathematical identity may change, over time, in response. There is a complicated relationship between how much the media influences the images of mathematicians and how much the media draw on the public consciousness to develop such images for consumption. What is clear is the relationship between the public and media, which shapes popular images of mathematicians, has received remarkably little attention despite the importance of this process in the mediation of mathematical identity. How such media is produced for public consumption and the role of research in media production of images of and stories about mathematicians warrants attention and highlights the importance of research

engaging with similar media production as both a means to explore identity and engage in this, very public, discussion. How filmmakers and researchers have been engaging with film production is the concern of the next section of this chapter.

2.4.2 In-between anthropological film and research

The purpose of reviewing film as an academic text is to consider how film relates to research in what we can learn from film as an academic text and also how film might be used as a methodology to collect, analyse, discuss and represent data and findings.   As with traditional ethnography and anthropology, visual ethnography is the study of people in activity but film rather than pen and paper captures the observations of the researcher as data collection and film editing as a mode of analysis where *"sentences are being cast as the film maker is recording"* (Barabantseva and Lawrence, 2015). This section starts with a discussion about the role of film and video in mathematics education research in respect of a recent paper by Elizabeth De Freitas (2016), which discusses the development of the scientific camera in research from an instrument of observation and moving towards understanding video data as scientific enquiry. Thereafter, this section moves to ways in which film, at the borderlands between film and research, may be productive for sensing mathematical identity. Three films (two BBC and one independent film) are discussed in more depth, whilst others are referred to as examples.

In research, film and video as observational data are profuse in educational research. In tracing the scientific camera in educational research, De-Freitas illuminates that much camera work is concentrated on the body and the relation to cognition. However, she clams researchers

> "know very little about our own practices of collecting, watching and
> interpreting video data, and often proceed to use such data without

examining the ways that video structures the kind of research we do"
(De Freitas, 2016, p.553).

De Freitas critiques the current use of video in educational research for its scientific enquiry of documenting and analysing above philosophically questioning the act of filming, in light of how the act of shooting is often intent on capturing the intricacies of the body as some way of defining mathematics as within the body. To compensate, De Freitas invites discussion.

> "how might our video-research practices begin to embrace the pure optical and sound images of modern cinema, demanding that we perceive movement not simply or only as a sensory-motor image, but also grasp the multifarious temporal dimensions of the image…?"

> (De Freitas, 2016, p.568).

It is proposed that film may be best served to explore the ritual of the classroom, knowing mathematics through interaction and human experience rather than merely situated in a body. De Freitas advocates experimental film practices such as Jean Rouch's cine-trans, as productive for exploring such things as memory, the animation, through activity, of mathematical objects and the classroom rituals of mathematical activity.

So far, film has been positioned as productive in education for making a livelier and interactive classroom experience, where mathematicians make film as a pedagogical tool and how film has been used in educational research as a tool. Drawing on De Freitas, I explore how mathematics and mathematicians are represented in research informed film. Firstly, the BBC has been instrumental in bringing visual ethnographic style documentaries about mathematics to the general public[18]. The BBC films can be argued as research informed, produced

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[18] BBC films of note not included in this review: *Fermats last Theorem*. (1995); on the life of the mathematician and *Beautiful Young Minds* (2007), a documentary following the U.K team

in collaboration with mathematicians and educational researchers but not subject to the same academic process of review; however, there is potential for research. How film can be regarded as academic, and what film can help us to understand about mathematical identity, is the concern here. The BBC either especially commission or purchases films which align to their broadcast principles.

Mathematics has been covered rather frequently in BBC commissioned documentaries, intimating that mathematics is consistently at the heart of the national debate and therefore worthy of exploration. The BBC has a long standing tradition of making, commissioning, and buying anthropological and ethnographic style documentaries. The BBC commissioning strategy statement drives to challenge the audience, to bring a new perspective where we think we know the story and to provide compelling storytelling[19]. However, the narrative drive for a compelling story is troublesome if telling a good story takes precedence over the analytic viewpoint and presenting factual accounts. To the BBC's credit, the authenticity and rigour of their commissioned documentaries into mathematics are attended to by commissioning films by experts in the field of film-making, mathematics and mathematics education.

For the purpose of discussion in this chapter the BBC films have been defined in two ways:

> (i) Film made by filmmakers with an interest in mathematics; notable examples include David Malone's *'Dangerous Knowledge'* (2007)[20] on

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selection for and participation in the 2006 International Mathematical Olympiad. Many of the young mathematicians featured in the film had a form of autism, which the documentary links to mathematical ability.

[19]   The   BBC   commissioning   statement   can   be   viewed   here http://www.bbc.co.uk/commissioning/tv/articles/documentaries-bbc-two .
[20] Dangerous Knowledge (2007) is a 'melodramatic piece', exploring mathematical genius, madness and suicide; "Cantour heard a secret voice calling him to Mathematics which he

this depiction of mathematician's deviancy (madness and sexuality) and *'High Anxieties: The mathematics of chaos'* (2008) which explores mathematics and explains the chaos of life and global events through mathematics.

(ii) Films made with mathematicians about their research or mathematical interests; notably Marcus du Sautoy's 4 part series *'The story of Maths'* (2008). Whilst the mathematicians often have significant input in the direction of the film they do not conduct the filming or editing.

This section briefly examines two BBC documentary films which focus on the lives of people using mathematics:

'Twice Five Plus the Wings of a Bird' (1986) was a collaboration between BBC filmmakers, mathematicians and maths educationists exploring connections between the everyday use of mathematics and mathematics education.

'Hard Problems: The Road to the World's Toughest Math Contest' (2006) was produced by the independent filmmaker George Csicsery about students entering the 'International Mathematics Olympiad' competition.

'Twice Five Plus the Wings of a Bird' (1986) is one of the earlier BBC commissioned Horizon series of documentaries. It is discussed here for what we can learn about mathematical identity and the ways the filmmaking way approached. The clip below is a trailer for the full film.

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assigned to god." – 1884. Cantour confides in a friend that he can't take the personal and professional attacks and suffering a nervous breakdown he was brought to an asylum. Not discussed in this review, it is an important film because of the links to anxious mathematical identities.

Clip No 3. Trailer 'Twice Five Plus the Wings of a Bird' (1986)

http://www.bbcactivevideoforlearning.com/1/TitleDetails.aspx?TitleID=23865

Twice five afforded the public audience an insight into current academic research on mathematics and associated pedagogical developments. The audience was treated to observations of occupational practice as explained by the workers and through interviews with mathematicians and mathematics education researchers. The observation and explanation of the social practice of mathematics, beyond arithmetic, elucidated the sensuous practice such as the scaffolding riggers 'eye' and how they visually conducted mathematical processes. Mathematical identity was captured in the way the workers performed their duties through sound, touch and vision, a qualitatively different experience to the mathematics they practised in the classroom, which led to observable problems as the workers narrated their difficulties marrying their work practices to mathematical practices. What film does is to open up the possibility that the narrative verbalised by the subject is not the whole of the story and that other elements of the world of the story, such as the subject's actions, are readable as a text and might offer insights beyond the narrative the subject tells.

'Hard Problems' is an independent film by George Paul Csicsery which was bought by the BBC for general distribution. Csicsery is a prolific filmmaker who has dedicated much of his film career since the 1980's to producing ethnographies and biographies/biopic of mathematics and mathematicians. Csicsery is specifically focused on producing work about gifted mathematicians

to provide insight into their lives and ways of thinking. In 2009, Csicsery was awarded the Joint Policy Board for Mathematics (JPBM) Communications Award for bringing mathematics to non-mathematical audiences. Csicsery[21] produced 30 biographical interviews with senior mathematicians for the Simons Foundation Science Lives web series between 2010 and 2013. These biographical narratives are the same narratives which are the bread and butter of mathematical identity research. However, the film is able to depict contextual information which a text narrative is not by overlaying or juxtaposing a range of images and voiced narrative simultaneously to make some sort of salient point or statement. In this way, the film becomes a deeper exploration of the story of the researcher and accounts for other voices and other experiences which relate to the subjects own story.

Whilst Csicsery's work is highly regarded and often cited in books in reference to the films he has made, he is rarely cited in the academic literature, particularly concerning mathematics research and any scholarly engagement with his films as a research object eluded this review. Many of Csicsery's films have also been commissioned or purchased for wider public consumption. *'Hard Problems: The Road to the World's Toughest Math Contest'* (2006) was picked up by the BBC for public distribution.

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[21] George Csicsery's web series can be accessed here https://www.simonsfoundation.org/category/features/science-lives/

Clip No 4.   Trailer 'Hard Problems: The Road to the World's Toughest Math Contest' (2006)

http://www.hardproblemsmovie.com/trailer.html

'Hard Problems' captures the lived experience of a team of American High School students as they compete in the International Mathematical Olympiad (IMO). Comprising of interviews with the students, parents, teachers, friends and observations of the team as they compete we learn about the stresses, trials, tribulations and triumphs of competing where mathematical performance becomes a sport. In the film bio, Csicsery claims the film "*shatters some of the stereotypes of the mathematically gifted*" (Csicsery, 2006). What Csicsery's work does is to bring into public consciousness the human lives of mathematicians and the various voices with which the contestants engage, with each other, the coaches, tournament officials and parents with differing viewpoints portrayed. Additionally, the film allows the audience to make the connection between ways the contestants present themselves on screen, their demeanour, facial expressions and the ways they perform in the contest in contrast with the interviews given. This film has the quality of situating the dialogue in human activity to view identity in practice. However, the filmmaker is also driven by the playwrights' compulsion to tell a good story. How much the research rigour may be undermined by the earlier critique that substance may be substituted for spectacle (McKee, 1997, in Gadanidis, 2012) is of particular concern to research.

The two BBC film examples, whilst not specifically intended by the filmmaker to represent mathematical identity, do so as the audience come to know the film subject in an intimate way, through the camera. The film is a way of seeing the relationship of the person(s) in mathematical activity. Many of these BBC documentary films focus on the 'professional mathematician' identity, as opposed to the 'just plain-folks'. This intimates that 'professional mathematician' identities are compelling story telling. There is a contradiction in the intention of the films to revere mathematics as something special and beautiful and to functionalise mathematics for the everyman/woman. These films become ways to see into mathematicians' lives, implicating how the film mediates the mathematical identity of the film subject (what do they want to be presented) and how the audience relate to the film.

The final part of this section discusses independent filmmaking. However, independent, or research films, by mathematicians and mathematical researchers are not widely distributed and difficult to source. Independent films with a mathematical content are not as widely represented in peer reviewed film festivals, which are the visual ethnography equivalent to academic publication. Very few academic journals accept films as scholarly contributions to knowledge and therefore there is a lack of scholarly engagement with filmic literature in mathematics research as a whole. A rare example of a film made by an independent filmmaker on the subject of mathematicians is *'Colors of Maths'* (Ermenenko, 2013).

Clip No 5. Trailer 'Colors of Math' (2013)

https://www.youtube.com/watch?v=O8UNZiL7Gag

The director, Ekaterina Ermeneko describes in her biography[22] how she was born to a family of Scientists and Engineers. After graduating with a degree in mathematics she pursued a PhD which was uncompleted after an accident changed her life course. A later career in TV brought her to filmmaking and back to the subject of mathematics, which she loves. *'Colors'* has circulated amongst the international film festivals but is not widely known beyond this selective arena. Shot in an observational style, following the action of the film subjects, the mathematicians are filmed talking about their use, thoughts, feelings, values and beliefs about mathematics and themselves as creative, sensuous, sensual beings where mathematics is central to their identity.

The perspective of the mathematicians in '*Colors',* reveals the troublesome, anxiety making practice, of identifying as mathematical, which transcends ability groupings and whether one is a 'professional mathematician' or 'just plain-folks'. It becomes clear that for this mathematician the anxiety around his mathematical identity comes from the stories about what mathematics is and what it means to be mathematical rather than anxiety towards the subject itself. A *'tense identity'* is defined in relation to the tension between anxieties about the stories of being mathematical and the mathematician's love of the subject; a tension made palpable in film. The mathematicians in the film touch on the

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[22] Ermeneno's biography and access to her film production company EEF films can be accessed here https://www.dokweb.net/database/persons/biography/68d3bfaa-4bd0-4549-8d86-0de311145520/ekaterina-eremenko

perceived emotional and mental state of mathematicians as fragile and try to undo some of the storying of mathematicians as mad or suicidal – a theme developed earlier in the chapter. The mathematicians in the film express themselves with passion, as evident by the excitable tone of voice, facial expression and sweeping gesturing, whilst the filmic style is evocative and contributes to the narrative through techniques of camera work and the editing process, such as close ups and long shots and other filmic devices. Shot both in and out of the classroom, the boundary between mathematics in the two contexts is blurred as the mathematicians narrate how their aesthetic thinking in the classroom also translates to their everyday life and vice-versa; evidencing the various voices in which the mathematicians speak. What this film contributes is an exploration into the imagination of the mathematician film maker, a visceral experience which gets to the crux of his identity in imaginative ways, making the imagination real –in film.

Since writing this thesis Ermenenko has since released a new mathematical film on the beauty of geometry *'The Discrete Charm of Geometry' (2016)*[23], which makes a connection between mathematical concepts, the lives of the mathematicians comparing their geometry and the creativity of human movement (dance) and music. Whilst this is a film about a mathematical concept, geometry is told in relation to the lived experience of the mathematician. In the film, the mathematics are related, not only to everyday life and nature but the everyday life of the mathematician is depicted for its ordinariness – the interaction with the child, days out on the river, in their working day. The subject of the mathematician and their identity is as much in questions as the discreet subject of geometry. There is a resonance, in parts, between this film and *'Performatics'* whereby performance, in movement; drama and music are entwined with the mathematicians' identity and everyday experiences of mathematics.

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[23] The trailer for 'The Discreet Charm of Geometry' can be accessed here http://www.imdb.com/video/wab/vi664449817.

To conclude, ethnographic style documentaries are more usually made or commissioned by a filmmaker or film production team rather than from the perspective of mathematicians or mathematics education researchers. These films have a strong resonance to common stories about mathematics so that the audience can be challenged and perceive mathematics and mathematicians in a different way, or to recontextualise the mathematician's story as dramatic and entertaining somehow. Whilst these films may be considered research informed, they are not rigorously answering any specific problem. Independent film, made by mathematicians, contributes to mathematical identity research the sensuality, emotional, aesthetic, creative and tactile quality of mathematics, which has received little critical or scholarly attention. The potential of film is in bringing to life the internal imagination as fundamental to mathematical identity. Made from a mathematician's perspective, the film becomes an extension of the mathematics, which may not always be accessible to the watching audience.

2.4.3 The potential for film as research

This summary defines a borderland, an in-between anthropological film and research. Firstly, I attend to how these films fit into academic research. Secondly, I discuss the depiction of mathematicians in film and the potential for film to disrupt common (mis)understandings or (mis)representations of mathematics, which would be useful for exploring mathematical identity in this thesis.

De Freitas (2016) has mapped the field of mathematical education research with respect to the camera as scientific cinema. She argues that observational footage, which situates mathematics as embodied, is missing something of the social, sensory experience of being and doing mathematics, instead arguing for more observational, experimental ethnographic cinema, abstract and avant-garde filmic investigations, citing the work of Jean Rouch as a possible avenue for filmic work on mathematics education. So what are some of the potentialities and problems of considering film as research? Firstly, I have

found that research informed films are more evident than research films. The commissioning process of research informed films has a different purpose to academic film and so there is some difficulty in discerning the research potential of such films. However, skilled filmmakers, such as George Csicsery, claim that film is research and has been awarded for his scholarly contribution to the field of mathematics communication. For Csicsery, film was a means to get to know the lives of the subjects and to disrupt common (mis)understandings of mathematics and mathematicians. Film offers the opportunity for a more visceral experience for the audience of mathematics research and through the social media platform an avenue to research a wider audience beyond academia. The filmic artistry through the camera work and editing process is a window into human activity with mathematics. Film can capture the dialogic imagination of the subject by simultaneously showing them in interaction with the various voices they encounter. Moreover, as a cultural object, the film itself also speaks to the wider social audience and keys into current human debate highlighting mathematics and anxieties about being mathematical as of particular public concern.

The film examples also highlighted how mathematical identity can be troublesome and anxious. Regardless of ability, there was some struggle or disconnect between common stories of being mathematics and actually being mathematical. Many of the themes of these films are about higher ability mathematicians and the tensions which arise in the space between being mathematical or not. Higher ability mathematicians struggled with being defined as mathematical in certain contexts such as not being mathematical enough (in the case of the mathematics Olympiad) or mathematical ability associated with deviance and mental instability (in *'Colors of Math'*). Anxious mathematical identities are therefore in tension with the space between who is and isn't mathematical, a line which shifts depending on context. Anxious mathematical identities were shown in the film to be around stories of being (un)mathematical and both identities (the professional mathematicians and Just plain-folks) were equally affected.

Like the researcher using text, the filmmaker is also a conduit or filter. It is as much the skills and subjectivity of the filmmaker that determines the story in the film as the researcher does in presenting data in a written mode. Film cannot offer a 'reality' of the maker's involvement in the re-storying of the subject, only their inter-subjectivity as evident by the film as a narrative, as akin to the written sense of constructing a story. However, that so much film is made about able mathematicians is intriguing; considering the concern focused on disengagement from mathematics and anxious mathematical identities the viewing public seem to have an appetite for exploring and understanding what it means to be mathematical.

Film, is sorely under-utilised in mathematics education research as a research tool. Films made by mathematics researchers or mathematics education researchers may be in circulation but evaded the scoping of this literature review. This may be more to do with access to resources, equipment and training rather than a lack of an inclination to use film as a medium for mathematical identity research. However, from the literature, I am persuaded that film, of an anthropological persuasion, can be regarded as rigorous research and that film has evidenced its potential to explore competing stories of mathematical identity.

2.5 Conclusion: Sensing mathematical identity through filmed drama

This review scoped a niche area of mathematical identity research concerned with the collective-storying of mathematical identity, as understood in relation to public images (as stories) of mathematics and explored through drama and filmed media. The review considered what was already known about mathematical identity as story asking, and answering

(i) How is mathematical identity story approached and conceptualised in the literature?

(ii) What is the current use and potential for filmed-drama to sense mathematical identity story differently?

From this questioning the review builds a case for ABR (filmed drama) as potentially sensing mathematical identity in new ways; bringing together oral and embodied identity story to attend to imagination, memory and the body as a sign – as productive resources for understanding identity. This conclusion synthesises the literature to draw out the potential usefulness of ABR for mathematical identity research.

2.5.1 Conceptualising mathematical identity as story

I conclude here, with a recap of the scoping of the literature and what it allowed us to know about the state of the art. I elaborate how 'story' has been approached and conceptualised in order to draw out some of the issues for mathematical identity research and propose some solutions.

The research was scoped through a narrative approach. Firstly, the area of mathematical identity was refined with the aid of a calling on mathematical identity researchers to assess the utility of Arts Based Research (Rosiek, 2013) and was then framed in relation to a recent literature review on mathematical identity (Darragh, 2016). The area of mathematical identity to be scoped was defined as those which adopted a position of identity as collective storying, and more recently, literature which adopted a more literary or performative approach. This scoping identified how this turn to more creative methodologies of experimental monologues (Boylan and Povey, 2009), parody (Solomon, 2016), experimental texts (Povey et al, 2006, Povey and Angier, 2016) and fiction (De Freitas, 2004) has occurred only more recently, and that none of the literature consulted had gone beyond the written word as a means of research or research presentation.

More recently, it has been argued that for mathematics education researchers to influence storylines – how the state of the art is viewed and respected, is largely dependent upon joining a conversation with institutions, such as the media, which affect the public's perception of mathematics and mathematics education (Herbel-Eisenmann, et al. 2016). Herbel-Eisenmann et al., go on to claim a common storyline that mathematics education research is not used and has broadly (with few notable exceptions), been impotent in affecting policy or practice. Their solution for the efficacy and re-positioning of mathematics education research is similar to Gerofsky and Gadanidis' earlier assertion that mathematics education must communicate to a broader audience, using alternative communication mechanisms – drama, film and online media. Herbel-Eisenmann et al., Gerofsky and Gadanidis claim that producing media content, inviting and instigating closer ties with media production, where the conversation about research becomes reciprocal through these channels, is particularly productive for mathematics education researchers to influence storylines about mathematics.   However, current approaches to mathematical identity research are problematic to this aim.

The mathematical identity literature strongly accounted for identity as an activity of collective storying around two senses; 'oral' (what we say) and 'embodied/enacted' (thinking, feeling, acting). Oral story and written accounts were more readily attended to. Mathematical identity research is identified along a continuum as depicted in Figure 1.

Figure 1. Continuum of identity research approaches

More or less

Presentational	←→	Representational
Written	←→	Aesthetic
Factual	←→	Fictional
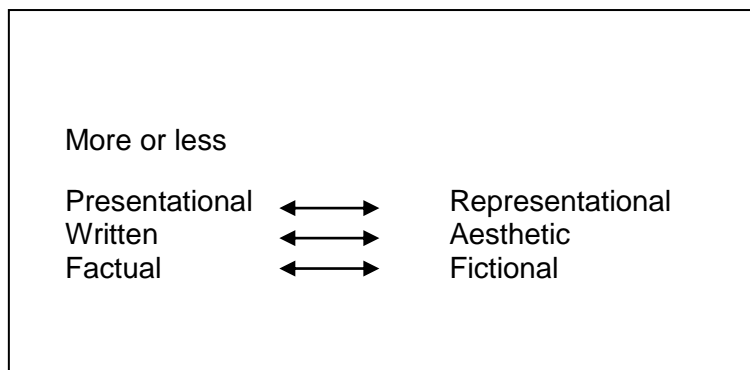
More often, mathematical identity research was presentational, attending to the oral story and consisting of an interview and observational data which were reduced to factual, written narrative accounts. There is inherent difficultly in these written accounts to do justice to the more embodied ways of being, thinking, feeling and acting because the researcher is focusing on what the subject can say. There may be aspects of identity which are bound up in the way the subject verbalise and enact their identity story as well as aspects that the subject finds difficult to verbalise, such as senses of stories, past memories, thoughts and feelings for example.

More recently, the literary arts have been adopted to accommodate performative, embodied aspects of identity (Solomon's earlier example of parody and Skaz speech) and also the other voices evident in the collective storying of identity (Povey, et al.'s, 2016, co-operative inquiry and experimental text) and the influence of the monologue on the reader (Boylan and Povey, 2009). These more literary academic endeavours are also taking on the form of the novel and fiction, where words, through their literary art, can create a vision and visceral experience for the reader. However, much work is done by the reader in interpreting the words and the visions which they make from them are their own and these are still re-workings of the interview and observational data reproduced as written texts.

Where the representational academic research was more successful was in their attempts to convey dialogic identity. They achieved this by situating the voice of both the researcher and subject in close contact, thus capturing some of the dynamic of collective re-storying. The potential to develop Solomon's exploration of parodic speech, Boylan and Povey's dramatic monologue and of Povey et al.'s co-operative inquiry as moving from experiential to aesthetic knowledge is great. How this might be achieved is discussed by synthesising how drama and film have been used in relation to mathematical identity research.

In addition, when we 'do' mathematical identity we draw on and relate to wider stories of mathematics. The narrative process or the recipe of what makes a good, entertaining, story (drama, tension, contradiction) was implicated in mediating identity - why we tell the mathematical identity stories that we do. Anxiety was manifest in the drama and film examples which presented a fine line between the creative genius and the madman–a pathologisation of mathematics which situated mathematics in the body and for certain kinds of people. The troubling of the higher ability mathematics group of the 'professional mathematician' identity intimates how anxious identities span the mathematical ability range and that often it is the story surrounding mathematics, rather than the subject itself, that is the source of those anxieties and 'tense identity'.

The 'act' of re-presenting story concretised the storying process, which was more noticeable in the aesthetic representational storying, through fictional writing, drama and film. The function of dramatic, tellable, entertaining stories came through forcibly, as a formidable device of mediating identity.

2.5.2 Use and potential: Filmed drama for mathematical identity research
The current use of, and the potential for, filmed-drama to sense mathematical identity differently are discussed with respect to the two ways drama has been identified 'drama-pedagogy' and 'drama-theatre, and the employ of observational filmmaking as research.

Two modes of drama have been evidenced in this review; 'drama-pedagogy' and 'drama-theatre'. Drama-pedagogy has included both representational and abstract drama where students perform as mathematicians and mathematics to improve academic performance. Drama-pedagogy was claimed as a dialogic mode which can 'shift' identity in response to an anxiety about being mathematical and doing mathematics. Drama was claimed as a powerful means for students to voice their mathematical identity. 'Drama-theatre' was claimed to

humanise mathematics because of the parsimonious relationship where both theatre and drama are concerned with big life questions. In this sense drama-theatre engaged with the collective storying of mathematical identity more explicitly from the perspective of the audience. The intention of 'drama-theatre' is to enthral the audience through narrative and make sense of the lived experience of character through their own experiences; a visceral experience and dialogic process. Drama-theatre presents possibilities to engage with life stories about mathematics and to include the audience thus affording a means to explore the dialogic imagination in collective storying. Overall, mathematicians and researchers were more likely to use drama than film to be a means of expression and exploration of the lives of mathematicians and the role of mathematics in everyday life. Drama can afford an immediacy and relatively simple way to engage with storied lives.

Film has been employed in the literature in a number of ways; as a means to convey drama pedagogy (in the case of Baldwin and Gadanidis), and to explore stories about doing mathematics and being mathematical in a more representational sense. Film has been found to have a number of applications useful to mathematical identity research. Firstly, film captures identity in practice (the 'riggers eye' for example) and the incidentals more difficult to capture in text alone. Secondly, film provides a judicial means to represent research that is more problematic in written text due to the complexity of narrative research. Finally, because filmed media is made with an audience in mind, the audience are drawn into the collective storying of identity, thus emphasising the state of addressivity in which identity develops. Film as research offers some opportunities to explore the dialogic process of collective storying as well as the narrative construct of story and how story form might mediate the identity stories we tell.

Problematically, like theatre, the BBC documentary films intention, to capture the attention of the audience, means these films draw heavily on narrative techniques of what makes a good story, rather than being guided by research

principles and ethical considerations. Research films made by mathematics researchers, based on sound research principles could attend to research rigour and validity more readily. Alas, film has yet to be capitalised on in mathematical identity research in the same way that visual anthropologists use film as a research tool to collect, analyse and represent data. Still, film may be limiting for mathematical identity research because filmmaking requires a degree of technical acumen, and access to technology, film as a research method is not as accessible compared to drama. Furthermore, unlike Povey et al.'s (2006) experimental text, film cannot make transparent the logic of the research analysis. What film can do is to represent the analysis as the narrative of the completed film; the audience knows of the filmmaker, their position and analysis through their choices of filmic style and the content and style of the finished film artefact.

The performative methods focused on in this review were Arts Based Research (ABR). I claim filmed drama as more able to capture embodied aspects of mathematical identity performance currently missing from textual accounts; emotions, thoughts, feelings and contradictions between what people say and what people do. Additionally, attendance to the role of the audience in mediating identity gives prominence to the wider voices we ultimately play to for a fuller treatment of dialogic mathematical identity. Filmed drama, undertaken by a mathematics researcher for the purpose of exploring mathematical identity situates *'Performatics'* as a unique undertaking in mathematical identity research.

2.5.3 Framing the thesis: Research aims and problems

The framing of the field, in this review, identified that mathematical identity research may benefit from dramaturgical and filmic approaches which exploit the richness of, and judiciously represent narrative research by (i) capturing the dialectic between oral and embodied/enacted aspects of identity (body language, inner imagination and memory), and (ii) accounting for the dialogic practice of storying by including and addressing in the research, voices other

than the research subjects. I propose that undertaking and assessing the purposefulness of an arts based methodology (filmed drama) for mathematical identity research adds a substantive contribution to knowledge and assists Herbel-Eisenmann et al.s issue of positioning mathematics education researchers to influence storylines in order to impact policy and practice. The following research aim and problems have been identified as answerable by this thesis.

Aim: To undertake, and assess the value of, filmed-drama for sensing and expressing mathematical identity.

Problem 1. Developing a theoretical framework of identity as a story.
How to Operationalised identity as a story?

Problem 2. Constructing Arts Based Research Methodology
How to develop a filmed drama methodology sensitive to uncovering alternative ways of knowing about mathematical identity story?

Chapter 3.　Conceptualising identity as a story through Bakhtin and Ricoeur.

3.1 Introduction

The aim of this chapter is to come to a more concrete understanding of what is meant by identity as 'story'. This discussion follows the perspective of identity which was set out in the literature review where identity storying is a dialogic process of collective storying amongst the voices of others, including the past, present and future imagined selves and identity as intimately tied to lived experience and emotions.

This chapter brings phenomenological hermeneutics (interpretation of human experience in practice) and dialogism (the self as social in social dialogue) to develop a conceptual understanding of identity as a story. The literature review identified two inter-relating senses of storying: (i) 'Oral' story, which was captured in, and mediated by, a written text (in the narrow sense) and (ii) sensuously embodied and enacted/performed. Whilst the two senses of the story come close, it was claimed that mathematical identity research would benefit from some conceptual distinction. However, in attending to the literature on narrative research, it became clear that the issue was not in providing some conceptual distinction between narrative and performative identity but rather to understand how these two senses inter-relate in order to understand how story powerfully mediates identity. In doing so, particular attention is paid to the collective storying of anxious mathematical identities of the 'professional-genius-mathematician (mad-eccentric etc) whose identities are the stuff of stereotypes and told of in films etc, and the 'Just plain- folks' (JPF) who are mathematically (in)competent.

To begin there is some conceptual disentanglement of what is meant by story, narrative and plot. When researchers in the literature review lay claim to identity as narrative or story they were mostly referring to narrative, the talk or voices identity. This chapter accounts for a broader conceptualisation of story in order to develop new understandings about mathematical identity. This chapter takes the perspective that story is a 'world' containing characters (or actors), narrative (discursive and embodied), and happenings or events. In a fuller narrative sense story, plot and narrative are distinct aspects of the whole; identity story is the sum of its parts. Cobley (2014) elucidates how story is all the events to be depicted, the plot (often following traditional dramaturgical tropes of comedy, tragedy, satire and romance) dictates the way the characters (or actors) are expected to behave in the world of the story and moves the narrative along in a chain of causation which determines these events are somehow linked. The narrative is what is told within the story, both discursively and extra-discursively The Character actors in the story will have their own perspective and may not be aware of all of the story events and so within any story plot, they may have similar but not identical experiences.

The conceptualisation of identity in this chapter will be used to ground this thesis Arts Based Research methodology in dialogism and phenomenological hermeneutic principles in order to underpin the main analysis of this thesis, which is to make sense of the research subjects (actors) mathematical identity through a filmed drama- '*Performatics*'. This conceptualisation of identity story can assist in two ways; firstly by illuminating both narrative and performative senses of the actors' identity and secondly, utilising the principles of narrative structure as a form of analysis and representation of research for an audience. In adopting this approach to the research, what story is and does become more concrete through the process of making the film. Through this process of the conceptualisation of identity and methodological development, the film will stand as the original contribution to knowledge and examples from the film will be used in the thesis discussion to clarify those contributions.

De-Freitas (2016), earlier in the literature review, had envisaged how film could attend to memory and the passing of time as integral to understanding mathematical cognition, whilst Darragh's (2016) review of mathematical identity literature, indicated in the conclusion that, whilst not attended to in her review, Ricoeur's narrative approach could be productive for mathematical identity research and a consideration of identity as performed. In attending to these concerns this chapter speaks to Jean Clandinin's (2007) invitation for narrative researchers to contribute to her (as yet unfinished) project of bringing *"story, memory and imagination'* into narrative inquiry. This chapter is structured thusly, to consider identity storying as both narrative and performative.

> **'Story'** (4.2), brings together Ricoeur and Bakhtin to explore dialogism and the narrative function of story (as recipes and canonised) in identity making by tracing narrative development through structuralism, post-structuralism and phenomenological hermeneutics.

> **'Memory'** (4.3) reveals identity as the plural self through time and in relation to the social lives of others through Bakhtin's ventriloquation and Voloshinov's 'I' as 'we', which is productive for understanding how the self is storied in relation to others (including pasts and possible future selves).

> **'Imagination'** (4.4) introduces 'Alcoholics Anonymous' and 'Mental Disorder' from Holland, Lachiotte, Skinner and Cain's (1998) 'Figured Worlds' which resonates with the literature on the 'professional-genius-mathematician as mad, bad, eccentric. Holland et al.'s case for cultural production and heuristic development as intimately tied to identity making holds a mirror up to these representations of 'mathematicians' to explore identity as imaginatively practiced and the body as a site for reading and mediating identity.

> **'Conclusion'** (5.5) consolidates how a Bakhtin/Ricoeur union can productively analyse the raw film data of '*Performatics*' to illuminate identity story in practice in the finished film '*Performatics*' so as to make claims to an original contribution to knowledge.

3.2 Story

The usefulness of a Bakhtin/Ricoeur theoretical union is discussed to position identity story as lived experience -identity in practice, the kind of aesthetic knowing of being in and of the moment. This section traces narrative research, from Bakhtinian structuralist beginnings to post-structuralists developments and finally to Ricoeur's phenomenological hermeneutics to clarify the function of story as integral to identity. This chapter concerned with rather getting to how Bakhtin and Ricoeur are useful to understanding and interpreting the collective storying of identity.

3.2.1 A brief encounter: Narrative structuralism, post structuralism and phenomenological hermeneutics.

Understanding that narrative research has developed though various 'turns' - through structuralism, post-structuralism to phenomenological hermeneutics is important to acknowledge if we are to shine a light on the function of story as fundamental to mediating the mathematical identity stories told. This chapter is not a literature review of those 'turns' but rather an indication of the development of the field in order to situate where, within narrative research, this thesis sits.   This section discusses how narrative might be structured around some form of plot or canonical narrative and indicates, through an understanding of dialogism, and touching on parody, how ventriloquation of others voices can be both disempowering and empowering.

Narrative research has many traditions with differing epistemological basis[24]. Narrative is variously defined as discursive, written text, symbolic and performed with a classic distinction between story 'told' through narration or 'shown' through drama (Elam,1980). However, Strawson (2004) argues that

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[24] See Clandinin, (2007) for a review of the historical developments of narrative inquiry and Barry (2009) for a tracing of structuralism and post structuralism.

narrative is misleading as life does not follow artistic literary devices. Mackenzie and Atkins (2008) refer to Strawson in agreement

> "events, and experiences of a person's life do not take the form of neat causal sequences, nor does a life have the teleological structure of a plot. Narrative approaches, it is argued, falsely assume that our lives are more coherent, structured and intelligible than they really are and that we exercise an improbable degree of authorial control over our lives" (Mackenzie, 2008, p. 13)

However, narrative research does not necessarily claim that life takes the form of a plot or neat causal sequence and nor does it afford improbable degrees of authorial control. Instead narrative can be useful to our understanding of the complexity of life events and of identity as stories in tension with the stories of others (Clandinin and Rosiek, 2007); a dialogic project. Bakhtin's defines the storying of the self in the process of addressing and answering oneself and social others as 'dialogism' (Bakhtin, 1981). A sense of self is linguistically produced through a process of 'othering', who we are in relation to others. In *Dialogism e*very expression is part of an ongoing chain and network of statement and responses, new statements presuppose earlier statements and anticipate future statements. Utterances are always addressed to someone and can generate a response /anticipate an answer to the polysemy of voices, which include our own.

Structuralism derives from linguistics and studies the structures of cultural artefacts and objects such as texts, for example, Ferdinand de Sausser's (1974) linguistic theory as a way to give literary criticism theoretical rigour. Language was considered a system of signs, a signifying system. Roland Bartes' (1988) cultural anthropology exemplified how signifying systems transcend language so that narrative becomes something much more than enunciated practice; narratives have a relationship to behaviours and ways of acting and being where human behaviour are 'codes' of cultural systems, Structuralists also view cultural codes as also driven by narrative function, beginning from a point of normalcy and social order and against which unusual

narratives are told. Todorov's (1977) narrative development depicts this usual narrative convention.

Exposition	Narrative begins from a point of normalcy and social order.
Disruption	Some causal event creates change
Complication	Obstacles to be overcome create tension
Climax	A dramatic high point releases tension
Resolution	The protagonist (main character) resolves the problem/normalcy returns, fulfils goals, and returns order.

Todorov's narrative structure exemplifies structuralisms binary narrative function whereby normalcy vs. disruption and complication vs. resolution are features of a tellable story. If identity is a story then the learning of what makes a good story may, therefore, impact how we story ourselves and each other.

Post-structuralism critiques structuralism from a position that focus should be on how knowledge is produced and the cultural production of language. Knowledge of an artefact or object comes from studying the object in relation to the structures in which it was produced. Language is not fixed to the object but is fluid. Additionally, post-structuralism looks beyond binary opposites as some sort of centre with which to 'mark' otherness to take account of historical development where sign systems are fluid and thus de-centred. In this way, identity can be conceptualised as a range of possible positions.

Bruner's seminal work *'The Narrative Construction of Reality'* (1991) is particularly enlightening for the purpose of understanding mathematical identity in terms of life histories and self-biographies (e.g. Black et al, 2007 and 2010; Gadanidis, 2008; Hernandez-Martinez, et al., 2011). Bruner's main premise is that story and narrative are ways to understand and read social lives, not as truth but through metacognition which *"converts ontological arguments about the nature of reality into epistemological ones about how we know"* (Bruner, 1996, p.148). Bruner asserts that the sciences attempt to address and report a

reality whereas narrative is about bringing human experience into the open to help think about what and how we know. For Bruner our sense of narrative is developed from an early age as we "*live most of our lives in a world constructed according to the rules and devices of narrative"* (Bruner 1996, p. 149). Bruner's borrows the structuralist, transformational aspect of Todorov's narrative form to argue that *"stories are told from the perspective of a norm or canonical state that centre on something unusual that breaches this state"* (Bowles, 2010, p.20). 'Canonical narratives' (Bruner, 1991) are templates of story plots which delineate how to be and act and against which those unusual stories are told. Overall, these devices or functions of narrative become a *'recipe'* for structuring experience (Bruner, 1987, p. 708).

In reviewing Vygotsky in *'Stage Theory: The Psychology of Art and the Actor'* Peter Smagorinsky (2011) comments on 'perezhivanie' (translated as lived experience) and the experience of the actor (in the theatre) and the social actor in everyday life as complicit in structuring experience.

> "in the last years of his life, he returned briefly to questions of the emotions, including the paradox of the actor's verisimilitudinous affectation of emotions on the stage and the drama of everyday life and its role in the development of personality. This strand of his work has received limited scholarly attention yet has potential for illuminating aspects of his larger project in ways that suggest the fundamentally emotional quality of culturally mediated personality development."

> (Smagorinsky, 2011, p. 320).

If experience and emotions are in fact storied, and reside somewhere between imagination and reality, then Vygotsky's work on perezhivanie (translated as lived experience), is productive to understanding the imagination as intimately tied to lived experience. Vygotsky's writings on the creative imagination, the improvisational nature of dramatic creativity (which may include learning about the self), draw on his interest in theatre and drama, and drama and learning

(Davis et al., 2015)[25]. In '*The Psychology of Art*', Vygotsky discusses *aesthetic perezhivanie* and the evocation of emotions in the artistic experience – having an experience. For him, artistic experience and creativity were the highest form of human development and where arts is *"a social technique of feelings"* (Vygotsky, 1971, p.244). Vygotsky theorises how artistic and cultural representations provide insight into how we might respond to such images and align our feelings with them. Smagorinsky points out the inattention to the role of emotions in culturally mediating stories despite. Vygotsky's canonisation refers to high art; of which mathematics has also been classified (Gerofsky, 2010). Smagorinsky adds how Vygotsky's view on the canonisation of cultural forms draws on cultural ideologies to dominate over others. The canonisation of mathematics, in the story, as highbrow, and therefore something unusual that excludes the everyman (or indeed woman), can exist because it conforms to dominant standards. In the consumption of these cultural forms, we pay attention to Vygotsky's theorisation on story being both material and form.

> "the material is what is readily available to the poet for his story, namely the events and characters of everyday life, or the relationships between human beings—in brief, all that has existed prior to the story can exist outside of it or is independent of it. The form of this work of art is the arrangement of this material in accordance with the laws of artistic construction."

> (Vygotsky, 1925/1971, p. 145)

It is not just the content of a story which one must attend to but the form the story takes. In summation, narrative offers identity some sort of tellable 'recipe'. If we follow Bruner's assertion that the 'recipe' is embedded from an early age, story constructs will guide the way we tell stories of self and any understanding

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[25] Both Smagorinsky (2011) and Davis et al (2015) claim Vygotsky's work on creativity and imagination have developmental potential for understanding emotional experience, but that his work on Perezhivanie hasn't been taken up to any great extent by academics or by drama education practitioners. Davis et al, especially, find purchase in a theoretical grounding of Vygotsky's works in their extensive exploration of Vygotsky's in *'Dramatic interactions in education: Vygotskyan and sociocultural approaches to drama, education and research'*.

of identity as story must be also underpinned by an understanding of narrative form.

Ricoeur's 'Hermeneutic Phenomenology', or the interpretive act of experience, is also a useful proposition for exploring identity storied in practice. Ricoeur states that human lives are more readable when interpreted in the function of stories. Like human experience, stories require a shared understanding of narrative practices (Ricoeur, 1992; Evans, 2013), which include verbal, non-verbal, semiotic and presuppositions as ways to understand the dialect between the self and the symbol, the self and the narrative (Ricoeur, 1967; Ricoeur et al., 1978). There are similarities here then between Bakhtin's dialogism and the polyphony of voices and finding a common understanding to interpreting the dialect between self and symbol.

This section has focused on the structuring properties of story; how identity might develop in line to some sort of recipe, which determines what identity stories could be told. It was also determined that identity development is an imaginative act and whilst story relates to the narrative development of the telling of some sort of oral or written story that follows an expected convention the affective properties of stories are intimately tied to emotions; how we feel about a particular story we tell of identity is also culturally mediated.

3.2.2 Ricoeur and Bakhtin: A union

From the proposition in the proceeding section, that story structure also structures what can be told, felt, and expressed about identity, I now move on to how a union between the hermeneutic approach of Ricoeur and Bakhtin's Dialogic perspective of identity marry well as a means to understand how identity story develops through human interaction.

Similarities have been drawn between phenomenology and dialogism as concerned with the ontological nature of self but for their differences, phenomenology looks inwards to the self, whilst dialogism looks outwards (Roberts, 1989, p. 120). Additionally, Ricoeur (1975) views conversational dialogism as short term and temporal. Dialogue is only part of the symbolic system which carries meaning across time. Thus narrative is not wholly a linguistic process. For Ricoeur, historicity illuminates the inter-subjectivity and interpretative condition of making meaning from the narrative, where the subject is the reader and writer of his own life (Ricoeur 1985, 2015). Alternatively, in Bakhtin's dialogism word meaning and history are concomitant; when we speak we speak words with their history of meaning but our inter-subjectivity allows space to appropriate words for our own purpose. For Bakhtin meaning making is the dialectic between the self and the social through language; the 'Dialogic Imagination' and a process of 'othering'.

> "I am conscious of myself and become myself only while revealing myself for another, through another, and with the help of another. The most important acts constituting self-consciousness are determined by a relationship toward another consciousness (toward a thought)… The very being of man (both external and internal) is the deepest communication. To be means to communicate… To be means to be for another, and through the other, for oneself. A person has no internal sovereign territory, he is wholly and always on the boundary: looking inside himself, he looks into the eyes of another… I cannot manage without another, I cannot become myself without another; I must find myself in another by finding another in myself (in mutual reflection and mutual acceptance)."

(Problems of Dostoevsky's Poetics, 287, cited in Danow, 1991, p. 59)

In a Bakhtinian sense story as a narrative is more open ended and a means of making meaning and process of thought rather than representation. For identity, Ricoeur sees stories as a product with a narrative structure which conveys meaning; stories are a kind of structured narrative.

In summary, what Ricoeur offers for mathematical identity research is a way to understand that story has some form of learnt structure, which itself is socially and culturally constructed, whereas Bakhtin attends to the developing identity. Both Ricoeur and Bakhtin account for the storying the self through time. This union assists the thesis to attend to, and analyse through the film '*Performatics*', how the actor's identity is mediated by and develops in relation to, narrative constructs.

3.3 Memory

This section details a theoretical exploration of how present and future possible selves are mediated through past experiences and in relation to the historicity of experiences of the social others we encounter, which have implications for the ways and kinds of memories we take on as important and recall. Memory is claimed as integral to the developing identity and is a testament to plural sites of self (the past, present and possible future selves). So far, in the studies sourced in the literature review, memory is accounted for as narrative self-biographies. This section attends to some issues with historical self-biography, postulating why some memories might be more readily storied that others. The ground is also laid for a potential contribution to knowledge whereby historical self-biography and accessing memory might be more fruitfully achieve through drama and film research methods which may potentially present memory as embodied, as it is sensed, which is beyond traditional discursive or written narratives currently adopted in mathematical identity research.

3.3.1 'I' as me: Understanding the self through time

Earlier iterations of identity as a fixed 'essential' self, have been replaced by a consensus of "*The idea of plural, even competing sites of the self*" (Holland et al, 1998, p. 29). Plural selves are changeable and formative, not set. A person may occupy any number of these identity positions - woman, mother, wife, daughter, and teacher for example and be described as such by any number of tellers through first, second and third person stories. Our own stories or 'first

person' stories are conceived by Ricoeur (1992) as narrated around whom one was, is, could, should and would like to be. This narration entailed an imaginative 'othering' of self; a reflexive stance to one's own being, a reflection on memory. Ricoeur and Bakhtin's complimentary positions on memory and time are the focus of this section. Specifically, personal memory and the storying of the self over time as requiring imaginative effort and the connections and disconnections between the developing identity of who one was, is and could be, which is useful for exploring the historical biographical identity experiences of the actors in '*Performatics*'.

Memory commonly has two meanings; a mental ability to store and retrieve information and the emotional, affective, sensory experience of recollection evoked by sights, sounds, smells etc. Western cultures often assume memory as an individual phenomenon, working with a camera recording clear images of the experience that remain unchanged in recall. This assumes a kind of disconnection between person and memory where memory is stored away, untapped, until some provocation invokes it and that a recalled memory is voiced in language. From this, there develops an understanding that personal memory is linked to identity and that a person's life story is an expression of a unified self. Ricoeur (2000) pointed to how memories of the past self narrate the present self and how these narratives are temporal, selective nature and socially shaped; people don't always choose how and when the past becomes part of them and what and how they come to recollect it.

Bal, et al. (1999) describes how memory might be laid down and recalled, identifying three kinds of memory: habitual, narrative and traumatic. For Bal et al., memory is practiced in the process of recall and through habitualised behaviours where cultural memory is something you actually perform as physical 'acts'. For example, traumatic memories are less linguistic and more symbolic or experiential, somatic even, coming into consciousness as sensory flashbacks, dreamlike, evoked by or including sounds, sights, smells, emotions (Brison, 1999, p.42). Discursive identity story, therefore, does an injustice

somewhat to experiential ways of being that are not so easily voiced. Moreover, like Bakhtin's Dialogism, memory, like language, *"arises in the relationship to others, becoming collective memory, shared memory, in the physical and emotional company of others"* (Evans, 2013, p.19). Memories are stored and recalled based on cultural significance, they require the ability to read the cultural signs and story oneself accordingly, for this reason, the memory may become ambiguous, subjective and selective as social interaction ay determine which memories are kept and which are recalled. Additionally, Bakhtin's contemporary, Voloshinov (1986) writes how experiences and sensations are bound up in the social context so our understanding of grief, enjoyment, even hunger (Voloshinov, 1986, p.87) are mediated by our experiences in the social context. In his writing of the importance of memory in storying the self and why and how we tell stories Schank (1995) asserts that one reason we tell stories is to express emotions that say something fundamental about us, they allow us to feel and the recounting of those stories serves to embolden them, to preserve them. Like Bal, Schank views memory as an important part of storying the self through habitualised behaviours but presents us with a problem for mathematical identity research in his assertion that *"we avoid telling stories that evoke feelings that we do not care to relive"* (Schank, 1995, p .47). Therefore, following Voloshinov's logic, troublesome/anxiety laden stories about mathematics may be told not as evoking difficult feelings but also because the cultural context determines negative stories about mathematics to be the norm and therefore re-tellable.

Time is a dimension of memory and storying that has received much attention. For Ricoeur time is a dimension through which past selves are understood and future selves are imagined. The link from past to present and future self can be thought of as a golden thread that affords some sort of continuity of the self, to hold together ideas about the self across time and space rather than the self being a fractured collection of experiences and memories. However, Bruner (1991) posits that narrative exists outside of traditional concepts and measures of time where chronology can be re-ordered to create a stronger narrative logic. Therefore stories of self are narrated across the temporal domain, existing

simultaneously in the past, present and future. For Bakhtin there is an intrinsic connectedness of temporal and spatial relationships in literature; which he terms the *'Chronotope'* or literally 'time-space' (Bakhtin, 1981). If we utilise literary devices to understand identity then the Chronotope is useful to understanding how stories of self and of others are situated in time-space. For example revisiting the self in the past or in another frame of mind has been defined by performance theorist Richard Turner as working in the *'subjunctive mood'* (Schechner, 1985). The subjunctive mood can be as simple as storying oneself through past experience connecting the time-space. The subjunctive, therefore, does not refer to something which is necessarily real. This is not to say that what is experienced as identity is not real but rather than past recollections are fallible and what you remember may not be indicative. Schechner (1985) says of recollection that invoking the past means performing *'as-if'* they were themselves, where the past is re written as it is storied in the present. Evans (2013) cautions how stories reformulated and re-worked from past experience in the present means recollections cannot wholly be regarded as reality. The person reflecting on the stories of the past are not the same person who experienced them at the time. Rather than a reality, it is an 'actuality' for the subject as told in the present context. However, reflecting on personal biography as first person stories is argued as a learning process that takes account of meanings individuals make of events. First person stories or 'personal biography' can, therefore, be claimed as an *"important and powerful way of seeing learning as a fundamental dimension of living"* (Field, Merrill and West, 2012 p.80).

Memory has been conceived here as an interplay between the individual and the social and between reality and, through the passage of time some kind of fiction, which, is taken by the author as having some semblance of an actuality of a lived experience. Memory has also been accounted for as coming into consciousness through words, actions and the imagination. The memory of lived experience is as much bound by the emotions of the memory as the discursive remembering.

Memory can also be problematic if we are trying to claim an essential truth. However, if we consider memory an act of storying an actuality for the author, then some difficulties are assuaged because these life stories are more about the author's realisations and sense making of those acts of memory rather than getting to some kind of essential truth of the situation.

3.3.2 'I' as we: Culture and collective storying

This account purposefully examines collective storying to address how identity is mediated by stories of others which are also embedded in a historicity, re-told in present day contexts and impacting future possibilities. How 'other' social voices speak through us, ventriloquating or silencing voices is important to understanding the mediation of the actor's identity in relation to their social and cultural contexts, and how different narrative styles, such as parody, comedy and tragedy, afford resistance to powerful voices.

Voloshinov's (1986) position is that stories of self are 'we' stories conditioned by social organisation and are social interaction. For Schank (1995), the sharing of certain stories defines cultures and subcultures with a 'sense' of a familiar genre where *"the stories that define a sub culture are typically so familiar to insiders that they do not explicitly appear"* (p.xviii). Stereotypes are well known social stories –such as the differentiation between the mathematical identity of the professional 'mathematician' as gifted, made, bad, and eccentric and the 'Just plain-folks' as un-mathematical. Seibt and Förster (2004) view stereotypes as problematic because of the power this imagined identity has on perceiving one's own and others cognitive ability which may result in behavioural modifications. Stereotypes are so powerful that even in changing times and new conditions, the self may revert to the stereotype as an authoritative discourse. However, Crapanazo elaborates that a characteristic of stereotypical thinking is the movement of recollection through time, which is reduced, frozen even, to a *"symbolic instant"* (Crapanazo, 1980, p. 32). What Crapanazo describes are stereotypes as symbolic remembrances (almost photograph like) and not wholly

a discursive process. Some aspects of identity story cannot be so easily reduced to language.

Additionally, how social stories are taken into the person can also vary. For Schank, the genre of stories are not what become indexical but rather the memory about the story becomes indexical in numerous ways, we do not remember a whole story but a 'gist' and are likely to recount it differently depending upon *"the occasions of the telling and the reasons for which it is told"* (Schank, 1995,p.xxiii). Social stories may also come to us in the form of persuasive language. Building on Bakhtin, Holland et al.'s cultural anthropology of identity (1998) describe how authors speak through language *"ventriloquating"* and being *"ventriloquated"* by the words or discourse of others (Holland et al, 1998, p.179) as *'authoritative'* discourse, powerful and subjugating and *'internally'* persuasive discourses which re-organise social words and intertwine with our own through creative process. Employing Bourdieu's premise of *"silencing",* Holland et al expound how authoritative discourse may lead to 'silencing' or "*self-censorship"* (Holland et al, 1998, p.60), where even internally persuasive stories become difficult to articulate. Yet discourse is not deterministic and one can escape ventriloquation when *"The prose writer makes use of words that are already populated with the social intentions of others and compels them to serve his own new intentions, to serve a second master"* (Bakhtin 1981, 299–300 in Holland et al, 1998). For Holland et al the re-purposing of language affords some agency to resist ventriloquation through the *"orchestration of and adoption of stances toward these voices"* (Holland et al, 1998, p.185). Holland et al posit that this state of 'addressivity', speaking to the polyphony of voices, inevitably breeds contradictions where *"Humans are both blessed and cursed by their dialogic nature—their tendency to encompass a number of views in virtual simultaneity and tension, regardless of their logical compatibility"* (Holland et al, 1998, p.5). These tensions usefully assist the project of not displacing identity stories about the self with wider social stories, thus assuaging somewhat that borderland issues which Clandinin and Rosiek (2007) contest are problematic for narrative research. Dialogic

conflict presents agentic opportunity to address the voices directly and appreciate both.

Equally, Bakhtin's work on parody highlights 'double-voicedness' as a means to appreciate self and social voices and how the stories of self can be a means of dissent against powerful voices by taking on another's words with subversive intent.

> "Analogous to parodistic discourse is ironic, or any other double-voiced, use of someone else's words; in those instances too another's discourse is used for conveying aspirations that are hostile to it…one speaker very often literally repeats the statement of the other speaker, investing it with new value and accenting it in his own way–with expressions of doubt, indignation, irony, mockery, ridicule, and the like. … One can parody another person's style as a style; one can parody another's socially typical or individually characterological manner…one can parody merely superficial verbal forms, but one can also parody the very deepest principles governing another's discourse."
>
> (Bakhtin 1981, p.194)

Through parody, words can be changed for one's own purpose and in doing so can also address wider social stories or discourse that serve to ventriloquate.

Parody, as a distinct narrative form, has its own function and purpose to present dissenting voices. Kozintse and Martin (2012) detail how parody is another speech which does not represent a linguistic reality but rather an inappropriate means to represent reality. They argue that the target of parody exists on a meta-level; the language itself and our own worldview (Kozintse and Martin, 2012, p.14). Voloshinov articulates this meta-existence explaining how parody has the purpose *"of focusing on the 'referential object of speech, as in ordinary discourse, and simultaneously at a second context"* (Voloshinov, 1986, p. 196); that is the speech refers to other existing social discourse. Kleberg (1991) elucidates how parody is more than form and in its function, it translates experience which exists simultaneously. For example, in referencing

Shakespeare Kleberg says *"the comic and the tragic were both there from the beginning, as two sides of the same coin, as the two aspects of dialogue"* (Kleberg, 1991, p. 101). Parody exemplifies the *"double-voicedness"* (Voloshinov, 1986, Kleberg, 1991) of speech; the words of the speaker and a reference to wider discourse across time.

Hutcheon (1989) tells how parody, references history and a tension in the changing of old forms of expression, into new; a productive, creative approach to expression. Hutcheon attests that parody is more than imitation, it is to subvert the iconic; making parody across the art forms from written prose to visual arts and also to new forms of artistic technology. Stories of self, through parody or otherwise, are contested as not just expressing the experience, but also as having some form of dramatic or creative intent. However, Bruner cautions that this narrative mode of human experience leads to *"good stories, gripping drama, believable (though not necessarily true) historical accounts"* (Brunner, 1986, p.13). Parody may serve a function; a means to express dichotomous experience and understandings and as a way of dissent against powerful voices.

This dramatic act of storying may not necessarily account for historical accuracy and authenticity but telling good stories is not a sole occupation. How story works in social interaction is also dependent upon the relationship between story teller and listener/audience; stories should be 'tellable' (Labov, 1972). Stories, it is argued, are treated as 'tellable' by the listener, positioning the listener as an active agent in the storying process. The listener asks 'so what', what is it about the story that is important (Sacks, 1992 and Ryan, 2005). In asking 'so-what' the 'tellability' of the story will be dependent upon the context of time, place and space (Bowles, 2010) and personal significance (Huhn and Sommer, 2013). Equally, addressing wider discourse draws attention to the purpose of story and the intended audience. Schank elucidates the important of the purpose of storying

"When we tell stories about ourselves our goals are often internal and difficult to determine, but when we tell stories intended for other people our goals tend to fall into five categories:

to illustrate a point

to make the listener feel some way or another

to tell a story that transports the listener

to transfer some piece of information from our head into the head of the listener

to summarize significant events"

(Schank, 1995, p .48)

The aspect of addressivity in Schank's terms is important to determine because the purpose of telling stories to others is different to the purpose of telling stories to the self. In telling stories to others the teller takes their experience and through the conventions of story, makes it *"the experience of others – a narrative event"* (Langellier and Peterson, 2006, p.155).

In summary, the historicity of storying the self is a reflexive process where we story our present and future possible self through past experiences. In doing so we encounter the historicity of social and cultural worlds, speaking to and becoming the audience. The imperative of the time of the context in which you are situated can determine which stories are laid down, what becomes significant, what stories you can recall in order to tell others about yourself. These historical stories are in flux and can be difficult to pin down, often drifting into consciousness as thoughts, feelings and emotions which can be difficult to discursively express. Identity as 'we' addresses the self as storied in concert with social others. There is a historicity of social stories imbued in a culture which develops over time. In telling stories of self we are telling stories of others in the process may be ventroloquised. A means of agency against ventriloquation is a parody, which serves to express stories told at different

levels of consciousness; parody makes conscious the powerful social stories and can express the dichotomy of experience. Finally, stories are told to an audience, the audience can powerfully determine the legitimacy of an identity story in reference to social, cultural and historical context.

3.4 Imagination

Herein discussion builds on the previous sections of story and memory to demonstrate how, through imagination, story and memory can figure actors/mathematicians as certain kinds of people. The discussion begins with performing narratives in everyday life and how personal narratives are intimately tied to the body, as bodily experience, intimating how a conceptualisation of an embodied identity is intimately tied to and not distinct from the traditionally narrated identity. Thereafter Holland, Lachiotte, Skinner and Cain's Figured Worlds (1998) take on dialogism and hermeneutics usefully offers two examples of imagining the self, which resonates with the improvisational 'imaginative' act of improvising self-experiences by playing the self as another - 'As-if' through stories of Alcoholics Anonymous and Mental health care. Holland et al.s work productively draw this chapter to a close as their accounts bring together the aspects of this chapter to account for story as narratively and bodily told. Through their accounts, unusual narratives are told against normative canonical stories, and in doing so the identity stories told to follow some form of a narrative structure where the dramatic element of storying (like Todorov's narrative development) drives what can be told. These stories are bodily and narratively told in an imaginative act of identity making.

3.4.1 Plot and narrative

Narratives are performed in everyday life and then imagined otherwise. Drawing on the work of Ricoeur and others I examine how the body, as a figure in a plot, acts as a certain kind of person, in certain contexts detailing and how identity is storied in relation to these experiences.

The act of performing is said to intervene*" between experience and the story told"* (Langellier 1999, pp.128). Langellier discusses how personal narratives come from bodily experience, told through a certain body with experiences of the world and positional discursive forces. Langellier cautions how performative narratives are not just referential and there is something artistic and aesthetic in the process of performance and storytelling which are also socially constructed; conventions and of telling and performing story. The conventions of story are implicit in the ways one might narrate identity, bodily and culturally. For Bruner, we are actors who

"walk on stage into a play whose enactment is already in progress - a play whose somewhat open plot determines what parts we play and toward what denouements we may be heading"

(Bruner 1991, p. 34)

Plots, asserts Ricoeur (1991) take account of historical development, what has come before and what we can imagine for the future self in relation to the plotline. The plot can be a guide for what can be imagined for an actor. A plot positions actors in relation to others and also accommodates the inanimate symbolic objects representative of the situation we find ourselves such as the environmental context, the actions and behaviours of the actors, the clothes one might wear.

Performing the self as a social actor entails not just a performance of physicality, the way the body moves but is the performed narrative is also symbolic where the body and accoutrements such as the style of dress are signs and symbols which are part of the world of the story. This speaks to Ricoeur's phenomenology to understand the nature and experience of the body, the narrative of the body, an ontological oneness; *what it means to have and be a body.* For Langellier (1989) performing personal narrative joins the body with voice, the body has a voice as narrative and narrative gives voice to

experience. However, Ricoeur claims that narratives about the body are readable texts, hermeneutic, but not completely accessible and this is what gives our body 'otherness' (Ricoeur, 1992).

In her work on gender, Judith Butler has drawn on Foucault. Foucault understands the body as politically understood, but also subjectively experienced[26]. For example, the power of institutions, such as school as a 'machine for learning', regulates bodies through discipline and punishment and ideas of madness and incarceration are means to 'other' against a set of cultural principles of normality. For Butler, bodies are not just personal narratives but also performative sites of social discourse that work on a conscious and unconscious level (Butler, 1990, 1993). 'Performativity' is an imitation in *"the reiterative power of discourse to reproduce the phenomenon that it regulates and constrains"* (Butler, 1993, p.2). When one performs gender, for example, she argues those performances are imitations based on discourse; there is nothing specific or inherent about gender. So behaviours and discourse can align to produce a harmonious discursive and performative identity.

Also writing on gender and race, Lewis, (2000) emphasises the body as a cultural artefact, detailing how labelling extends to the body to signify and position people in the world. The body, they claim, can be viewed as a system of signs. Physical characteristic indicates capabilities so that the body becomes indexical, categorical, and hierarchical; suitably illustrated by the feminine/mathematics and genius/mental illness dichotomies attested in the literature review. Moreover, Lewis and Butler account for how the body is both the material and form of an identity story. Simplifying social relationships in a semiotic manner, allow for making immediate or quick judgments about who fits

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[26] Foucault (1977, 1973, 1980) has been variously translated for his works on the medical clinic, the development of 'madness' and the power of institutions. Of interest to this thesis is how the social discourse 'others' the body, not just discursively but also a sign and site of political and dramatic intent. The body is therefore narratively charged, we read the body beyond words and understand something of their subjectivity and position within society.

in the systems and what commonalities or difference you may have (Waitoller and Kozleski, 2013). From Ricoeur's phenomenological perspective, embodiment helps us to understand experiences of what it is like to be a type of person.

3.4.2 Performing 'As-If'

Influenced by Bakhtin, Vygotsky and a socio-cultural anthropology with a performative persuasion, Holland, Lachiotte, Skinner and Cain's (1998) *'Figured Worlds'* is a complex theoretical proposition which suggests cultural production and heuristic development (the facilitation of self-discovery) as intimately tied to identity making. Broadly, Figured Worlds are described by Holland et al. as 'narrativised' and 'dramatised', depicting how social worlds are populated by social actors who position themselves according to cultural models, voice themselves in tension with the voices of others and perform according to some socially acceptable life script or *'standard-plot'*. What the reader should note here is that 'plot' does not infer that all actors within the plot will tell the same story, or indeed, have the same experiences. The plot is the overarching theme, if you will, which structures experience. Four main plots have been identified in the narrative literature, these being Romance, Comedy, Satire and Tragedy. Plot dictates the way the characters are expected to behave in the world of the story, it (Cobley, 2014). Plots delineate how to be and act and against which unusual stories are told. For example, the literature review identified how mathematical identity stories are more often anxious stories and often driven by conflict and contradiction. Doxiadis (2003) intimated that conflict, as drama, is entertaining, making stories of paradox and dichotomy particularly compelling, relatable, tellable and therefore reproducible and durable. Brown et al. (2016) similarly found that images of mathematicians pull in different directions, producing alternative conceptions and a disparity of vision which points to an uncertainty ontology of mathematics. The plot of mathematical identity could, therefore, be considered as an overarching plot of tragedy and stories are told in relation to this. The examples from Holland et al. are chosen for their resonance to some pathologised idea of mathematics as being 'within' the body,

either through intellect or a pathologisation of addiction to and abuse of mathematics.

In *'Personal stories in Alcoholics Anonymous'* (AA) Holland et al highlight the medicalised view of alcoholism as addiction and addiction as a disease, illness or malady made apparent by an observable set of "deviant" behaviours; a mental disorder (Holland et al, 1998, p.69). Similarly, the psychiatric classification of mental disorder comes about from a phenomenological, descriptive system where disorders are categorised according to observed sets of symptoms or syndromes that are different to what is designated as normal behaviours rather than from general theory, neurological causation or aetiology (Holland et al, 1998, p.198). Holland et al. note that whilst psychology maintains that patients are distinct from their illness, patients are most often identified by their diagnosis. Thusly, the psychiatrised identifications, or labels, become semiotic devices; words of others which are appropriated to language oneself. This shines a light on how phenomenological processes are implicit in mediating identity in relation to certain kinds of bodies for certain kinds of people.

In *'Mental Disorder, identity, and Professional Discourse'*, 'Roger', a mental health patient, recounts his experiences with mental health services. Roger's 'disorder' is made apparent through their description of the incongruence between Roger's tone of voice, expression and bodily gestures. Roger's body became a sign against which a set of societal norms or expected behaviour are read. However, persons may not identity as alcoholic or mentally ill. Therefore the individual experience is read in concert with wider social stories rather than displaced to look for some general themes about society, but which may say little about the individual experience (Clandinin and Rosiek, 2007).

In their chapter on *'Alcoholics Anonymous'* (AA) Holland et al cite 'role performance' as instrumental in structuring identity stories through a cursory mention to Irving Goffman's undercover ethnography of the mental asylum.

Goffman (1963) claims stories of self-align more readily in 'total institutions' (hospitals, prisons, school systems) as neophytes are indoctrinated into expected ways of being where one's role or identity can be prescribed to a greater degree than in other ordinary social contexts. Goffman found that institutions foster an *'appropriate storyline'* of expected behaviours through institutionally produced and approved materials such as newspapers and newsletters and that identity roles are conveyed through role separation and hierarchical categories of peoples (Dr/patient etc). In 'AA' Holland et al. describe how the sharing personal stories become a symbolic device where *"personal story is a cultural vehicle for identity formation"* (Holland et al, 1998, p.71). The alcoholic socially performs in an 'as-if world'. Through the figurative and metaphorical world of 'AA', alcoholics learn *"the appropriate storyline"* (Holland et al, 1998, p. 74). The storyline is passed on from 'old timers' to neophytes in the AA meetings through a form of behaviour modelling where new members witness 'old timers' recounting stories in the AA meetings as 'confessional' accounts. Additionally, the AA 'big book' (Holland et al., 1998, p.77) is a written collection of archetypal AA member stories which is used by members as a cultural artefact, recording and informing what an appropriate AA story might be. Interestingly, the AA member stories were remarkably similar, despite a wealth of differences across the members. They suggest similarity is to be expected because member stories are re-formed to fit the AA story structure – the figured world of AA (Holland et al, 1998, p.83.) AA Members learn how to tell an AA story by first by listening to the stories of other, older members as experts before structuring their own stories to fit the AA model through social interaction, or in Ricoeur's sense, a plot line which drives the personal narrative.

Holland et al.'s examples offer a means to hold a mirror up to anxious and pathologised mathematical identity stories in order to understand experiences as embodied and the body as a site of storying. Whilst the literature review presented bodily representation is a way to claim mathematics as something within the body 'naturally gifted', Holland et al.'s examples provide a way to think of the bodily identity as mediated in an 'As-if' world in relation to a 'standard-plot', a canonical story about mathematics which frames the lived experience of the social 'actor' (Holland et al, 1998) and of who and what a person can be and do. This As-if' world is based on Bourdieu's imagined identities lived as social realities; not dissimilar from Turner's (Turner, in Schechner, 1985) 'As-if world' of the social actor where lives are lived in the' subjunctive form, which is the self as another, either contemplating the self through self-reflection or indeed using one's own experiences in a drama.

In summary, there is some aspect of performance in everyday life, the identity we story or perform includes both the narrative and embodied forms. Stories are performed in relation to a plotline, which drives what can be told. These plots structure experience and what can be told about them; however, the plot is an overall structure –romance, comedy, tragedy, satire. Whilst individuals may story identity in relation to these plots, identity is not constituted by them.

3.5 The conceptualisation of identity in this thesis

This conceptual framing of identity was founded on the articulation of mathematical identity as a story. Consideration was given to the problem of how story is conceived paying attention to narrative conventions, what makes a good story and how story is equally performed and co-constructed in the social endeavour. The purposefulness of the Bakhtin/Ricoeur dialogue is the bringing together of story, memory and imagination as crucial understanding dialogic identity as referenced to a historicity of a polyphony of voices. I take the stance that identity as story is performed discursively and extra-discursively; including

the body as a cultural artefact, emotions and imagination as part of a psychic reality. The story is multidimensional, existing in the past, present, future; in actuality and imagination.

The form of the narrative or ways of telling the story includes dialogue and embodied ways of being in a dialogical process of addressing and being addressed. Often these worlds are rarely contemplated without provocation for reflection, which in itself if a difficult task because in recollection we story ourselves in the present, through the past. Each time we visit past experience we re-figure it anew. Imagination is a way to escape being recursively reproduced to imagine the future and thus develops an identity and enables imagining of future selves. The same creative and imaginative processes can canonise signs, symbols and cultural artefacts, such as the body, as resources with which to mediate identity. Identity story can also be considered as told in relation to a plot, this is not to say that all actors will story their identity similarly but rather use this overarching plot to structure their own experiences.

These narrative resources (the world of the story) however, are also a means to re-figure identity in creative ways by adopting a different plotline, such as satire. For example, 'parody', as a form of satire, can be a creative means to express an identity story which is different to, or subverts, the plot, thus making anxious or tragic stories of mathematical identity, for example, open to scrutiny for their perceived ridiculousness – i.e. the stereotypical images of the 'professional mathematician' as somewhat tortured, socially inept and eccentric.

Through a Bakhtin/Ricoeur union of a phenomenological hermeneutic perspective identity as a story has been conceptualised to account for both narrative and performative senses of a story as well as the dialogic aspect of storying the self amongst the voices of others, including the past, present and future possible selves. The ground has been laid for a potential contribution to knowledge whereby accessing memory and exploring the interplay between

oral and embodied/enacted aspects of identity might be productively achieved through drama and film research methods. In the creative process of storying, we are also reminded that the material and form of a story, as identity, is a social process of identity work. Identity story is, therefore, fallible, in flux; a lived experience. The difficult work of capturing identity story would, therefore, benefit from a suitably sensitive methodology. Chapter 4 builds on this conceptualisation of identity story, detailing, in response, the methodological approach of this thesis.

Chapter 4.   Between fact and fiction: Arts Based Research (ABR) and the making of 'Performatics'.

4.1 Introduction

Grounded in the preceding conceptualisation of identity as 'story' (both oral and embodied/enacted), this chapter guides the reader through the Arts Based Research methodology adopted in this thesis for the making of the research film '*Performatics*'. The chapter discusses how filmed-drama was developed as a research method which constitutes a whole research process, including data collection, analysis, discussion and dissemination. This discussion is underpinned with some theoretical debate about ABR and concrete examples from the field and this research. This introduction provides a brief overview of the structure of chapter and the salient points which are necessary for the reader to understand the research process undertook in the making of '*Performatics*, which also contribute a recipe for replicating this research.

The chapter begins, in section 4.2, with a discussion of the ABR epistemology which details how the arts, and aesthetic beauty, can be considered rigorous research. Elucidated is how arts methods value the expression of thoughts, feelings and emotions; an approach hypothesised by myself as having the potential to uncover alternative understandings of mathematical identity.

In section 4.3 I detail the ABR design of filmed drama. Firstly, discussion attends to the 'Playbuilding' approach to research which was developed by Joe Norris. This approach was used to structure the drama. During the Playbuilding various drama, techniques were employed, including forum theatre, playback theatre, scripted drama and improvisation. Next, the discussion moves on to the observational cinema techniques of Jean Rouch, where ethnofiction and cinema-verite privilege the actor's imagination as inherent to their experiences,

and therefore fundamental to their identity. I elucidate how Rouch's cinematic approach dictates an intimate filmic style through the use of a hand held video camera to get close to the action. This closeness captures the drama to account for the various voices in the research, including; the research subject, audience and my voice as the researcher-filmmaker. Both film and drama techniques are also discussed in relation to their roots in psychodrama and socio drama, as an alternative to the therapeutic mode, as a way to look outwards from the individual to the wider society and common social stories about mathematics.

ABR as analysis clarifies how the drama and film methods are considered analytical. Examples from the research illustrate how the drama structured experiences through thematic coding. Thereafter, an explanation, with examples, of how the film editing technique of 'parallel editing' was applied to the raw video material to make sense of the data and re-present it as a film (3.4).

The recruitment and access section deals with the recruitment strategy. I detail the ethnographic and co-operative inquiry principles which guided me in developing connections with like-minded individuals to explore a topic of mutual concern (mathematical identity). Some issues related to the recruiting of film subjects and getting access to film locations are also covered (4.5).

The ethics section sets out my reasoning for adopting a consequentialist approach to ethics; clarifying how non-anonymisation can be considered an ethical approach to this research. I cover the informed consent process and how the research subjects, and others captured in the film, are protected. I detail how data handling was a co-operative activity where I worked with the research subjects (actors) to select appropriate data to include in the film. Additionally, filmic work has some significant impact on the researcher. I also deal with how I was affected by the filming work, including the physicality of camera work (4.6).

A brief conclusion draws together how ABR is applied in this thesis as a film which constitutes a whole research process to provoke a social audience (including the general public and academic community) to critically question mathematical identity.

The ABR film *'Performatics'* is integral to the research as a process, analysis and representation of findings; where method meets arts' (Leavy, 2015). Clips from *'Performatics'* are used as examples throughout and are indicated by a 'timecode' to guide the reader to the example in the main film e.g. Timecode 1m 30s (scroll to 1 minute and 30 seconds into the film). Through the examples of the film, the researcher is briefly introduced to the film actors, Claire, John and Rob and the drama facilitator Maddy. A fuller introduction to the actors appears in the next chapter which deals with the film structure and how it is to be viewed/read.

4.2. An ABR Epistemology

This section outlines the epistemological position of ABR, and how it operates as a method of inquiry. Discussion of the development and applications of ABR is grounded in recent reviews of the state of the art by McNiff, (1998), Denzin (2001, 2003, 2009), Barone and Eisner (2012), Leavy (2015), and also Beck et al.'s (2011) comprehensive account of the spectrum of drama/theatre based ABR. This discussion begins with a brief overview of the roots of ABR, how art and beauty can be considered rigorous research characteristics and how experiences and the senses come together as a form of knowing as 'aesthetic knowing'. Concluding remarks highlight how, despite some criticism to the contrary, artistic endeavour can be considered valid and rigorous research.

To being, Denzin (2001, 2003) has usefully outlined the field of arts in research. Denzin found that whilst researchers utilise the arts in various ways, the arts are mostly used as a means to gather data or present research. For example, Denzin highlights that 'performance ethnography', as a visual arts method,

recreates traditional field data into performance for dissemination purposes. The 'performance' is a tool for dissemination and the art component is not fully constitutive of the research. Whereas Arts Based Research is art as research (Leavy, 2015). ABR research takes the artistic process as addressing, answering and representing the research problem - ABR makes the 'art' into a whole research process.

Arts Based research has been variously documented for its applications and potential[27]. Sitting within a qualitative paradigm its inductive approach to research begins from the position of the researcher/artist through their practice and praxis; which then reaches out to the subjects of their art, and to a wider audience (Rolling, 2010). Barone and Eisner (2012) chart ABR's roots to their earlier work in 1993. Eisner was writing on arts and education and Barone was involved with Eisner in setting up a seminar on what arts based research might be at the epoch of what they termed a *dissolution of the arts-science dichotomy"* (Barone and Eisner, 2012, p.xi). Science began to be thought again as an artistic process, and artistic processes as scientific because of the rigour, the questioning approaches to knowledge, and the meaning making that artistic representation affords. However, In charting the historical development of ABR, Cahnmann-Taylor and Siegesmund (2008) caution how ABR should not be in opposition to traditional methods but positioned as a way stretch the researchers capacity for creating and knowing as a synthesis of approaches. (Cahnmann-Taylor and Siegesmund, 2008, p.5). Alas, despite the claimed dissolution of barriers, and the forging of bridges between art and scientific inquiry, they also attest that ABR in Education (ABRE) is still a relatively new and underused methodology for educational research. They go on to state that there is some tension about what ABR is, who conducts it, and the integrity of aesthetic inquiry as a marker or research validity. The problem for Cahnmann-Taylor and Siegesmund is that there are more researchers writing about ABR than producing it. The same claim can be made for mathematical identity

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[27] See, Mc Niff, 1998; Denzin, 2001; Cahnmann-Taylor and Siegesmund, 2008; Beck et al, 2011; Barone and Eisner, 2012, and Leavy, 2015 amongst others for discussion on ABR methodology and applications in social and educational research.

research where the issue of using more performative approaches has been mooted but not readily adopted (Rosiek, 2013; De Freitas, 2016; Darragh, 2016). Cahnmann-Taylor and Siegsmund claim it is critical that more educational researchers take risks, at the edge of inquiry to hybridise and experiment with ABR so that critical sensibilities, and what counts as good, valid, rigorous ABR, can be refined (Cahnmann-Taylor and Siegesmund, 2008, p.12). Whilst De Freitas argues for more experimental filmic investigating in mathematics education research, which take approaches adopted by the likes of filmmaker Jean Rouch. '*Performatics*' is me, taking a risk, to employ filmed drama to assess the utility of   ABR for mathematical identity research.

In addressing issues of validity and rigour ABR approaches to research by claiming that art is more than data; the process of artistic endeavour is *"the primary way of understanding and examining experience by both the researchers and the people that they involve in their studies"* (McNiff, 1998, p.29). Leavy (2015) counters how positivist paradigms would view ABR for apparent issues with subjectivity, inconsistency and perceived a lack of rigour, instead arguing how ABR rigour derives from an authentic, artistically and aesthetically sound piece of art interrogated by the audience. Rigour is redefined as the 'trust' of the audience, reader or viewers, in the arts authenticity (De Freitas, 2004) and beauty is considered as validity (McNiff, 1998). What ABR has at its core is an aesthetic, artistic object or artefact which encapsulates the research process, analysis and representation. Therefore a researcher conducting ABR will produce a significant piece of artistic work or endeavour as integral to their research study. The rigour and validity of such research should be evaluated by the trustworthiness and beauty which manifests itself as the research.

Leavy (2015) explains how art is not recognised but sensed, in what Kant terms 'reflective judgment', and Deleuze describes as a 'transcendent exercise'; aesthetic beauty fosters reflexivity and empathy. Ultimately, *"ABR is linked to the utility of the work-how it affects people"* (Leavy, 2015, p.20). The utility of

ABR is an artistic representation and its affective properties to promote engagement with the subject, and to provoke further questioning, critical awareness and to open up the inquiry, rather than to provide answers, closures and knowledge claims (Rolling, 2010; Barone and Eisener, 2012; Leavy, 2015). For instance, Rolling (2010) declares that ABR is wasted on conveying facts about mathematical test performance and ABR should be used instead to exploring habits, rituals, reflections, expressions of emotion and social agency.

Examples of ABR in mathematics educational research are rare. Examples of arts inspired research in mathematical education include, but are not limited to: the use of photo voice to explore girls experiences with, and anxieties towards, mathematics (Harkness and Stalworth, 2013), the affective properties of music for mathematics learning (Haynes, 2004), and watching documentary film to improve mathematical performance. (Hekimoglu and Kitrell's, 2010).

Of note is Katz-Buonincontro and Foster's (2012) study which used visual art media to understand student engagement with mathematics game based learning. The video was used to record students as they created 2D and 3D graphic Avatar images to represent them in a mathematics video game. In follow up interviews the students discussed how they engaged with mathematical learning in the game, helped by their Avatar. The students reported, somewhat surprisingly for the authors, that the Anglicised Avatar (white, straight hair), which are usually available for player selection, were problematic for student inclination to connect with mathematics in the game. In creating their own Avatar, which the students felt better represented their identity, it was found that the students were freed somewhat from cultural expectations, endowing their *virtual self/game avatar "with knowledge and skills that the real self does not possess"* (Katz-Buonincontro and Foster, 2012, p. 351). The artistic undertaking had revealed that it was the students' mathematical identity, and relationship to fictional representations of self in the game, which was the issue in their disengagement for mathematical game play. Once the students were freed somewhat from discursive communication,

through the creation of artistic representations of self, the body was illuminated as an important sign, and mediating factor, in their developing mathematical identity.

Critically, the epistemological position of arts based research (ABR) is that arts create and conveys meaning beyond the *"limiting constraints of discursive communication"* (Barone and Eisner, 2012, p.1), in its narrow sense of the verbal as opposed to the wider sense, to attend to the sensory and ineffable.

> "If there is a commonality in art it lies in the fact that certain activities everywhere seem specifically designed to demonstrate that ideas are visible, audible? and one needs to make up a word here? tactible, that they can be cast in form where the senses, and through the senses the emotions, can reflectively address them.
>
> (Geertz 1983, quoted in Blumenfeld-Jones 1995, p. 393)

De-Freitas (2016), describes sensing in two ways, the sensing as in making sense and meaning and sensing as experience, sensing the world through sight, sound, touch etc. Sensing' has also been described by others as an 'aesthetic knowing'. Aesthetic knowing here has two understandings. The first is situated in practice (Carper, 1978; Galvin and Todres, 2012), with an in-the-moment, perceiving, feeling, sensing of a situation, linked to the hermeneutic phenomenological interpretation of human experience (Friesen, et al. 2012). The second is 'aesthetic knowing' through beauty. For ABR in this thesis, I link human experience to the sensual. Whilst the thesis film '*Performatics*' is grounded in the literature (Chapter 2) and how I have conceptualised identity (Chapter 3), the purpose of the film is to provoke a critical awareness of mathematical identity and open up the inquiry, rather than provide concrete answers. The audience, academic and otherwise, will engage with the film, employing their own interpretation.

4.2.1 Becoming an Arts Based Researcher

Here I outline my position as the researcher and the considerations of researcher subjectivity in the ABR process. I immersed myself in a variety of performance, film and science/mathematics activities integral to developing my own understanding of performance and as a means to ingratiate myself with research subjects

> -Technical and theoretical training: I undertook three post graduate level filmmaking courses (two practical and one theoretical course on visual ethnography and observational cinema). I also gained camera experience as an academic filmmaker shooting academic interviews, guest lectures and conferences.

> -Performance training: As I began the research I joined a local improvisational drama group at the University for one semester, until it ceased to operate. I also trained and volunteered as a STEM communicator for the University and undertook training in stand-up comedy to represent research as a stand-up with the academic comedy group 'Bright Club'.

Although these experiences developed my knowledge of the research methods I was cognisant that producing trustworthy data meant acknowledgment of my own experiences which shaped my standpoint and assumptions (Thomas, 2009). In accepting that researcher subjectivity may potentially compromise researcher observation (Cohen et al, 2007) this research makes no claim to objective truth but rather to present a credible and trustworthy account of the interactions between researcher and performance subjects in producing an artifact, *'Performatics'* film, which explores their mathematical identity. Indeed, Cahnmann-Taylor and Siegsmund (2008), extol how no method can reveal everything. Knowledge and meaning were co-constructed between the research subjects and me in a "*mutual shaping and interaction between researcher and participants"* (Lincoln and Guba, 1985, p. 155 in Cohen et al, 2007, p. 170). Ann inductive process, with an emergent design (Jacob and Fergerson, 2012, p. 5), draws on principles of participatory cinema whereby

"the film maker acknowledges his entry upon the world of his subjects and yet asks them to imprint directly upon the film their own culture...By entering actively into the world of his subjects, he can provoke a greater flow of information about them. By giving them access to the film, he makes possible the correction, additions and illuminations that only their response to the material can elicit. Through such an exchange a film can begin to reflect the ways in which its subjects perceive the world."

(Mac Dougall, 1995, p.125)

The researcher position and contribution to the research process is evident in the way that the film captures analysis and conveys the data. The researcher as a film director, camera operator and editor co-constructs the research subject stories through the camera work, shot composition and in the choosing of which events to film and how to edit. The researcher brings not only brings subjects stories into relief but through artistic endeavour, I also situate myself in the research. Although the research subject's stories of mathematical identity (captured and presented) are credited to the subjects, the researcher co-constructs those stories (in the technicalities of using the research instruments), providing an additional authorial stance which is distinct from subjects and which answers to a different (academic) audience. Thusly, whilst the actor's stories are privileged, two distinct stances are represented by the research, and oftentimes, a dialogue between them.

4.3 ABR Methodology and Methods: Filmed drama.

Illustrated here is the research design schedule (Table No. 1), as an overview of the research process and a guide to the methods to be discussed in this section. The film process took 1.5 years over 3 main stages of ***Pre-production'***, '***Production'*** and ***'Post production'.*** The production stage incorporates the principal research method of 'Playbuilding', which itself is conducted in stages. Alongside the description of 'Playbuilding' is a methodological discussion of drama methods appropriated into the research, and the usefulness of such methods for exploring identity illustrated with examples from the research undertaken. The film is then discussed as able to

capture the drama process, analyse data and re-present as an academic text. I begin with some contextual information of how the final methods were augmented following the pilot study.

The research began with a pilot study[28] between April and May of 2014. The details of the study are summarised in Appendix 7. The pilot study consisted of some crude filming of observations of quantitative analysis students in their class. This was played back to them as provocation for producing a drama, as well as some direction by me to explore past experiences with mathematics. The method and methodology of the pilot study are not discussed in detail in this but are useful to understand the minor changes to the methodology and methods of the main study, which was refined in respect to reflections by me, and the pilot subjects, in the research process. The pilot refined the main study in three ways. Firstly, the crude camera work of the pilot, filmed on a video camera which was static, missed some of the attention to detail of the intricacies of the drama because the camera was too far removed from the action. The camera work was addressed by attending technical and theoretical courses in observational filmmaking which led to the observational cinema approach detailed in this section.   Secondly, feedback from the pilot subjects indicated that a more systematic approach, with more provocation, would be beneficial for them in remembering past experience, which was problematic in the pilot (memory remained an issue in the main study and is discussed in Chapter 6 as to how the methodology assisted this issue). Finally, the subjects felt more practice play would help them to develop the drama rather than jumping straight in to building a drama piece. My reflection and the subject's feedback led to the adoption of *'Playbuilding'* in the main study to account for provocation and practice and observational cinema as a secondary methodology to strengthen the research.

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[28] The pilot study film was shared with the participants permission at the University of Manchester Methods Fair . Manchester, November, 2014. http://www.methods.manchester.ac.uk/medialibrary/docs/methodsfair/Fair2014.pdf The permissions to share the pilot footage do not extend to sharing beyond that occasion and so only the written pilot report is attached as an appendix with this thesis.

Table 1. Arts Based Research timetable spanning 1.5 years.

Table 1 describes the whole research process which produced 60 hours of film

Stage 1. Pre- Production April 14 – December 14:

April –May	Pilot study
July	Filmmaking for fieldwork practical, anthropological film theory.
December	Recruitment.

Stage 2. Production November 14-April 15 Playbuilding as analysis: Filmed

November-	Playbuilding Stage 1: Filming Testimony and Observation
December	Individual Testimony of experiences with mathematics: 1.5 hrs each.
	Individual Observations: 2 x half days each.
February	Playbuilding Stage2: Pre-planning group meeting
	An initial planning meeting between the actors: 1 half day.
March	Playbuilding Stage 3: Drama building-collection
	Actors make written notes on themes from the stage 1 film.
	Construct a 'story shower' script, Forum and Playback theatre.
April	Playbuilding Stage 4: Compilation drama.
	Actors use stage 3 notes to compile 3 dramas: 2 x half days.

Stage 3. Post Production April 15 – Dec 15:   Film Edit as analysis

April	Log and transcript Audiovisual material. 60 hours of film.
March – May	Edit as analysis. The first public showing May 15.
May – Dec	Subsequent edits

4.3.1 Drama as research: Joe Norris' 'Playbuilding' as a dialogic approach

There are multiple ways in which drama has hitherto been appropriated into research from drama as pedagogy, drama to represent research and drama as research. Beck et al (2011) and Leavy (2015) both provide informative historical accounts of the performative turn in research. The thesis is concerned with drama as research; as a means to expose the various voices mediating the actor's mathematical identity. Examining the process of the drama building is as important as the finished filmed drama. I purposefully approached the theatre based [29] literature to source a systematic drama research method which paid as much attention to the process of constructing the drama, as to the drama content; the purpose being to capture the dynamism of the storying process. Here I detail the principle research method of *'Playbuilding'* (Norris, 2000), which is a framework for conducting drama as research. The framework is loose so that a variety of drama methods can be used.

For this research drama techniques of playback, forum and ethnotheatre were appropriated into the Playbuilding method for this research and are discussed in relation to the research process. Dramatic performance is both methodology and method. The drama was a way to explore the lived experience of the research subjects (actors) in relation to wider stories of mathematical identity. Drawing on Participatory Action Research (PAR) models of drama, which use research subjects life stories as the basis for the drama performance termed *'ethno-mimesis'*, the research subjects, as actors, were involved in the creation of a piece of visual, expressive art

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[29] Beck et al. (2011) have defined a spectrum or theatre based research. I adopted the approach of participatory audience, to account for the collective storying of identity and theatrical research based performances where artistry was a primary goal. Yuval-Davis advocates drama as research, as a private drama to a closed group (2008, 2010). Whilst Conrad (2009) and Macintyre et al. (2012), present data as public theatre acted by professional actors.

> "as the inter-textual relation between an ethnographic life story and a dance/performance as living art represents a re-covering and re- telling of lived experience as embodied performance"

> (O'Neil, et al., 2002p. 83).

Ethno-mimesis plays to an audience to provoke thinking at individual, group and societal levels to

> "undercut identity/identitarian thinking and in the process facilitate a space for the viewers to approach a genuinely felt involvement (see Nicholsen, 1993: 12) which demands critical reflection. Thus generating what Bakhtin calls 'Dialogic texts' and facilitating the de-construction of stereo- types of 'otherness'.

> (O'Neil, et al., 2002, p.84-85)

Ethnodrama of lived experience draw the audience in, igniting their emotions and in doing so have the power to disrupt traditional or longstanding notions of particularly identities or stereotypes and in doing so bring into relief stories of mathematics and mathematicians which are resources mediating the actor's mathematical identity. This dialogic interaction between actor, audience and society is made all the more apparent through theatre. Turner (1987) and Schechner (2003) theorise that drama will naturally draw on the performers social experiences and in creating theatre the actors make sense of their social worlds. There is a dialectic between the social every day and the aesthetic and performance is developmental rather than simply representational. Figure 2 represents Schechter's illustration of social drama.

Figure 2. Turners Dramatic cycle in Schechner (2003, p.215)
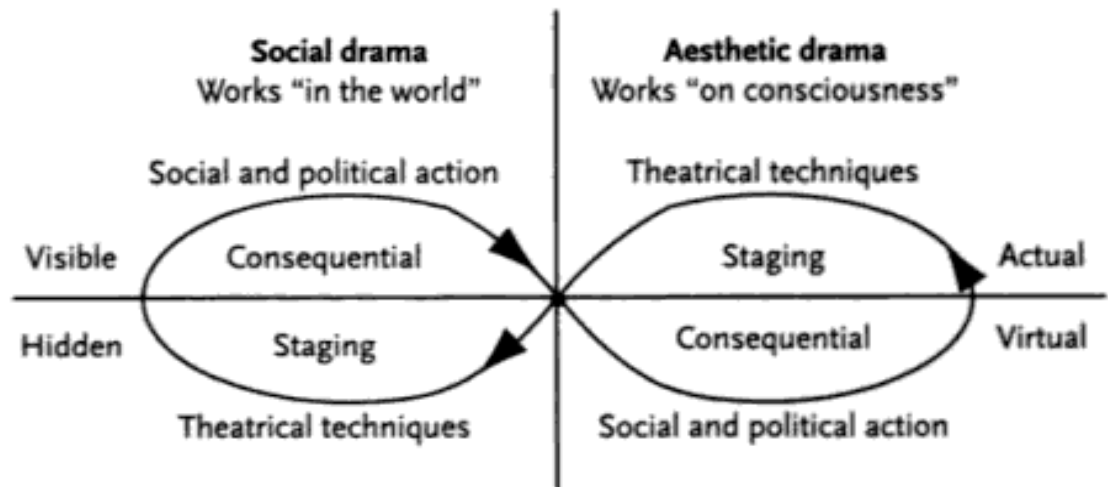
The social drama includes the behind the scenes preparations and rehearsals of the social performances acted out. In aesthetic drama the reverse is true; we make explicit those practices and rehearsals that are developmental for the drama. Drama can, therefore, be a way to make explicit the hidden rehearsals of social enactment, including the often hidden social enactment of mathematical identity.

For example, Participatory Action Research (PAR) models of ethnodrama, for example, use research subjects life stories as the basis for the drama performance termed *'ethno-mimesis'* where the subjects are involved in the creation of a piece of visual, expressive art

> "as the inter-textual relation between an ethnographic life story and a dance/performance as live art represents a re-covering and re- telling of lived experience as embodied performance"

> (O'Neil, et al., 2002, p. 83).

Ethno-mimesis intends to bring the audience into the drama as integral to the purpose of the research to challenge stereotypes and provoke change at individual, group and societal levels to

> "undercut identity/identitarian thinking and in the process facilitate a space for the viewers to approach a genuinely felt involvement (see Nicholsen, 1993: 12) which demands critical reflection. Thus generating what Bakhtin calls 'Dialogic texts' and facilitating the de-construction of stereo- types of 'otherness'.

> (O'Neil, et al., 2002, p.84-85)

Thus ethnodrama of lived experience are positioned as able to explore identity construction and the experience of the individual, in relation to wider social contexts –looking outwards.

However, the filmed drama did offer some sense of exploring the self and the actors questioned their experienced with mathematics, and anxiety became influential motifs of the film.   The psychoanalytic 'psycho-socio' drama of Jean Rouch, and his surrealist artistry of bringing the imagination into the formation of individual consciousness (De Freitas, 2016; Henley, 2009), utilised the expressive function of drama to tap into the imagination, memory and dreams of his actors (Morin, 1985). Drama is used in the thesis research process to represent and sense the actor's experience of mathematics, drawing on imagination in relation to their recall of past experiences with mathematics.

4.3.1.1 Playbuilding stages

This section detail the principal drama method adopted in this Thesis. Dramatist Joe Norris (2000) developed 'Playbuilding' as a drama research method where 'actors' ask and answer questions through drama[30]. Norris claims that drama provokes the actors to think about their social worlds. Playbuilding was chosen as a principal research method for this thesis because it was well developed and accounted for as a means of data collection, analysis and distribution/representation whilst being open ended enough for exploring lived

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[30] Filmed examples of Playbuilding, by Joe Norris, can be viewed on his website at http://www.joenorrisplaybuilding.ca/?page_id=149 [last accessed 10/07/2016]

experience, and also to take account of the various voices of researcher, subject, wider society and culture. Playbuilding also offered a way to structure the drama and facilitate the imaginative effort required.

Stage 1: Individual filming

Playbuilding is an auto-ethnographic approach that blurs the lines between the researcher/actor roles. The drama often begins with the sharing of stories often starting with the researcher so as 'story begets story' (Norris, 200, p. 46). These first stories act as provocations for discussion, opening up a critical inquiry of a problem or issue. In the instance of this thesis, the beginning story came from myself in recruitment as I conveyed, to prospective research subjects, my interest in mathematical identity, recounting the story I had outlined in the thesis introduction of my school self who I felt was denied a mathematical identity. The purpose of telling this story was to contextualise my research so that prospective subjects (actors) had some sense of the types of stories of interest to me and what they might be expected to share. After recruitment, during the early days of the research, the subjects (now actors) were filmed (i) giving testimony (a filmic type of interview) about their experiences with mathematics, and (ii) observed in their everyday life at university. This early filming had a dual purpose. Firstly, to gather 'oral' and 'embodied/enacted' stories of the actor's mathematical identity: and secondly, to provide context for those stories, and the film. This film footage was used in stage 2 of the Playbuilding as provocations to develop a drama about the actors' personal experiences with mathematics. The filmic treatment of testimony and observation are discussed in their own sections of this chapter.

After the filming, the first get together of all the actors was convened in the theatre. Their thoughts were gathered on the type of drama they wanted to portray. The actors collectively directed me to edit, as I saw fit, the stage one testimony and interview footage thematically, in terms of common feelings

towards mathematics. This edited film constituted the 'provocation' for the drama in stages two and three.

Stage 2: Drama building 'collection'

The collection is a key component of Norris's drama research technique. Norris proposes that in this collection/planning/exploratory stage the provocations (in this case film) are engaged with by the actors and any discussions surrounding the provocation are documented as potential scene references with which to base a fuller 'compilation' drama on.

The first set of the film, edited as requested by the actors, was played to the group in the drama classroom. I then directed the actors to work as a group and write notes on themes emerging from the footage. I guided the actors to think about the theme of 'common feelings' which they had identified as useful for formulating the drama. I directed the group to critically consider similarities, differences and contradictions between their own and each other's stories. After which, Maddy, the drama facilitator, instructed the actors to think of an experience they have had with mathematics, which resonated with the film and the themes based on the themes the group had come up with. This experience was written as a kind of script which I termed a 'story shower'. The story shower method was adapted from my work with the STEM research dissemination comedy group 'Bright club' where story showers had been used as a concrete way to structure experiences to make them tellable.

After compiling the story shower Maddy engaged the actors in drama games as a way to move the written scripts to an enactment. Fox's *'Playback Theatre'*[31]

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[31] Fox (1987) Playback Theatre is a technique where the audience tells their story and the actor's play them back. In the rehearsals for the drama in 'Performatics' the actors told their story and in some cases these were 'played back' to them by the other actors. In contrast, Boal's Forum Theatre (1979) entails the actors telling their own story and the audience stepping in to their shoes at various points.

(1987) was used to focus on lived experience, building up scenes over time through short performances about their past experience with mathematics. Then, using Boal's '*Forum Theatre'* (1979), which gets actors to step into the shoes of other characters, through improvisation, the actors broke from the scripts and improvised short scenes, playing each other. Putting themselves in the character of one of the other actors was useful to check the tellability of the story they were trying to convey and to find points of commonality and difference. Playback and forum theatre were useful methods to structure experience, assisting the actors to organise their thoughts and restructure their experiences as tellable/performable to an audience. In *'Performatics'* we see Maddy (in clip number 6 below) as she guides the actors through their initial playing out of the story scripts in, which are then overlaid with the finished drama in the final film edit.

Clip No. 6 'Performatics' compilation drama: Maddy guides the drama.
Time Code 5m 30s

Scene 2: Performing mathematics stories

The actors coding and playing out of short scenes was used as a basis for the further compilation drama performance and served as a guide for what was important to include in the final film. At the end of the collection stage the themes the actors had drawn out in their group discussion, documented in their collective notes, and detailed in their story showers, were collated by me and emailed to them to check my understanding of what they had produced.

14th March – some thoughts on yesterday's performance session

Themes which were similar, yet contradictory, different maths 'voices'

Maths causing anxiety

Initially in lower sets for it and having to work up (Rob).

Not liking the performance aspect, feeling small/being picked out.

Being good at maths individually but not when performing in front of others (Claire)

Being good at maths and this not leading to popularity

Being 'quietly good at maths and loudly disruptive (John)

Maths alleviating anxiety/source of enjoyment

Counting to get to sleep, puzzles, countdown etc (Claire)

Passing boredom time with own made up puzzles (John)

Playing music and seeing music as maths (John and Rob)

Nature vs. nurture

Nature - More easily just seemed to have an ability/affinity with maths (John, Maddy)

Nurture - having to work at maths (Rob, Claire)

Maths people

Schizophrenic characters!

Logical, pragmatic problem solvers, without personality, boring.

Creative, philosophical

Dangerous/mad scientist.

These notes, made by the actors, and collated by myself, were a form of coding the themes for the drama. These emerging themes became concretised and evident in the final drama and film.

Stage 4: Compilation drama

Norris's final movement in the stages of Playbuilding is to move from collection to compilation of the drama. In this final stage, the group moved from the classroom rehearsal space to the theatre space. The group of actors began to move from the drama games of the compilation stage to adapting their own drama techniques. The compilation drama developed from the collection stage paper exercises and drew heavily on ethnofiction principles. The actors used the notes they had prepared in the collection stage to compile 3 pieces of drama. The first two scripted performances very closely followed the story shower scripts of the protagonists Claire and John and could be described as more factual accounts of anxiety causing experiences with school mathematics as remembered now by using 'ethnofiction', where imagination and creative re-storying is considered indicative of doing identity work. The final collective improvisational drama was set in the present day and was loosely based on Rob's recount of mathematics anxiety told in a fictional 'group therapy' entitled 'Math Therapy'. In this scene, the actors played fictional accounts of themselves. This improvisational drama more closely resembles an ethnofiction, where characterisation facilitates distance between the actors and character, so as to explore lived experience more freely as an 'other'.

'Ethnofiction' (Saldana and Casas, 2005) as 'reality theatre' is a methodology which reproduces lived experience for an audience through filmed fiction. Subject-performers fictionalise accounts of their lived experience with the space to change aspects of the performance such as the context and the characters. Acting as themselves in some form of altered reality, through fictionalisation evokes the 'subjunctive mood' (Schechner, 1985); acting as themselves but 'beside themselves'. Actors step outside of themselves, claiming some distance between themselves and the experience, which can offer some distance for reflection and also provides an opportunity to re-story experiences they may not want to attribute to themselves in a public forum.   For example, Sjoberg's (2009) ethnofiction film *'Transfiction'*, about the lives of transgender sex workers in Brazil, facilitated the actor's exploration of their experiences through fictionalized characterisation. Bibi as 'Zilda' felt as if she were another person,

however, Fabia, as the character 'Meg', reported how the characterisation did not protect her from re-enacting painful past experience (Sjoberg, 2009, p. 169). Acting as the other may not assuage difficult feelings and emotions of difficult situations for all actors and this is an ethical dilemma in research. In 'Performatics' the actors fictionalised themselves in the improvisational 'Math Therapy' as the salacious characters often associated with mathematics in the literature and filmed media, as identified in the Chapter 1 review as the mad and bad. In doing so the actors were able to explore aspects of their own identity in relation to these wider stories of what it means to be mathematical by claiming some distance between themselves and their fictionalised self.

Additionally, ethnofiction notably brings imagination into dramatic being. Film maker Jean Rouch's ethnographic sensibilities dramatise his actor's internal imaginings or dreams to make them central to the characters lived experience; Most notably in 'Jaguar' (1967) and 'Chronicle of a Summer' (1961), which Rouch shot with Sociologist, Edgar Morin. Sjoberg's documents an intricate account Jean Rouch's works, sensibilities and methodologies so rather than cover similar ground I explain, in the upcoming section on visual anthropology, how Jean Rouch's work fits with the methodology of this study. Where ethnofiction assists this project is centralising imagination as a part of the actors lived experience, a part of their identity story and how improvisation and fictive accounts of the self, offer a means of reflection on the actor's experience. In the scripted drama of 'Performatics', the actors dramatise their imaginings as accounts of their experience with mathematics in school, providing the audience with a visceral sense of what it was like for them.

4.3.1.2 Summary of Drama as research

Dramatic performance is detailed above as methodology and method. The drama was a way to explore the lived experience of the research subjects (actors) in relation to wider stories of mathematical identity. The drama process has been depicted as particularly rigorous research method where questions are posed and answers attempted in the drama and where analysis occurs

through taking notes on scenes and building to a final compilation drama. The rigor of this method instills confidence in the quality of the research and sets out a recipe for reproducibility so that ABR (as filmed drama) may be adopted more widely in mathematical identity research. Whilst Joe Norris often films his drama Playbuilding to example the whole process, this is not contextualised by the wider lives or experiences of his drama actors, and the camera is often fixed. It could be argued that some sense of the actors' lives is lost when taken out of context. Because identity is argued as a psyco-social-cultural production I felt it prudent to contextualise the drama by including testimony about, and opbservations of the actor's life.

4.3.2 Film as research: Jean Rouch's psycho-socio observational cinema

I now detail the filmic approach adopted in this research. Whilst the pilot study was conducted with a more scientific camera approach (filmed with a still camera), this was a crude undertaking and the camera did not get close to the research subject; meaning that some important details of the research could be lost. Moreover, little attention was paid to the 'act' of filming as a research process and how that might impact the rigour, validity and analysis of the data. analysis of the data and attend to the research rigour and validity. To attend to such issues I undertook technical and theoretical training in 'filmmaking for fieldwork' (an observational cinema approach) and specifically drew on the work of Jean Rouch. I detail Rouch's observational approach which specifically includes ethnofiction and cinema-verite (cinema of truth) and how they were adopted and used in this research. Also of concern are Rouch's approach to film (as psychodrama) and his praxis (an observational filmmaker). I relate the filmic approach directly to the making of *'Performatics'* by using some examples of the filmmaking process in action.

Film is used in various ways in social research and has adapted over time[32]. One form of filmmaking in research is visual anthropology, which has become an established discipline recording performances and rituals of everyday life in film and video. There are various schools of thought in anthropological and ethnographic filmmaking; most of which began with films of a common humanist standpoint, asking universal questions about life, living, and death. By making these familiar questions strange, visual anthropology aims to find what is interesting about the usual, by comparing western life with exotica (exotic locations and peoples). Styles of filmmaking bring their own epistemology, theoretical intention and belief about the way knowledge about these universal questions should be conveyed[33]. For example, in the 1930's Margaret Mead and Gregory Bateson were interested in exotic cultures and viewed the scientific camera as objective reality (Ruby, 2000). Conversely, Robert Gardner viewed film as art, where the filmmaker reconstructs experience to get to the bottom of things (Barbash and Taylor 2007). Whilst I could have chosen from any of these filmic styles I chose to draw on the filmic techniques of Jean Rouch, who went beyond Gardner to explore the dialogic imagination.

'*Performatics*' was heavily influenced by my encounters with filmic study through 'Filmmaking for fieldwork' and a postgraduate theoretical course on observational cinema. I drew especially on my instructor's expertise and particularly Professor Paul Henley's work on the observational cinema of Jean Rouch[34]. At the same time as my filming Elizabeth De-Freitas (2015) was also building a philosophical argument for the inclusion of Rouch's surrealist imagination in mathematics education research as a way to understand the relationship between the body, emotion and cognition. At her time of writing the film, *'Performatics'* was already nearing completion.

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[32] Erickson's (2011) brief history of video in social research concludes that close descriptive video work will continue to be productive for understanding social phenomena.
[33] Notable contributions on the historical development of observational filmmaking include: Taylor (1994), Mac Dougall, (1998 and 2006), Ruby (2000) and Pink, (2006).
[34] See Henley (2009), for a biography of the observational cinematic work of Jean Rouch and his exploration into the imagination, and Henley et al.,(2010) on the application of the cine-trans in observational filmmaking in practice.

In this section, I examine Rouch's filmic style of 'ethnofiction', as 'cinema-verite', which is based on his own conception of a psycho and socio drama. Cinema-verite explores personal experiences in a play between fact and fiction in order to bring psychic reality into material form (Henley, 2009). Rouch's particular style of observational cinema is a window into social action and the dialogic identity (which includes imagination). I describe how I translated Rouch's cinematic approach to my own work. For a more detailed account of Rouch's psychodrama see Henley (2004) and Rouch and Morin, in Feld (2003).

Visual and performance anthropology are purposefully blurred in the dialogic filmic techniques of Jean Rouch. Rouch describes film ethnography in terms of a 'grounded philosophy, where the film is an open ended study that starts with a good question to discover something new. The capacity of film to ask questions, to discover something new and bring about change by bringing experiences into relief provokes a reconsidering of existing ideas about those experiences. Moreover, Rouch felt life, as it really is, must also include one's own dreams and imagination *"the dreams and fantasies that underlie the everyday experiences of reality"* (Henley, 2009, p. xiv). Rouch's approach claims films artistic imagination should be accessing both the subject and filmmaker imagination, to get deeper into how cultural ideas embed into the person and how the person then expresses those ideas. I draw your attention to 'Chronicle *of a summer'* (1960) and *'Jaguar'* (1967) as examples of Rouch's films that draw on the actor's dreams. 'Cinema –verite', the cinema of the 'real', was conceptualised by Rouch in order to explore the actions as well as the inner thoughts of his actors. Where cinema helps with making these inner thoughts visible through cinema's capability to reveal an *'eye'*, a *'Kino eye'*, that human experience can't always see (Vertov, 1984). Vertov's Kino eye inspired Rouch to develop 'cinema-verite'; moving Rouch away from traditional anthropology and ethnography, in his exploration of the urban and imagined. For example, Rouch worked with Sociologist Edgar Morin on '*Chronicle of a summer'* (1960) to capture the everyday life of Parisian's to explore their inner emotions as well as their experiences. Rouch and Morin were concerned with authenticity, and in creating a 'psycho-socio drama' the actor plays out a game

with the camera where the hidden or repressed comes to the surface in some form of psychoanalytic truth (Musser, 1996, p.526).

> "Our film will not be a matter of scenes acted out or of interviews but of a sort of psychodrama carried out collectively among authors and characters."

> (Morin, 1985, p.6)

Rouch came to his psychodrama from the mindset that fiction ought to be considered as coming into reality *"in the formation of consciousness"* (MacDougall, 1995, p.238), where the imaginative play is part of the actor's reality. Whereas Morin felt the drama was a psycho or socio drama with an analytic, psychoanalytic perspective. This interplay between fact and fiction is notable in Rouch and Morin's *'Chronicle of a summer',* where the filmed subjects view footage of themselves and are asked if participation has changed their way of thinking (Henley, 2009, p. 152). This ties in to the drama approach adopted in this thesis whereby a provocation of some sorts (in this case the earlier film footage of the actors in testimony and observation) is included in the film to detail these stories and to also show the process of how the actors used those stories to develop their understanding. '*Performatics*' opens with Rob asking *"what are the stories?"*

Whilst encompassing lived experience and fiction as imagination, Cinema-verite also attempts to provide a more naturalistic cinema experience. To capture everyday life the cinema-verite style moved more naturally in synch with the film subject with the use of a hand held camera. Attempting a more naturalistic relationship with the subject through the camera locates the filmmaker researcher in the research through the proximity to the subject and captures processes in naturalistic ways complementary to an ethnographic ethos, *"This camera should be mobile, following subjects and events rather than requiring them to be brought, by prearrangement, to be played out in front of it"* (Henley, 2004, p. 114). There is a clash of sorts here between the observational film style and 'performance'. It could be claimed that my intention to get the actors to

'perform' aspects of their experiences in front of the camera goes against the principles of observational cinema. However, the purpose of the film is to observe the process of making a drama and so I claim this purpose still fits within an observational style.

4.3.2.1 Observational cinema in 'Performatics'

The observational cinema style in '*Performatics'* attends to the naturalistic style of observational cinema. How that was achieved is detailed here with respect to the potential of, and issues with, using observational cinema in research practice with some examples from the filming process.

The craft of the filmmakers to achieve a naturalistic observational cinema style is to move away from filming the entirety of a scene, uninterrupted, but to think of the camera like the human eye. The way to get this variety of naturalistic shot, to capture how the human eye flits across its subject, was achieved in my use of different camera angles (wide, medium and close); moving between the face, hands and activity that the subject is engaged in. I moved in close to the subject, close to the action to garner the intricacies and even repetitions of the process you are trying to capture in proximity to the subject (Barbash and Taylor, 1997). This camera-work is the filmmaker's means to view the world as the subject does, taking account of the subject in relation to their environment. Film can embrace the minutia of cultural life by exploring it more, not less closely because film does that difficult thing of capturing the incidentals and intangibles which are more problematic to describe in academic writing. Film captures *"the subjective and embodied aspects of human experience so frequently omitted from textual accounts"* (Henley, 2004, p.103) and brings *"hidden issues into public view"* (Pink, 2006 p, 81). These hidden issues, Rouch would argue, are integral to the human experience and therefore identity. Henley (2004) describes this as a means of putting the film to work.

For *'Performatics'* I adopted the observational filming style which privileges hand held camera work as a way to get close to the action and represent it more naturally, shots from un-naturalistic angles (too high/too low) are avoided. Attempting a more naturalistic relationship with the subject, through the camera, locates the filmmaker (myself) in the research process through the proximity to the subject. Filming '*Performatics*' often involved getting down to the level of the actors as I filmed them. The logistics of getting close to the actors was often difficult. I had to negotiate the spaces in which I was filming; positioning myself to get a clear shot, whilst not disturbing non-participants. This is where the skills of the filmmaker, and the physicality of filmmaking, should not be underestimated. For example, as I leant in to get a close shot of his face and hands Rob made comments (not included in the film) about trying to ignore the camera, which was intruding on him as he was working. Both Rob and I were overcome with an uncomfortable self-awareness. This intimacy was often unsettling and jarring for both me and the actors. I had to think about this intimacy in the rest of my filming and what it felt like to be close to the actors. As I became more experienced and technically proficient, myself, Rob and the other actors began to relax and the filmmaking became more natural. With developing technical confidence I began to feel the camera was a natural extension of me. As I got used to the camera, as a tool, I began to think of the camera as a physical space between myself and the actor which gave a sense of physical distance and offset the uneasiness of proximity, which in turn gave me the confidence to get closer to the subject.

Part of observational cinema is also about locating the actors and film in the context in which they are filmed and in a wider social context. The actors put forward film locations which said something about their lives, capturing an 'atmosphere' (Classroom, theatre, pub), which contributed to the storying. Context filming might be deemed the extra digetic materials, the places, spaces and feel of those spaces, that whilst not of the person, says something about them, their life at university and possibly something of their mathematical selves. The context shots say something about the actor in relation to the space they occupy, implicating meaning in relation to the actors "*local practice"* (Pink,

2013, p. 55). The actors were filmed going about their usual day on and around campus to provide a narrative context and counterpoint to the drama. Part of context filming includes 'cutaway shots'. These shots are of short duration, a few seconds of film. They are most usually locations (a glimpse of a building, an outside space, or artifacts and objects (a desk, a book, a poster, mathematical equipment) which occupy the world of the actors. In '*Performatics*' the cutaways served two purposes, (i) to illustrate the life of the actor and contextualise the film so the audience has a sense of when and where the filming took place and (ii), in the technical edit as a method for moving from one scene or idea to another, much like punctuation in writing.

Finally, there are two voices present in observational cinema, the filmmaker and the film subject. Through the movement of the camera, the placing of the shot, the filmmaker enters into the performance (Henley, 2004) and *"sentences are being cast as the film maker is recording"* (Barabantseva and Lawrence, 2015). Whilst the filmmaker's contribution, voice, and subjectivity are made transparent, overall, the observational filmmaker respects the integrity of the story. Authorship is not directional, not dominated with the researchers own authorial stance.

> "the general aim should be to achieve a congruency between the subject as experience by the film maker…in general they should resist the temptation to…impose intellectual or aesthetic agenda that members of the audience can no longer draw their own conclusions about the significance of what they are seeing.
>
> (Henley, 2004, p.115)

Paul Henley (2004) states that through film the actor, audience and researcher/film-maker interrogate the performance as activate participants in the construction of meaning.

4.3.2.2 Testimony as reflexive performance

With reference to Paul Henley's work on testimony[35] I outline how, and why, this method was applied in *'Performatics'.*

The interview is a much used and productive means of data gathering in qualitative research. Here I discuss 'testimony' as a specific form of a filmic interview. Denzin says that the reflexive interview as a performative event.

> "Performance interviews are situated in complex systems of discourse, where traditional, every day and avant-garde meanings of theatre, film, video, ethnography, cinema, performance, text and audience come together and inform one another. The meanings of lived experience are inscribed and made visible in these performances"
> (Denzin, 2001, p. 26)

For observational cinema, the interview, as oral testimony, is a performance event. The manner of the testimony performance is integral to the film content. As opposed to a formal interview, 'testimony' is situated in a context where relationships are drawn between the testimony given, the activity which is undertaken whilst giving testimony, and the context of the setting (Henley, 2003). Henley describes how the purpose of testimony is to elicit a narrative rather than statements of facts. This he says requires a careful framing of questions and provocations. For example, the testimony in '*Performatics*' was elicited from the actors with questions loosely phrased around:

What is a Mathematician?
What is Mathematics?
What are your experiences with mathematics?

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[35] Paul Henley (2004) writes on modes of oral testimony in observational cinema. Using filmic examples he details how oral testimony is approached, its uses and its critiques. Testimony is approached beyond the usual notion of the interview where voices can be disembodied and ethereal, offering anonymity or explicitly grounded in the subjects lived experience as they undertake activity in their daily lives. Henley concludes that, despite testimony being somewhat unappreciated in cinematic observational cinema, that along with other modes of film artistry, testimony can still be a powerful means to understand the subject.

The style of the testimony was 'loose' to allow *'more space'* for the actor's voice to come forward (Stinson and Bullock, 2013). Forsey (2010) claims this giving of space requires '*active listening'.* Active listening meant taking the lead from the actor as to when and if prompts were necessary, without leading the subject. The aim then was to give the subject space to speak rather than overlaying it with theory and a rationale. Allowing this space gave the actor time for reflection to assist with their recount of past experiences (Lincoln and Guba, 1985), particularly as they may be difficult to immediately recall. However, Evans (2013) cautions on how these inter-connecting stories are reformulated from the past and re-worked in the present meaning no recollection can be regarded as reality. Rather than a reality, the interconnecting sub- stories of the actor's mathematical biography amount to a kind of 'actuality' for the actors, as told in the present context. Connecting and disconnecting these sub-stories is assisted by the filmic aspect of the research in the editing process (described more fully in a later section of this chapter). In editing the film the testimony footage was used for contextual information. In addition, the testimony provided a counterpoint to ho the actors storied themselves differently, in different contexts. The editing process allowed this to be made more transparent in the film where the additional content of testimony can include other images of the subject such as pictures, or overlays of previous film footage to create a deeper exploration of the context of their lived experience (Henley, 2003). This technique of overlaying film, in order to draw comparisons or provide a deeper meaning, is employed throughout '*Performatics*'. For example, the testimony footage is overlaid over the drama footage in order to provide contextual information.

Testimony explores the actor's mathematical identities by inviting them to narrate stories of experiences which they felt significant, or at least felt able to tell. The actor's 'testimony' provided a background context and provocation for the filmed-drama and a reflection on the research process. The testimony became a reflexive performance between the actors, myself, and some imagined film audience.

4.3.2.3 Summarising film as research

Observational cinema is useful means to understand human lives. An ethnographic approach facilitated a deeper involvement in the lives of the actors because the camera captured the intricacies of their social life through the proximity to the actors. The camera work was an expression of the researcher. However, the researcher expression was in asking the interesting questions and attending to the story of the actors, which unfolded in front of the camera. The purpose being to provide a critical analysis and documentation of phenomenon that is not overlaid with intellectual or artistic reasoning but rather to provide an account where the audience can make sense of what is presented to them

However, the camera is but a research tool and has some drawbacks and limitations. The camera is as selective as it is discriminatory; the range of the camera frame is only a microcosm of the four dimensional, 360 degree contexts, in which I was filming. In that selected frame the camera does not discriminate and will capture everything there. This led to ethical considerations of capturing people, activities, and sensitive material. Equally, the sound was captured from the whole of the context, beyond what could be seen. This was particularly problematic as extraneous sound detrimentally affected the filming on a number of occasions. A drama session was omitted from the research due to building works detrimentally affecting sound quality, rendering the footage useless. Using film in research can be an excellent tool, but one which requires technical skill and practice. The filming schedule and technical data are available in Appendix 3.

4.4 ABR as analysis.

This section builds on the discussion thus far in order to clarify how film editing will be used as analysis. The data produced and used for analysis, were the footage of the testimony, observations and drama which were captured on digital video, a researcher diary, and a film method of categorising and storing data known as a 'log and transcribe'. Drama as analysis has already been significantly covered in this chapter and so only a brief recap is included in this

section. The editing of the raw film footage into the thesis film *'Performatics'* contributes a significant part of the data analysis. This section focuses largely on filming and post production editing. Using examples, I discuss how drama, and film editing, are collaborative approaches to research analysis. This approach provides an extra dimension to the research, attending to rigour and trustworthiness as the data is considered through the many perspectives of me as a researcher and the actors. The film stands as the research findings and analysis with which the general public, and academia, can make meaning from.

4.4.1 Drama as analysis: A recap

This brief recap of drama as analysis underlines how the actors conducted their own analysis of mathematical identity through participating in the drama; asking probing questions about what the drama might be. The actors set a drama (research) problem and used 'enactment' to work through the problem (mathematical identities), analysing as they did so (Norris, 2000). The performers set a framework for what was to be explored about mathematical identity and ways it could be explored by choosing the themes of the drama, the content and directing the drama action. The actors questioned their own and each other assumptions and experiences with mathematics, unpicking those experiences in order to re-form them as a dramatic play. Of critical concern to this thesis is how Norris (2000) clarifies, like observational cinema previously, the aim of drama is not to impose generalised meta-narratives on data, but rather to invite conversations to make sense of what we know.

4.4.2 Participatory film analysis.

Participatory film analysis is detailed here in two ways: as a means to refine the research hypothesis and what might count as data; and as an ethical means for the actors to decide what data is used and how it would be edited together into the final film.

De Freitas (2016) has recently questioned how video data might be used and analysed in mathematics education research, positing that video data is often viewed as if it is the data and that the editing and refinement process is not often considered. In earlier work, Derry et al (2010), draw on video research in the learning sciences, and mathematics classroom, to claim the process of reviewing the video data is as important as the data gathering. Their paper makes some claims to how researcher and respondent interaction helps determine what might be appropriate data. The iterative research process, where I conducted multiple viewings of the filmed data, strengthened the research findings through a 'progressive *refinement of hypothesis'* (Engle et al, 2007 in Derry et al 2010, p. 23). In *'Performatics'*, the actors co-produced, and co-analysed, data by directing their dramatic performances by planning scenes, framing shots, choosing props, lighting and at times directing myself as a filmmaker. The actors were active in the composition of their dramatic performances and also of the final film edit. As a participatory audience, the actors viewed the film at various stages in its progress; as a means to garner a variety of voices to add clarity to data analysis. From an ethical perspective, data checking also confirmed if the actors felt comfortable with their portrayal in the film. The actors, aligned with me, were engaged in a process of "*continuous reflexivity and analysis"* (Springgay, Irwin and Kind, 2008, p. 903) to get to the crux of the data; not in a finite reductionist manner, but to question if the data produced reflected the meanings the actors wanted to convey. The actors were given the opportunity to view this footage individually, with me, as a group. The actors viewed both raw and finished film footage before making deciding if they were happy to be included in the film and for the film to be broadcast.

Below is an extract from my field diary exampling how I approached ethical issues and editing of the filmed data, with respect to one of the actors.

███ and I watched the footage through.

When ██ talks about math's being 'touchy feely' ██ wants to cut that with the image of ██████████████████████ as ██ is worried the

wording of 'touchy feely' could be viewed by others as not appropriate. ███ feels contextualising it would be better.

(Pickard-Smith)

By deciding what data was appropriate the actors edited themselves by reviewing their performances. This interaction between me, actor and data assuages some ethical issues about what footage would be appropriate to show to an outside audience and provided the actors opportunity to have footage deleted. However, in this instance, the actors were happy with the footage in the edited film and I received no requests for footage to be deleted, either from the original source files or from the final edit of the film.

4.4.3 Post production film editing in Final Cut pro 7

The editing process is technical, analytic and creative. Tracing the film editing process enables an understanding of how film editing (as a form of narrative construction) is a form of data analysis. I detail the observational cinema editing technique of 'parallel editing' as a means to analyse and drive the narrative and discuss the technique of 'log and transcribe' as the first steps in the technical film editing process. The hardware used in the edit was a Mac Book Pro and the software was Final Cut Pro 7.

From the perspective of observational filmmaking (as discussed earlier) editing is part of the discovery of the data, which culminates in a finished film; your final analysis. Rather than have a chronological edit anthropological filmmaker Robert Gardner proposed *'parallel editing'* (Barbash and Taylor 2007, p. 36) as a technique to establish the relationship between the filmed subjects and contexts whereby simultaneousness allows the audience to view juxtapositions, similarities, contradictions and conflict. To produce a realistic montage of events sequences, outside of the scenes and chronological order, are cut together to go beyond the specific footage. This method is claimed to academically interrogate the humanistic questions posed and provoke issues not just specific to the subjects but in a wider more general sense. From a cinematic sense, parallel editing drives the narrative and has been proposed as important to a

western sensibility towards conflict as *"an almost essential discursive principle"* with the parallel convergence of multiple storylines or significant happenings on an eventual collision (MacDougall and Taylor, 1998, p.145). The chronological order of the actor's stories is manipulated to achieve a stronger narrative logic but keep true to their story. Once you have your film data, technically termed 'rushes', the editing process begins with a 'Log and Transcribe' of the footage.

During 'logging' the film footage was downloaded from the camera memory/media card to the editing software. For *'Performatics'* an Apple Mac processor with Final Cut Pro 7 editing software was used. During download, the film data was broken up into smaller, manageable chunks. The data from each media card from within the camera was downloaded to the main file on Final Cut Pro 7. Each main film was coded with a file name (the day, activity or person filmed etc). The editing software then automatically breaks the longer footage of the main file into smaller sub sections and allocates each a digital numerical code. The footage for each digital code was reviewed by the film maker researcher to determine what constitutes a 'scene'; a scene being an activity that the researcher/filmmaker has decided where it finished and ends. The scenes were then described by time codes to indicate their duration. Once all of the footage was logged, downloaded, given main file names, time coded and then broken down into scenes transcribing began.

Each scene was transcribed describing the content, context, camera shots used, facial, body language and dialogue. This was a lengthy but necessary process which was repeated for all of the footage. The filmmaker imbues themselves in the data through watching and re-watching of the footage as they transcribe (Henley, 2004). This re-watching is a rigorous process crucial to the analysis to develop thinking and find points in footage that were salient to the research question. However, film is a contradictory medium which creates tensions, difficulties and opportunities because it is simultaneously objective/subjective, selective/specific, and indiscriminate/intimate. It's not until the footage is reviewed that unseen instances, extraneous and distracting data

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become apparent, leading to unusable footage. However, reviewing data this also meant that I came to new understandings.   Table 2 is an example of a 'log and transcribe' of Classroom footage of Rob which was used in the film for contextual reference. The 'log and transcribe' contained roughly 70 thousand words which represented dialogue, action and context.

Table 2. Log and Transcribe

File 365	Length 13:52	Content Math class	Dialogue
	1s	Rob folding paper – looking at teacher	Teacher "does anyone know the one line that gets a rhombus?"
	1:10	Rob gets out equipment. Checks angles of the kite. Close up of hands.	
	2:14	Medium shot. Making kites.	Rob "I think maybe we should put our names on them...I've put me name on, I don't want anyone pinching me kite you know

After the log and transcribe comes a 'paper edit'. The paper edit is written evidence of my thinking and the analytic process of drawing out merging themes from the data. Themes were chosen based on what the actors had already specified as important to them – i.e. in terms of feelings and the earlier themes which came from the 'collection' stage of the drama, as documented earlier in the chapter. Using 'find' functions on the Microsoft word document enabled tracking and exploration of common themes, commonalities and contradictions based on aspects of the filmmaking that revealed something about mathematical identity – which includes both 'oral' and 'embodied/enacted' stories. Table 3 is a section of the paper edit and illustrates this process, exampling an early exploration of how 'anxiety' emerged as a theme of the data. This is a copy of the original 'log and transcribe' where salient data was highlighted after using the find function for the key term of 'anxiety' and the

comments boxes were used to make written notes on that scene. Other associated words and synonyms were then highlighted in the text, across the whole of the transcribed document, which contained roughly, 70 thousand words.

The paper edit became a physical storyboard to explore themes, comment on the data and develop my thinking. At the start of the drama process, Claire and the rest of the actors had decided that common 'feelings' would be a category of data to explore. I searched for the word 'feelings' and any other associated terms such as 'anxiety', 'panic', 'happy' etc. This was an open process which didn't adhere to strict search terms because the idea of the edit is to uncover the story as it emerges from the actors. Equally the notes made on 'body language' and 'context' was as valuable to search as the actor's dialogue. This process of exploring the possibilities of the data to create compelling narratives can be said to be a deeper, academic investigation of the data. The emphasis is to make a film that speaks to the research. Filmmakers may worry about imposing on the data but you need to be more, not less blunt and probing.

Table 3 is an example of the search for Claire's story about mathematics and her feelings of doing mathematics in the classroom, under pressure. This scene was selected for the final film as it encapsulated Claire's story about her experiences with mathematics in school and expressed her feelings, which tied in with how the group wanted to explore feelings about mathematics as a possible common thread.

Table 3. Paper edit

Shot description	Transcription	Researcher comments/notes
Big hand gestured showing the board whooshing. Facial expression to show feelings of <u>anxiety</u>, crunches herself down small	I remember at the very start he whooshed the board up. And there was this big kind of graph. And we had to get up and it was this x and y axis and it was algebra. And you had to do some sort of working out and he picked on me. And I got to the board. It was huge this sum. I got to the board and I couldn't see, it was so big, if you know what I mean? And it was just out of perspective and I couldn't solve it. And I remember like the feelings of <u>panic</u> really distinctly, and <u>feeling</u> really hot. My cheeks got really hot and I <u>felt</u> really kind of <u>panicky</u> and all the <u>adrenalin</u> was rushing through me and I was just mortified really that I couldn't do it	Physical feelings of maths being imposing, whooshing board, huge sum, perspective. – Physicality and anxiety. Responding to the feelings of mathematics rather than the subject itself.

When the technical edit of the film began, using Final Cut Pro 7, I was able to refer to these written notes and insert salient footage into the film edit at the required points to build the narrative, the story of the data. The beauty of the written notes was that they could be searched much more quickly than scrolling through what amounted to over 60 hours of film footage. In the typed document, I was able to highlight the specific text of gestures, context or dialogue. The typed document meant I could locate, very quickly in the raw footage, the scene I required. Each scene which was deemed as useful to compiling the overall

narrative was then placed on a timeline in Final Cut Pro 7. Blue icons on the timeline are visual data and green are sound. Both sound and visual images can be manipulated on this timeline, cutting them shorter and overlaying the. As is evident, the timeline is a visual representation of the interlacing of data.

Image No. 1. Editing timeline example

Image No. 1 is an example[36] of an editing timeline. The timeline enabled me to overlay footage from various points during the research, and mix image with sound. Thus building a story that was technically non-chronological, nevertheless, a stronger narrative logic was achieved because connections were made between the various aspects of the actors storying from testimony, observation and drama. Editing required technical knowhow, which I received through the 'Filmmaking for Fieldwork' course that I attended.

My chosen editing style was in keeping with observational cinema. I used 'parallel editing' to establish the relationship between the filmed subjects and contexts; whereby the simultaneousness allowed me, and a watching audience, to view juxtapositions, contrasts, contradictions and conflict in the actor's

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[36] Example image courtesy of USC Berkeley media training. Available here https://multimedia.journalism.berkeley.edu/tutorials/finalcut/ My own timeline could not be used for an example because of a degradation in the image as it cut screenshot.

mathematical identity story. To produce a realistic montage of events sequences outside of the scenes and out of chronological order were cut together to go beyond the specific footage to academically interrogate the actor's performances of mathematical identity. From a cinematic sense, the parallel editing drives the narrative through the aforementioned western sensibility towards conflict as essential to the narrative through the telling of multiple storylines or contradictory significant happenings.

Two instances of parallel editing are exampled. Film clip No 7 is an example of 'representational parallel editing'. John reflects on an earlier experience of how he used mathematics to build a draw divider. The testimony footage is so that we hear John talking about an earlier activity and it is the activity that we see.

Clip No 7. 'Performatics' Parallel edit example 1: John Building drawers.

Timecode 1m10s to 1m 52s

For continuity, like the other actors in *'Performatics'*, Maddy (the drama facilitator in the research) was also filmed giving a testimony about her experiences with mathematics and observed in her university life, which included her involvement in various drama groups. Film clip 8 shows some observational footage of Maddy as she participates as a volunteer for Theatre In prisons drama group. In this clip, Maddy is using rhythm and counting. In the parallel edit, we see the rhythm and counting and hear Maddy's earlier testimony of how she cannot see mathematics in her drama. Maddy's use of

mathematics (in rhythm) is usefully juxtaposed with her dialogue to show that whilst Maddy can't see the mathematics she uses, it is evident in her activity, in the drama work, nonetheless.

Clip No 8. 'Performatics' Parallel edit example 2: Maddy Drama and rhythm of mathematics.

Timecode 4m to 4m.15s

The technical edit is a recursive process with both a technical and narrative refinement of the film over numerous edits. In example (1) approximately 15 minutes of footage was available to choose from to represent John's engagement with the mathematical tools which was narrowed down to but a few moments shown in the final film. It is the researcher's artistic license and theoretical eye which then drives the narrative by selecting what footage to be edited together to form the narrative. For example (2) I was able to use the paper edit to search for contradictions where Maddy has said in her testimony that she cannot see how she uses mathematics to juxtapose it with actions where she is using mathematics. The audience is then made aware of how Maddy uses mathematics at times when she regards herself as un-mathematical.

4.4.4 Summary of ABR as analysis
The analysis process of ABR has been depicted as in depth, rigorous and a recursive approach to analysis that includes a contribution from both actor and

researcher. Technical acumen is required in the editing process in order to cut together the data in a polished manner; which also attends to the ABR epistemology of artistic beauty as rigour and validity. The potential of the edit as analysis is to imbue oneself with the data and to see it in a different dimension through parallel editing which allows the researcher to explore congruence and incongruence between dialogue and gestures to make evident the various stories which are in agreement and contradiction to each other but in subtle ways. The finished film artifact is a record of the analysis process and an object which represents the research findings.

4.5   Recruitment, Access and Ethics: Problems and potential of ABR.

The problems and potential of the ethnographic approach of this research on the recruitment, access and ethics are discussed herein. This section discusses the recruitment, sampling and access strategy and the ethical considerations for the research subject, the researcher and the management and storage of the research data.

4.5.1 Recruitment and access

Purposive sampling was appropriate as the purpose of this study was testing methods and transferability not generalising results (Cohen et al, 2007). In choosing subjects for the study I considered the following criteria/characteristics.

> *A single setting or 'frame':* Dramaturgical research is best undertaken in a single setting or 'frame' in which the social interaction occurs (Johnson, D.P, 2008): Students from a single university.
>
> *Availability of mathematical identity stories to be told:* Students are engaged at university in reflexive practice on their own learning, which, even allowing that mathematics may not be their university subject, their skills in self-reflection on learning can be adapted to reflect on their

experience with mathematics learning and mathematics in their social everyday practice.

Openness to drama and performance: Subjects open to drama sought through a range of recruitment activities.

The actors were purposefully selected as inhabiting an identity somewhere between the 'professional mathematician' identity and 'Just plain folks' (JPF) However, these mathematical identities may be considered more or less professional or JPF depending upon the context. For example, John may be regarded as a professional mathematician to a layman but not in professional mathematics circles, and so these identities, are somewhat slippery. The recruitment strategy follows an ethnographic approach to get to know the subjects in their context and is detailed here in Figure No 3.

Figure 3. Recruitment strategy

Selection criteria		
Activity 1: Group participation	Activity 2: Email	Activity 3: Facebook

Drama group	STEM outreach	Course Modules

Theatre in Prisons	Drama group	Science Busking	PGCE Mathematics induction Assistant	MA film course
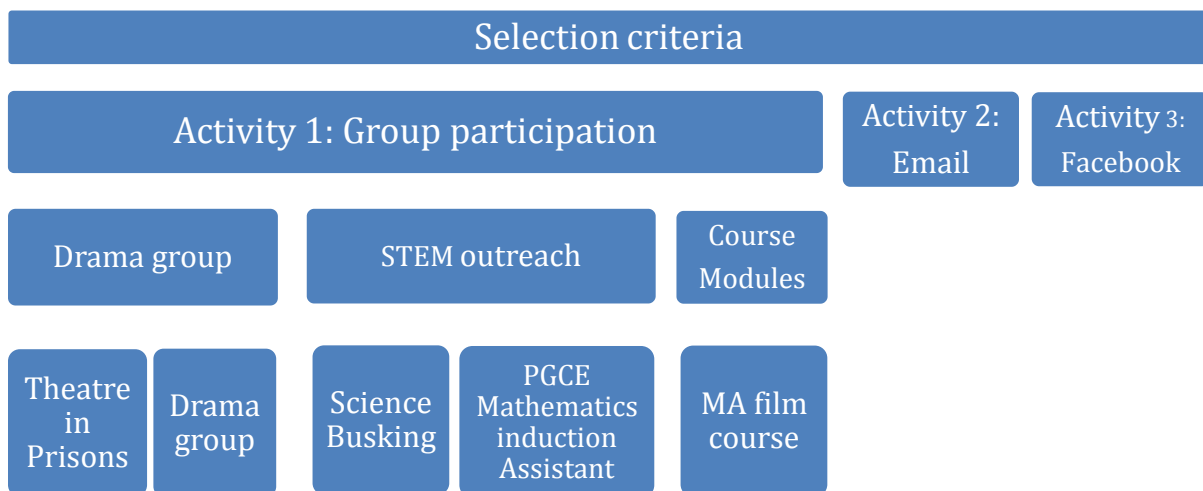
Activity (1) Group participation involved joining various groups at the University, undertaking outreach work and assisting with PGCE mathematics induction week to get close to potential subjects and get to know something of their contexts. This approach, whilst very labour intensive, was the most successful recruitment strategy because I was able to build relationships with

the possible subjects before explaining the research to them. Three subjects were recruited from this group.

Activity (2) was approaching potential recruits through an official email sent via university sources to mailing lists for students on mathematics and mathematically related courses. Potentially hundreds of prospective subjects received the email though the distribution lists. Three possible recruits responded with 1 recruit who met the criteria.

Activity (3) involved posting the details from the Activity (2) email on various university Facebook pages which students use such as drama groups, mature student websites and subject specific pages. One potential recruit was contacted who declined as they felt the research was too risky to their professional identity.

In undertaking these activities access to participants was at the forefront of the the recruitment process. My student identity gave familiarity to University practices and building purposes, facilitating access to subjects. Getting to know students by joining in the various groups where I might be able to recruit was ultimately the most beneficial because this provided a common ground with subjects as a way in to the research (Robson, 2011).

Recruitment activities were undertaken over a rolling four month period until an optimal level of subjects (with back up subjects) was recruited (3-5 subjects). Recruitment began in August 2015, 4 months before the first film shoot. Five subjects were initially recruited from all activities as a manageable cast which allowed each subject's story to be explored in the drama whilst also allowing for the reduction of stories to be told in the film to concentrate on those which were more developed. One of the five subjects was not included in the final edit of the film because of limited observational filming which resulted from difficulties gaining access to their study context. A second participant (Maddy) who did not fit the criteria of taking a mathematics course was included for her expertise as a drama facilitator.

The sample is small and unrepresentative; two white British males and one white British female. The data could be considered potentially biased in a number of ways, including gender and cultural bias where the data would be specific to this group of subjects and not generalisable across other populations (Cohen et al, 2007). Because the research is concerned with individual stories of mathematical identity, explored in depth and richness, over an extended period, fewer subjects were required in order to generate adequate data. In all, over seventy hours of film footage was recorded.

4.6 A Consequentialist approach to Ethics: Ways of having a voice and non-anonymisation as ethical research.

Here I detail the ethical considerations of using film and non-anonymisation. I begin by outlining the consequentialist approach to ethics[37], which I adopted in this research. I then outline the safeguards to the research subjects, myself as the researcher and the responsibilities to the research community as a whole. In doing so I make evident how informed consent was applied in this research and how the research subjects, as actors were integral to deciding appropriate data. I direct the reader to the various protocols and ethics forms which were necessary for this research, and where they are located in the appendices of this thesis. The section concludes with how the data is ethically stored.

The ethical stance of this research is a 'consequentialist' approach where "*an action is morally right if it will produce the greatest balance of good over evil*" (Wiles et al, 2008, 2:2). This stance is adopted to claim non-anonymisation as an appropriate and ethical approach for this research. This change in thinking

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[37] I closely followed the ethical guidance of Wiles et al (2008). Their review of ethical issues for visual researchers synthesises, and outlines, the various ethical approaches to visual research. They describe both consequentialist and non-consequentialist perspectives. This guidance also provides legal and moral obligations to the researcher, research community and research subject. http://eprints.ncrm.ac.uk/421/1/MethodsReviewPaperNCRM-011.pdf. I also take direction from a related book 'SAGE Visual methods (Hughes, 2012), which documents research issues and ethics as related to visual mediums. For ethics see the chapter 'Visual Research Ethics at the Crossroads (Wiles, Clark and Prosser, 2012).

about anonymisation of data began in social research, where researchers are saying anonymisation is not always the ethical thing to do, especially in attempting to address areas such as inequality and stereotypes etc.

However, there are specific ethical concerns with filmmaking and non-anonymisation. Firstly, digital video has a 'connotation *of surveillance'* that has associated risks to the film actors and the University through the relinquishing anonymity (Cohen et al 2007, Wiles et al, 2008). However, Wiles et al (2007) report how some researchers say anonymisation is increasingly regarded as not necessarily ethical as it may silence some voices and privilege others. Additionally, performance and visual mediums can move research from representational to presentational to position the subject's voice and other ways of having a voice as equally powerful (Denzin, 2003, Gerofsky, 2010, Stinson and Bullock, 2013). In the case of this research, the aim was to give voice to mathematical identity stories in ways that the subjects, as actors, wanted to tell them; which weren't always easily discursively expressed.   Additionally, data of embodied performances and non-verbal communication intrinsic to dramatic performance (gestures, facial expression, movements, pauses, props, lighting etc) would not be given justice by the researcher in transcription alone due to the difficulty in capturing and conveying such intricacies through written accounts. The film opened up possibilities to equally privilege ways of having a voice other than the traditional textual/written research accounts.

4.6.1 Co-production of data: The actor/researcher relationship

Earlier in the chapter, ABR was claimed as a robust research methodology with the actors positioned as integral to the research process. The earlier sections detailed, in turn (through drama and film), how the researcher and the actors were situated as co-contributors to data production and analysis. This section focuses on the ethical implications of the close relationship between me (as filmmaker researcher) and actor, and ways of having a voice in research.

The drama was a means to support the voice of the research subject equitably. Qualitative data was co-produced by me as the film-maker researcher and the actors. The actors set scenes, directed action and choose the stories to convey. The contribution of the actors to the research process, through choosing and amending data was carefully considered and few issues around anonymisation occurred.   However, the actor's voice in the research was not the only consideration. Having a voice as a researcher was also not without issue. Problematically, non-participants were captured in the film. At the start of any public filming, I introduced myself and asked if it was ok to film and reassured the non-participants that they were not the focus of the research, withdrawing from filming if asked. For this reason, observational filming was the most contentious area of the research and I was refused permission to film in certain locations on a number of occasions. Access issues were improved by considering the professional appearance of the filmmaker researcher. Wearing a University of Manchester film crew uniform legitimized my position (identity) as opposed to dressing informally; leading to fewer questions about the purpose and legitimacy of my filming around the university. Taking care of the researcher's identity became crucial to conducting research and having a voice as a researcher; an aspect of the research process which I hadn't initially considered.

Image No 2. The professional identity of the filmmaker researcher

The problematic nature of gaining access limited the scope of the observational filming and changed the nature of the film narrative by focusing more on the drama process than the observations as provocations. This was not detrimental to the overall aim of capturing the drama process and the dialogic identity in practice because the research process was one of progressive refinement and the observational

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filming became useful as context to the drama.

4.6.2 Informed consent and possible harms: Managing the researcher – participant relationship

The informed consent process, possible harms to research participants such as disruptions to their mathematical identity, identity as professionals and academics and emotional harms are discussed below through the timeline of initial consents, managing relationships during the research process and the exit strategy and ending of the participant's involvement in the research,

Various safeguards were put into place to protect research participants using evidence based practice (see the previous discussion on consequentialist ethics and footnote No. 38 for the literature consulted) and my university guidelines and protocols. These safeguards included ongoing withdrawn consent with research information sheets makes explicit the purpose, function, methods and uses of data (Appendices 1 and 2), sources of support for their emotional wellbeing and detailing who they should contact in the event they had an issue with the research, as well as detailing the research process.

Consent was an informed, ongoing process where participants were given explicit details about their involvement in the research and any possible harms or indeed benefits. Through this process, participants were able to decide if to proceed, what information they are willing to share and to withdraw from the research. Informed consent also detailed when and if the researcher may cease the research or their inclusion in it (Cohen et al, 2007). An informed, voluntary, withdrawn consent and research information sheet (Appendices 1 and 2) made explicit the purpose, function, methods and uses of the data. As part of informed consent 'contracting' at the consent stage of the research was a process where the researcher and participants clarified what may and may not be appropriate for disclosure whilst the camera is rolling. In this stage, the researcher obligations to break confidentiality was made clear in the case of

participants (or others on camera) revealing that themselves or others are at serious risk of harm or are undertaking illegal activities. Equally the researcher duty was to depict the participants on film with sensitivity towards their professional status as employable graduates.

Managing the relationship between me and the research participants in the consent process required listening to my participants and modifying the research accordingly (where possible). Giving the participant time to settle into the filming was necessary to make them feel comfortable. However, this was often impacted by time bound agreements between me, the actor and whoever was responsible for the space in which I was filming. Another dilemma in the field was ensuring that no harm was done to participants through their participation and that the research did not 'impinge' on their personal, professional and academic life/activities (BERA, 2014). In filming in an observational manner, yourself and the equipment navigate various obstacles for various reasons, to get a better shot, better sound quality and so that you did not film people who do not wish to be filmed, capture sensitive conversations, or impede people in their everyday lives. One participant made comments (not included in the film) that the camera was impinging on them as they were trying to work and other non-participants echoed this sentiment. The camera was moved in response. Another occurrence was a participant cautious about the language they had used and how that might be misconstrued and so that scene was deleted from the film. Additionally, another participant had reservations about joining in the drama after they had given testimony and observation and we exchanged emails about this. The data below is an extract from my field diary.

29th Feb nerves

██████ is still a little unsure about the drama and is panicking a bit. ██ is short on time ████████████ and doesn't feel able to do both a drama finished performance and music. I have assured ██ that the drama isn't to be a polished piece…██ seems ok with this and now says ███ looking forward to the 2 days of performance. A lot of the background emailing

and meeting and chatting with participants has been to calm nerves, settle and reassure them – managing expectations really. I find this and the pre-production booking rooms and equipment has by far been the most time consuming part of the research so far and has outstripped the actually amount of time gathering the data. It goes to show that in this kind of research you really do need to plan in extra time to get to know your participants well and that man managements is a vital skill.

Keeping in close contact with the participants was useful for them to be able to ask any questions about the research.

Participants were made aware that they can withdraw from the research at any point up until the final edit of the film, at which point participants were given a 6 month waiting period between the final edit which they viewed in May 2015, after which any other edits of the film were minor rearrangements of existing footage with no inclusion of any new footage of which they had not had the opportunity to view.

Difficulty navigating exit strategies from the subject because of the proximity of the relationship when making the film can be an ethical dilemma for the researcher. There are expectations from the participants about what the relationship might be once the film is over. This is linked to how filmmakers can be seen as having some sort of power, particularly when we consider how the media are positioned as a powerful entity, therefore even small independent researcher filmmakers can, in participants eyes, have power and participants may want to extend the relationships to extend their story and get their points across to wider audiences. Participants may feel that the researcher filmmaker can facilitate this for them and thus the relationship can become a facilitator one but one that can be difficult to navigate. Participants were given clear guidelines and expectations detailing their role in the research and the research end point which was an invitation to view the film amongst their peers at a celebratory event and first public showing of the film at the international

research festival 'Pint of Science'. This event was a marker, signaling the end of the research process for the participants.

Participant informed consent was gathered using the following forms found in the appendix.

- Appendix 1: Participant information sheet: Detailing the research.

- Appendix 2: Consent form: Signed at the start of the research.

- Appendix 3: Technical set up.

- Appendix 4: Visual Release form: Signed agreement to the general release of the film to the public and ownership of the filmed data by the researcher.

- Appendix 5: Confidential Disclosure: Signed agreement at the start of the research to not discuss the research until the completion of the project.

- Appendix 6: VASTRA: Video and Still Image Recording Declaration.

4.6.3 Risk to the researcher in the field

Ethical considerations also extend to the researcher including their physical and emotional safety and the impact of those on the quality of the data.

The use of expensive equipment in the field can make the researcher especially vulnerable. Special consideration was given to the safe keeping of the equipment, such as storage and transportation of the equipment. Filming was conducted in and around the locality of the university. From a health and safety perspective, the camera equipment was heavy and cumbersome. I received assistance to move equipment across the university campus. Adequate and frequent breaks were planned for each filming day. These breaks and refreshments also extended to the participants who may have become fatigued

from the physicality of performing. The strength and stamina required to carry the equipment and hold the camera and microphone were initially overlooked. However, in order to keep to an ABR method of inquiry, to produce something which is aesthetically well put together, the physical and mental impact of the camerawork for the researcher should also be considered. For example, Jean Rouch describes film camera work as a 'cine trance', a tunnel vision of sorts. In becoming enamoured with the filming process, and what you are trying to subjectively portray, you became so attuned to the present moment that there is a detachment from the wider reality. You lose the sense of peripheral vision in the extended periods of concentration and the art of viewing the world through the camera eyepiece or screen. This intense concentration was mentally and physically exhausting. I found myself flagging after a period. During the early filming, I had assistance from a fellow ethnographic film student, (under my guidance) to share the burden of the weight of concentration and of the camera. This assistance, whilst physically necessary, felt like a failure to stay true to the initial vision of shooting everything myself freehand and this was a dilemma in the field where I had to be pragmatic in order to capture the data and put data before film style. And of course, there are the times when you have to turn the camera off and miss interesting data. Some of the most interesting data came when the camera was off! Problematically, you cannot immediately start recording. This is a particular drawback of camerawork. It is not as simple as picking up a pen and writing what you see. In order for the film adhere to the aesthetic standards of an ABR approach rushed footage, out of focus footage and footage you don't get does not contribute to the overall finished piece.

4.6.4 Data storage

The electronically recorded data is kept in accordance with university guidelines and downloaded to two encrypted external hard drives which are only available to the researcher. Two copies of the film data are kept to ensure that data is not lost. In accordance with the informed consent, the film footage is viewable by the supervisory team with researcher permissions. The final film has been downloaded to the cloud storage sharing space 'Vimeo', which is used by professional and amateur filmmakers. The film is securely stored and

throughout the filming, up until the actors gave their permissions, the film was password protected. Only the researcher and those with the password (supervisory team) were able to review the film in its unfinished format. In its finished state, the participants have given consent for public dissemination and the film is now available for public view via the Vimeo link embedded in this thesis. Any filmed material not used in the final film will be held securely on those two aforementioned encrypted external drives with permissions in place to use that footage for any future academic publication in written format. Any footage the participants have identified as confidential has been deleted from the source data.

4.7 Conclusion: How ABR is used in this thesis.

Arts Based Research is a relatively new methodology in education and as such it has been difficult to source examples using filmed drama in mathematical education research or mathematical identity research respectively. This chapter has attended to the call for researchers to undertake more ABR so that it may be critically evaluated as a research method. The research design was integral to more than just providing a fuller account of phenomena of mathematical identity. The research design facilitated ethical and trustworthy research in terms of '*credibility, dependability, confirmability and transferability'* (Lincoln and Guba, 1985)*.* Filmed drama with a group of participant actors assisted with the triangulation of data (Thomas, 2009) by offering different perspectives of the research problem, coming from different angles to provide credible accounts through comparison of the various viewpoints depicted. The methods of drama and film have been discussed in this chapter as being inherently rigorous and offering validity through the attendance to aesthetics as a means to explore, question and present research data. By attending to ABR methodological principles this research was conducted in good faith to undertake ethical and trustworthy research that will not *"jeopardize the reputation of the research community"* (Cohen et al, p. 75).

The film, as an artefact of the research, constitutes data collection, analysis, discussion and dissemination; a whole research process. It has been argued throughout this chapter that the purpose of ABR, and therefore '*Performatics*', is to provoke critical questioning of mathematical identity by the audience, rather than to impose a meta-analysis based on the researchers (my own) academic or other perspectives, whilst acknowledging the researcher's subjectivity.

MAIN FEATURE

Chapter 5. 'Performatics': Performing stories of mathematical identity through filmed drama

This chapter is represented by the Arts Based Research film '*Performatics*'. This short written introduction to the film indicates to the reader, that if they haven't already done so, to watch the film now. I provide a brief synopsis of the purpose and structure of the film, an introduction to the actors, and some indication as to how the film is intended to be read (watched and understood).

'*Performatics*' breaks new ground and constitutes a significant contribution to mathematical identity research by advancing emerging performative/narrative approaches by adopting Arts Based research methods not commonly utilised in educational research, or currently used so far in mathematics education research. The filmed drama is data collection, analysis, discussion and dissemination. To acknowledge the hard work undertaken by the research participants throughout the research they are referred to as actors. This is to acknowledge their commitment to the drama over an extended period and their contribution to the drama planning, rehearsal and final production stages. The actors, as a cast, determined the content and style of the drama at all stages, directing themselves and the drama.

The film is intended to be a provocation for the audience to make sense of the actor's mathematical identity, through an aesthetic knowing, by partaking of the film and drama. The thesis audience is privy to the filmmaker's sensibilities and reasoning for the making of the film through the written component of the thesis, which has detailed ontology of mathematical identity as collectively produced and an epistemological position that Arts Based Research can provide an alternative sensing of mathematical identity through aesthetic knowing. Read with the thesis, the film can be understood in relation to the researcher's

position. However, the film is also intended as a cultural production in its own right and the validly of the contribution of the film can be judged by the watching audience, without reference to the written thesis, as a way to know the actors through the beauty of the film and attention to the filmic craft.

The core methodology of this thesis is 'drama' in the 'Playbuilding' approach, which we come to know through the film. It is the construction of the drama, and how the provocations of the observational and testimony footage fit into that drama (or not as the case may be), which is of interest to this thesis. This is not to say that the testimony and observational footage is superfluous, but rather they serve as counterpoints to the drama. As such the testimony and observational footage are discussed in the film, and in the final discussion chapter of this thesis, in relation to their salience to the drama. To this end, the film is structured in two main parts. Scene one details the stories the actors drew on to construct the drama and Scene two concentrates on compiling the drama.

Scene one: Introduces the subject of mathematics and the actors. This scene is approximately five minutes in duration. The actors were observed in their everyday lives around the university campus and then giving testimony about those observations and their experiences with mathematics, what they think mathematics is and who mathematicians are. These initial stories and observations are used as provocations to then construct a filmed drama about the actor's experiences with mathematics in Scene two. Whilst this data may be considered productive in its own right, the intention was as a provocation and as such the testimony and observational data is intended to be superficial, rather than a deep exploration of identity, which was the intent of the drama.

Scene two: Constitutes the main body of the film. Scene two is twenty five minutes long and focuses on the principal methodology of the drama production. Scene two details the process of the actors building a drama from

the Scene one material from initial rehearsals in the drama classroom through to performing in the theatre space. The actors engage in the 'Playbuilding' process which was detailed in the Chapter 4 Methodology, and the audience witnesses how the actors construct the drama in a series of drama workshops. The actors bring some of the Scene one material into the drama, not only in their re-enactment of experiences with mathematics but also through their use of overdubbing their initially silent drama with their testimony.

The film intention: How the scenes work together as a whole was carefully considered in the film edit. The film, as a whole, represents the conceptual ideas about identity discussed in Chapter 3 of this thesis and evidences the Chapter 4 rationale for ABR where art and beauty can be analytic. Whilst the film is an alternative way to sense mathematical identity, it is also an alternative way to move the field of mathematical identity forwards by engaging wider audiences in the discussion, and in new ways; as watching audiences, rather than readers. The film doesn't offer answers for the audience. Rather, the audience is cordially invited into the sense making process. No more so than making sense of the two scenes, which are sutured together as a whole. On the part of the filmmaker, there was a purposeful intent for the inclusion of the scene 1 stories and the way in which both scenes are constructed and edited together; a tale of two halves. There is a jarring of the scene 1 stories in comparison to the stories of the drama in scene 2. This juxtaposition is intended to provoke the audience to question the material and the relationship between the stories and the different quality (and content) of the mathematical identity performances.

It is intended that the actors as known through the film and so only the most basic of introduction to them is given in this thesis. All the actors are students at the University of Manchester and are studying a range of post graduate level courses with a mathematical aspect.

The actors:

Claire: At the time of filming Claire was a second year student on a PhD in Education. Claire undertook post graduate level course in quantitative analysis as part of her first year training and to assist with her research. I was introduced to Claire through my own studies and also through some earlier filming in the quantitative studies class she attended as part of my own participation in a film course. Claire was very agreeable to participating in this PhD study.

John: I came to know John through involving myself in STEM outreach activities at the University. I first met John whilst on a course training to be a STEM communicator. It was at this time I approached him as a possible research subject. John had much trepidation and was unsure about participating in a drama. Through our continued contact in our network of Science communication John came to think that he could possibly be involved and his participation in the project developed over time and he gradually became more involved as the project progressed. At the time of filming John was a first year PhD in Chemical Engineering.

Rob: I met Rob in the initial stages of recruitment. The PGCE Secondary Mathematics course convenor had, very kindly, agreed that I could approach students for recruitment. In return, I conducted an induction week session for the PGCE students. Rob was very keen from the start of the process to be involved.

Maddy: Maddy responded to a recruitment advertisement for the research through Facebook. As an undergraduate student in English, the drama aspect of the research was interesting to her, and she had taken mathematics as 'A' level. Maddy and I also found ourselves members of the same improvisational drama group with the students union that I had joined to improve my knowledge of drama ready for the research. It was originally envisaged that Maddy would be part of the research drama. However, it became clear that her mathematical background discounted her somewhat and she also came to the conclusion herself that she felt better able to assist as a drama facilitator, particularly when in the first group meeting John and Claire discussed how they were unsure about drama techniques. However, in doing some exploratory early filming with

Maddy (she was the first research participant to be filmed) the footage proved to be useful as a counterpoint to Claire, John and Rob's stories and the footage also somewhat explain her presence in the film and role in the research.

Ben: Ben was also discounted from the final film as an undergraduate. There were also technical reasons for discounting Ben's data which rendered that footage unusable because of noise pollution. There is a fleeting glance of Ben but he does not constitute a part of the film. However, that he was part of the drama should be acknowledged and was gratefully appreciated.

The purpose of this written section was to introduce the reader to the filmed component of the thesis, the purpose of the film, how it is intended to be read/watched and to provide a short guide as to the structure of the film.

To watch '*Performatics*' please follow the link:

https://vimeo.com/147449932

Should there be any technical difficulties a hard copy disc of the film has also been provided in the main sleeve of this thesis

'

REVIEW

Chapter 6. The value of *'Performatics'* as research: Critical reflections and claims to knowledge.

"Only a few of us are going to be willing to break our own hearts by trading in the living beauty of imagination for the stark disappointment of words."

-This Is a Story of a Happy Marriage (Ann Patchett, 2014)

6.1 A portrait of the artist as an academic

The thesis began with an Arthur Miller quote on the arts as our last great hope; through which we find our identity, and wherein, through the Arts, I found my own identity as an Arts Based Researcher. The thesis concludes with a quote from Anne Patchett's series of essays *'This Is a Story of a Happy Marriage'*, which seemed a fitting dovetail to the opening address and to foreground the conclusion to the written aspect of the thesis in an acknowledgement of the unhappy marriage between the written aspect of the thesis and the film thesis. The main premise of *'Performatics*' was the judiciousness of film to represent rich data, to sense mathematical identity in a different way to written accounts, and to communicate research more broadly so as to engage the field in conversation with key policy and media influencers of mathematics education. As a consequence of this premise, the writing process of this final chapter has been brutal, and often bruising, because of a disconnect between the principles of the research and craft of academic writing. As an 'artist', it felt uncomfortable and counter-intuitive to 'justify' the work beyond the artefact produced. To explain the art feels like an undoing of its purpose. Therefore, this paradox demands acknowledgement before any sense is made of the research. In this sense I am very grateful for my supervisors' caution that to recognise the 'alternative', and those of us that value the 'alternative', one should take care that non-traditional aspects should not present themselves as academically weak, or be regarded as 'cover' for weakness by traditional standards of rigour.

But I also acknowledge that valuing the 'alternative' means we have to push boundaries and make things uncomfortable. To this end, the methodology (Chapter 4) has already intricately detailed the academic rigour of the alternative (Performatics). However, as is necessary to tie together the thesis as a coherent whole, and to seal the marriage of filmed drama as research, I find myself writing some form of justification for the film in the form of a conversation about what has emerged about mathematical identity from the ABR process.

Perhaps, as Ann eludes, the writing will break my heart, and this chapter is doomed not to live up to the contribution of the film, but it is academic folly not to make some sense of it. This chapter, as the conclusion of the written thesis, is a resolution of sorts - between the 'art making' and the academic justification as written text. As such, this thesis is not so radical that it demands the thesis contribution be known solely through the film, accompanying literature and methodological discussion - as with a visual anthropology thesis. Some sense of the value of Arts Based Research is made in this chapter by putting the film into conversation with the literature, the conceptualisation of identity and the methodology. In making sense of the contribution to knowledge which this thesis makes, I situate this chapter in the overall structure of the thesis, revisiting the aims of the research, making three claims to knowledge which we come to know through '*Performatics*' and the main body of a discussion structured around those claims. A contribution to knowledge is carved out where words and imagination share a more equitable space; writing the imagination through drama and film, and then drawing attention to the film's value as research.

6.1.1 Synthesising the original contribution and claims to knowledge

This section synthesises the thesis as a whole and elucidates how the chapter contributions come together, concluding with three key claims to knowledge.

The thesis is structured in an alternative format, structured around three movements – the 'Preview', 'Main Feature' and 'Review'. The 'Preview' indicated what was to come -framed the state of the art in the literature, conceptualised identity and constructed an ABR methodology. The 'Main Feature' was the research film '*Performatics*' as a whole research process. There are purposefully no written data analysis chapters in this thesis because, as set out in the methodology, the filmed drama represents the presentation of data, data analysis and discussion. This chapter concludes the thesis, bringing the whole together by drawing on the literature review (Chapter 2), conceptualisation of identity (Chapter, 3), methodology (Chapter 4) and the filmed drama - '*Performatics*'. The purpose of this concluding chapter is; to discuss the value of '*Performatics*' as research, to make claims to knowledge, expose limitations of the study and make recommendations for further work. From the outset, mathematical identity was defined as a process of collective storying and the problem of the stereotypically dismal and anxious mathematical identity story was the guiding concern of this thesis, addressed by the research aim to:

'**Undertake and assess the value of Arts based Research (filmed-drama) for sensing and expressing mathematical identity.**'

Firstly, the aim of this research was addressed by scoping the state of the art. Elucidated was an increasing application of performative, artistic/aesthetic approaches to mathematical identity research which explored feelings/emotions, memories and senses of experiences. For example, extended narratives (Boylan and Povey, 2009), fictional texts (De Freitas, 2004; Nardi, 2016) and parody, (Solomon, 2016). In addition, film was argued in the literature as a means to, (i) sense mathematical identity differently (De Freitas, 2016), and (ii) enhance the impact of the field of mathematics education (Herbel-Eisenmann, et al. 2016). Secondly, the scoping of the literature identified two problems which required addressing by the thesis in order to achieve the aim of this research: (i) to conceptualise identity and (ii) construct an ABR. I built on emerging responses to performed identity in the literature review, to (dis)entangle and conceptualise identity as a story in Chapter 3 and

developed an Arts Based Research in Chapter 4, which could capture identity storying in action, and explore emotions and past experience by employing filmed-drama. A methodology based on Joe Norris's 'Playbuilding' (2000), employing ethnofiction techniques (Saldana and Casas, 2005; Sjoberg, 2008, 2009), and filmed using Jean Rouch's principles of observational cinema, accounted for memory, imagination and the body as integral to the telling and mediating of a mathematical identity story. The drama was a means to crystallise those common stories about mathematics which powerfully mediate identity, whilst the filming also allowed the audience to witness the dynamism of storying the self.

Overall, the research film *'Performatics'* which was guided by ABR principles of aesthetic knowing as inherently analytic, was positioned as a whole research process where the actors, researcher and the audience, interrogate and negotiate identity through an act of collective storying. In the film, close attention was paid to both the 'oral' and intangible 'embodied/enacted' (memory, imagination, emotions, feelings and the body as a sign) senses of storying, which were fundamental aspects of the actor's mathematical identity. I focussed on the actors' experiences, which they framed in terms of 'shared feelings' of anxiety. Throughout, a struggle between 'tellability' and 'authenticity' was a testament to the affective power of storying mathematical identity, which thrived on contradiction, tension and anxiety. The following discussion highlights, with reference to *'Performatics'*, how even a positive mathematical identity can be storied as anxious, as an 'internally persuasive' story of the 'other in me', an identity that 'I am not'.

Two common stories emerged through the filmed drama as sites of shared understanding.

Story 1: Identified school as a context for a shared understanding of the subject –what is mathematics? All the actors situated their scripted dramas in biographical, historical experiences of the school classroom. Both Claire and

John recounted anxious experiences of hiding perceived mathematical in/ability, thus highlighting the tension between ability and inability, and a perceived difficulty/ease of mathematics. The school was a site of shared understanding about mathematics, which very powerfully mediated the identity stories expressed. This was despite the actors having long since left formal education, and the availability of more recent, and more positive stories evident outside of the drama. When asked about experiences with mathematics, the group all interpreted this question as meaning past experiences of school mathematics.

Story 2: Identified the media as a resource for a shared understanding of mathematicians. The improvisation was based on semi-fictional caricatures of the actors playing a fictional self in 'Math Therapy'. The actors were freed, in some small way, to draw on wider, more recent experiences with mathematics. The actors drew on a shared understanding of popular, stereotypical images of mathematicians as anxious and troubled, as a resource to play out their own experiences in a parodic skit entitled 'Math Therapy'. However, drawing on more recent, personal experiences, didn't foster the same sense of shared experience as the school story. John and Rob, who storied themselves as more able mathematicians, participated in the parody to a greater degree than Claire, who storied herself as less able. John and Rob were more successful in imaginatively critiquing unhelpful stereotypes about mathematicians, consciously distancing themselves through 'parody'. In contrast, Claire wasn't as active in the parody because mathematical anxiety was still relevant for her.

These two common stories, which emerged through the filmed drama as sites of shared understanding for the actors are referenced for their use in understanding three key claims which support an 'aesthetic knowing' of mathematical identity and identifies Arts Based Research as fruitful for exploring alternative ways of knowing, and sensing about, mathematical identity.

Ordinarily, in the more traditional thesis, discussion and inclusion of data would be presented in discreet analysis chapters and then claims to knowledge are built on this data in the subsequent discussion chapter and conclusion. This thesis necessarily requires a somewhat different concluding structure whereby the filmed analysis and discussion are drawn on in this concluding chapter in order to assess the value of '*Performatics*' as research and claims to what '*Performatics*' can contribute to mathematical identity research. So as not to make this large chapter too unwieldy, it is structured in three interconnecting parts, which constitute three claims to knowledge based on three selected scene's from each actor as a 'case' with which to explore the value of '*Performatics*' as research.

The selected scenes are: *'Sum Anxiety'*, which exemplifies Claire's finalised scripted drama performance; *'Tense identity'*, which depicts the actors in the process of constructing John's scripted drama and *'Math Therapy'*, an improvisational parody loosely based on Rob's story of maths anxiety. All selected scenes are based on the actor's experiences of mathematics in a school context; however, the 'Math Therapy', parody, is set in a present day context. Each section contains its own brief review of associated literature, with which to make sense of the film data. The three claims exampled by these scenes are that Arts Based Research as filmed-drama:

> Claim 1: *'Sum Anxiety'* expresses emotions, memory and imagination as fundamental to identity. (Section 6.2)
> Claim 2: *'Tense Identity'* exemplifies the dynamism of storying. (Section 6.3)
> Claim 3: *'Math Therapy'* reads the body as both a sign of identity and for its dramatic intent, evidencing the affective property of story (Section 6.4)

Whilst these claims serve to structure this chapter in three sections, they are inherently interrelated so that discussion of one claim necessarily reveals something of the others. Rather than being problematic, this entanglement

speaks to how identity research benefits from Arts Based Research as a holistic approach. What will be shown through these claims is set out below.

1. *'Performatics'* adds to previous methodological approaches taken in order to understand and investigate mathematical identity. The methodological contribution is located in relation to both previous research on mathematical identity, the use of drama in mathematics pedagogy, and to a more limited extent to previous Arts Based Research in mathematics identity research. *'Performatics'* supplements knowledge on identity by claiming (i) that there are features of dramatic methodology and film that can be adopted from other fields (observational cinema and theatre studies) to show the intangible, inner aspect of identity. Features that include a wider grasp of emotions and cultural semiotics, and a means to represent past experience in the non discursive ways that the storyteller may recall them, (ii) In doing so the affective property of story becomes more apparent and (iii) the audience becomes witness to the dynamism of storying in a way not possible in a written text.

2. Whilst this methodology draws on two existing methods, the approach in 'Performatics' is a novel adaptation. More usually in ethnofiction, the drama is incorporated into the film more seamlessly so that the audience cannot distinguish between fact and fiction, whereas 'Performatics' makes plain the distinction between the drama and other footage making a distinction between fact and fiction to understand what we can learn at that intersect.

The conclusion consolidates the contribution to an aesthetic knowing of mathematical identity, documenting research limitations and implications for further work.

Because the filmed data was so rich, any number of instances had the potential to be explored. In making this abundant data transparent, the researcher risks a critique of their frame of reference from the thesis reader and film audience. The

data selection in this chapter is clearly justified to the reader/audience by situating the film amongst the gaps in knowledge as drawn out in the literature review, the conceptualisation of identity and the rationale of the methodology. I focus on Scene 2 of the film in this chapter because it constitutes the main body of the film and focuses on the principal drama research method. Scene one, which contains the actor's testimony and observational footage which were provocations for the drama, are infrequently referred to, and where they are featured, it is as a counterpoint to the drama. This is not to undermine the contribution of those aspects of the film, but rather I acknowledge that the film is a significant contribution in its own right, and as the methodology indicates, the words in this chapter were never going to be sufficient to discuss all aspects. The sections of the chapter detailing the limitations of the study (6.5.3) and recommendations for future work make some headway in addressing what can productively be done with the Scene 1 footage, beyond this thesis.

This introduction has framed the methodological contribution to knowledge that this chapter will address. The following discussion situates those claims, which emerged from the film '*Performatics*' in reference to the literature, conceptualisation of identity and ABR methodology. Where the filmed data is exemplified it is presented as a script rather than by traditional in text quotations. The data is presented in such a way to stay true to the form of the drama.

6.2 *'Sum Anxiety'* expresses emotions, memory and imagination as fundamental to identity.

This section determines how attending to the process of making a filmed drama focused the mind on the act of constructing a story; to appreciate how 'story' functions in a way which structures experience. With examples from the film, this section explores how the affective properties of storying became evident, through the drama. The school mathematics story, as a site of shared understanding of anxious mathematical identities, is the context for this

example. The film 'case' in this section is entitled 'Sum anxiety', and depicts Claire as she re-plays her school mathematics experience. I revisit the literature on the function of story plot and the affective domains of memory and emotions. I then introduce and discuss *'Sum Anxiety'* in relation to the methodology and what was sensed about mathematical identity.

6.2.1 The affective property of story: Plot, memory and emotions
The affective property of 'story' was conceptualised in Chapter 3 as mediating identity in relation to story plot, memory and emotions.

Stories are claimed by Ricoeur (1984) to make human lives more readable. However, like human experience, stories require a shared understanding of narrative practices (Ricoeur, 1992; Evans, 2013). In a disentangling of story in Chapter 3, story, plot and narrative were elucidated as distinct aspects of the whole; identity story is the sum of its parts. This section focuses on the role of story plot and how it can affect feelings towards mathematics.

'Plot', dictates the way the characters are expected to behave in the world of the story, a chain of causation which determines that these events are somehow linked. Bruner's borrowing of Todorov's narrative development assists an understanding of how story plot might develop following some form of common story and common understanding of narrative functions; claiming that *"stories are told from the perspective of a norm or canonical state that centre on something unusual that breaches this state"* (Bowles, 2010, p.20). 'Canonical narratives' (Bruner, 1991) are templates of story plots, which Ricoeur claims are the foundation of narrative structure –what can be told. The plot moves the narrative along and delineates how to be and act, and against which unusual stories are told. The plot is the scaffolding of the story, often following traditional dramaturgical tropes of comedy, tragedy, satire and romance (Cobley, 2004). The plot also pays close attention to grand narratives of human experience, fear, anxiety, joy, tragedy, which implicate emotions as intimately tied to the

storying process. For Schank (1995) stories are told to express emotions that say something fundamental about us, they allow us to feel and the recounting of those stories serves to embolden them, to preserve them. Schank, however, presents us with a problem for mathematical identity research and the vociferousness of anxious identity stories claiming that *"we avoid telling stories that evoke feelings that we do not care to relieve"* (Schank, 1995, p .47). However, following Voloshinov's (1986) logic, troublesome/anxiety laden stories about mathematics may be told, not as evoking difficult feelings, but because the cultural context determines negative stories about mathematics to be the norm and therefore re-tellable –mathematics anxiety is not a difficult feeling to recall because it is culturally acceptable. Psychoanalytic approaches to mathematical identity are concerned with such stories where student's emotional experiences are languaged as difficultly, frustration, struggle and hate (Brown et al, 2008). This psychoanalytic approach revealed the formation of 'subjectivities', and the personal, psychic, 'investment' one makes in taking up a position over another. Similarly, Bibby (2002) reported how mathematics is often experienced as intensely emotional, and particularly how absolutist/product conception of mathematics provides opportunities for shameful reactions to criticism of mathematical ability by others. Bibby argues that attention to behaviours, language, and what cannot easily be articulated, facilitates a deeper exploration of the feelings towards experiences with mathematics. For example, fragile and febrile emotional states not often heard or noticed by teachers (Bibby, 2007).   However, from a psychoanalytic perspective mathematics as a subject, and the way mathematics is taught, is heavily implicated in the affective reaction of the student. In comparison Doxiadis (2003) intimates how the theatricality of such emotional states, such as conflict and tragedy are entertaining drama are entertaining and therefore the property of the story makes such anxious and dismal mathematical experiences more tellable, and reproducible. It is conceivable that western sensibilities of story, driven by conflict and contradiction, could, therefore, be influential in mediating mathematical identity. This affected performance may then be implicated in a self-censorship of alternative, possibly more internally persuasive mathematical identity stories. In considering the story as a whole (story, plot and narrative), aspects of identity story, which are not so easily

voiced (feelings and emotions) but are significant to the storying process, warrant attention?

The actors had already cued into the affective property of story when choosing 'shared feelings' as a way to theme and identify the stories they wanted to dramatically portray. However, the actor's feelings towards mathematics may also be socially shaped and affectively recalled. Crapanazo, (1980) claimed that memory is recalled through habitual, narrative and traumatic memory in a process of recall, performed as physical 'acts' or a symbolic instance. Memory can be less linguistic and more symbolic, experiential, somatic even; coming into consciousness as sensory flashbacks, dreamlike, evoked by or including sounds, sights, smells and emotions (Bal, 1995; Brison, 1999). Ricoeur (2000) pointed to how memories of the past self, work to narrate the present self. These memories he claims are temporal narratives, selective in nature and socially shaped; people don't always choose how and when the past becomes part of them and what and how they come to recollect it. Sharing experiences, in the drama, will necessarily cue into the social shaping of emotions and identity and assists with bringing emotions to life through the drama.

With some theoretical understanding of the use of exploring identity story through drama the reader is guided to what can be expected from the first scene, chosen as indicative of a contribution to knowledge, whereby drama is a means to imaginatively represent past memory and to convey emotions. The next section presents *'Sum Anxiety'* as an example.

### 6.2.2 *'Sum Anxiety'*: Film clip and discussion

The affective function of story plot in mediating identity was discussed in the Chapter 3 literature review and a brief overview was provided in the previous section. Here, the affective function of the story is discussed in relation to Claire's scripted scene about her experiences with mathematics in secondary school. The scene is entitled *'Sum Anxiety'*.

In constructing the drama Claire suggested that the group would more likely have shared feelings about mathematics than a specific shared experience, thus indicating the affective aspect of how a particular experience, or story, resonates amongst the stories of others. The group of actors framed the drama to develop a performance about how they felt about their experiences with mathematics. In doing so the actors, independently of each other, all wrote (in the story shower session) and later performed (in the drama), a story about mathematical anxiety set in a school context (Story 1). The school mathematics anxiety story emerged early on in the research, indicating the tellability of this story and the commonality of shared anxious feelings about mathematics at school. There is a paradigm shift in the drama where the actors' become more acutely aware of performing to a general audience a publically palatable story and the school mathematics anxiety story surfaces as a shared site of understanding.

Discussion attends to issues with narrating the self through past memory and how the filmed-drama was able to convey the feelings and emotions (embodied aspects of the story) which were bound up in the actor's identity story. By drawing on drama sensibilities towards aesthetic knowing (Chapter 4) the actors, in 'Pantomime' (acting without words through facial expression, gesture, and movement), depicted past mathematical experiences as they were for them. The actor's experiences were recalled as sights, sounds and imaginative remembering, which didn't necessarily represent the actuality of the experience but rather their recollection of it. In '*Performatics*' we see the actors negotiate the form and content of the memories which they recall. The clip below depicts Claire as she recalls a pivotal experience she had with mathematics which was anxiety causing. An experience which she says 'shaped' her feelings about mathematics thereafter. For Claire, this secondary school experience was pivotal in developing a negative disposition and anxiety towards mathematics which became internally persuasive and a story consistently told throughout the filming testimony, observation and drama production.

Clip No 9. Performatics: Sum anxiety

Timecode 10m 43s
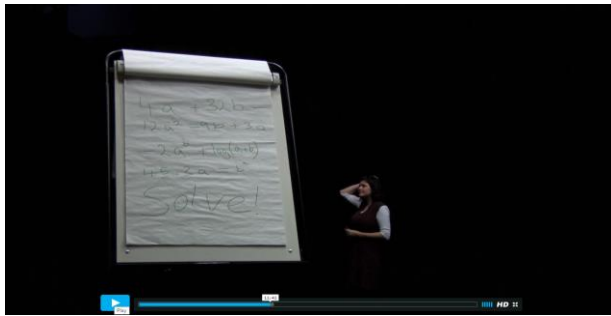
Claire: I felt tiny. In my memory I feel tiny. I don't know if I did at the time but now that I think about it I felt tiny.....

I felt that everyone's eyes were burning into me.

 I remember distinctly that the heat in my face…My heart beating.

People were talking under their breath and I'm assuming that it's all about me.

I just kind of, feel really uncomfortable.

The drama afforded Claire the opportunity to represent her remembrances of the mathematics experience, which were abstract recollections, in a more authentic way but which would still make sense to a watching audience. Claire recollects a space where the board is huge, the scene is grey and she is tiny. The props of the whiteboard and chairs demonstrated Claire's anxiety through the imposingly large 'SOLVE' on the whiteboard and her diminutive physical presence in contrast. Mathematics was made huge in comparison to her physical self and also in contrast to her perceived intellect and ability. The imbalance depicted by the contrast in size between mathematics and Claire was the memory of the experience as for how it was recollected by her. This visual image was represented in the drama in a more authentic way for Claire, than she could present through telling the story orally, through a layer of interpretation. These suggestions, that are so directly communicated in the play, through the physical actions and virtual editing, illustrate how the case of an

event, which caused such anxiety, can be viscerally, and perhaps relatively easily (i) produced and (ii) communicated by Claire so much more easily perhaps, and certainly more viscerally, than if it were done in an interview one to one format. The significance of this for the field is a truly emotional validity of Claire's emotional experience which is captured, in the video-film. Whilst researchers experimenting with narrative may convey emotionality in their writing, the film lends a judiciousness not afforded in writing (a picture paints a thousand words). Moreover, a scene directed, and played out by the actor removes a layer of researcher and audience translation. When one reads one may imagine the scene but in the drama the actors are providing us with the image of the scene that they want to represent.

Previously, memory recall was discussed as problematic because traumatic memories (anxiety for example) are less likely to be discursive, coming to us as sights, sounds, feelings, emotions (Bal et al., 1999). The drama was a means for Claire to represent how the experience was and felt for her. The film makes palpable Claire's mathematics anxiety and the physiological (hot, heart racing) and psychological (imagined judging voices and the abstract imagery) responses to doing mathematics which was affected by shameful reactions. The film could potentially benefit the psychoanalytic approach presented by Bibby (2007), whereby attention to emotions will necessarily direct the researcher to the what cannot be so easily articulated, and emotions which may be missed by the teacher, in this case the teacher misses the commentary of Claire's anxious and shamed inner voice

For Claire, this depiction is representational of the remembrance she holds in her mind of that experience. However, when Claire states that she doesn't know if she was *"tiny at the time"* also acknowledges the remembrance as abstract and points to how these experiences, recalled through imagination, are not necessarily how the events happened but are depictions of how they are remembered. Claire's depiction points to how stories can be crafted in imagination; beyond the discursive. Through ethnofiction sensibilities, which

regard imagination, dreams and past memory as integral to identity, the filmed drama enabled the actors to bring their imagination, which is integral to their identity, into a concrete reality.

The filmed drama assists in making observable the actor's mathematical identity in tension, and how their behaviour and feelings towards mathematics were tempered by common stories about mathematics. The audience is witness to the affective properties of storying. Drama and film were tools to bring to life Claire's memory, and senses of stories, which existed for her outside of traditional oral storytelling practices. Claire had attempted to orally story this experience in the drama practice but in the theatre, she instructed how she wanted to portray the scene *"without words"* – as a mime. However, afterwards, Claire (and the other actors) requested that their oral stories be dubbed over the action in the film editing process. The overdubbing of the actors oral storying onto the drama serves to highlight the different quality between the mime acting and oral storying. The drama can free the actor from words so instances which might be more difficult to articulate are still portrayed, in some understandable sense, to the audience. Claire, in particular, was able to articulate a different, more sensuous sense of experiences with mathematics about an experience with mathematics which fundamentally shaped her identity thereafter. Drama, as ethnofiction –acting as the self but another self, was an opportunity to explore ways to represent recalled memory, representatively, metaphorically and abstractly. Ethnofiction drama principles (Rouch, 1960; Saldana and Casas, 2005; Sjoberg, 2008, 2009) were used to make the actors' imagination and memory accessible for analysis.

The filmed drama elucidated qualitatively different data from written accounts with which to further our understanding of mathematical identity; where stories we are able to tell about mathematical identity are tempered by our ability to authentically represent often abstract, incomplete and sketchy notions of past experience into some sort of tangible and understandable sense. Privileging 'oral' storying and interviews, over more enacted, performed ways of being, as

evident in the methodological approaches to mathematical identity (Heyd-Metzuyanim et al., 2016), therefore does an injustice to experiential and embodied ways of being that are not so easily voiced, such as those involving feelings and emotions such as anxiety.

Claire also stories herself through and in relation to the voices of others. These voices relate to Claire and her anxieties about mathematics; she doesn't want to get the sum wrong *"and I just couldn't do it"* (Claire). Whilst Claire's story of her difficulty with mathematics does not explicitly account for a gendering of experiences with mathematics the inclusion of the other voices intimates how storying is a collective process, told in relation to and through the voices of others. Claire's story can, therefore, be regarded as referential, told in relation to wider social stories of the problematic nature of girls' mathematical uncertainty. This may be explained by the social act of memory, whereby we do not always choose which identity stories are available to us; which stories we remember and recall are based on cultural significance and cultural understanding (Voloshinov, 1986; Evans, 2013). That Claire voiced imagined criticism from her classmates about a lack of mathematical ability, rather than voice a positive story about being a top set mathematician, indicates how the girls and maths story may, surreptitiously, become internally persuasive. In a Bakhtinian sense, the imagined voices of the classmates are ventriloquated by Claire; foreground in various discourses of girls fragile mathematical identities (Boaler 1997; Solomon et al, 2011), disaffection and disadvantaged from the classroom structure of 'ability grouping (Boaler et al, 2000), and mathematics being difficult and for geeks/genius (Lucey et al, 2003; Epstein et al, 2010). Thus Claire's classmates are imagined as judging Claire and her mathematical ability. Claire gives life to phantoms – imagined actors, imagining what her classmates might say about her in this context, ventriloquates them with her own voice, which also speaks to the wider voices of girls and mathematics. This speaks to how mathematical students can be affected by the critique associated with mathematical performance (as skills and test performance), particularly when expected to perform mathematical tasks in front of their peers. The phantom actors are given life through the drama, which plays between fact

and fiction, whereas interview is more firmly situated in factual accounts. The interview is a less likely space for this kind of imaginative practice of storying to occur. Drama, as a methodological approach, is a means to contrive such instances to purposefully facilitate dramatic interaction.

 'Sum anxiety' evidenced how drama was a valuable resource to bringing to life aspects of identity which may be more difficult to orally express; specifically emotional memories as sensuously felt and imaginatively remembered. Identity storying has been shown to be mediated in relation to the affective property of story. Story plots have been shown to mediate not only what stories are told but how they are felt. The drama ably accounted for such emotional remembering; depicting stories as memories, as felt emotion, rather than solely discursively practised. Towards the end of this account, the influence of other, persuasive voices has begun to emerge. The next section specifically addresses 'other' voices in the storying process and the storying process in action.

6.3 *'Tense Identity'* exemplifies the dynamism of storying.

As the process of collective storying becomes apparent in the film, and through the previous section, I turn to dialogism and some difficulty and tension in claiming identity stories for oneself and the struggle for authenticity. *'Sum Anxiety'* referenced voices of the past and of the imagination, exhumed in the present. The subject of this section is the scene *'Tense Identity',* which brings us to the present 'tense', to witness the dynamism of collective storying in action. I begin with some discussion on dialogism, before introducing the scene, which depicts the tension between the actors (Claire, John and Rob), and specifically John, as they develop his school mathematics experience into a drama performance. I term *'Tense identity'* to be productive for understanding the emotional quality of storying identity. Firstly, 'tense' is understood as the present 'tense'. The in-the-moment activity of storying. Secondly, 'tense' pertains to identity making as 'work', where identity can be in tension between a personally authentic and socially understandable story. Finally 'tense' is the

state of mind and emotional quality of the work of doing identity; the provoked or elicited feelings of tension experienced in the storying process.

6.3.1 Dialogism in *'Performatics'*

The literature pointed to how the theoretical works of Bakhtin's dialogism have been recently incorporated into mathematical identity work as analytically useful for considering mathematical identity as a process of collective storying. The literature also documented moves to explore the dynamic of collective storying to account for the various voices implicated in the mediation of the research subject's identity (researcher, lecturer, parents, wider audience etc); through the use of parody (Solomon, 2016), Monologue and voicing social stories through the self (Boylan and Povey, 2009 and Di Martino and Zan, 2010) and in experimental texts (Povey et al., 2006 and Povey and Angier, 2016). Some theoretical grounding on dialogism and collective storying is provided before exploring the film clip *'Tense Identity'*, in order to foreground the example in the literature and how I have understood the conceptualisation of collective storying.

The literature review made some claims to how written narratives of the research subject's identity can only go so far in expressing collective storying as a dynamic process. I argued that whilst some attempts have been made to incorporate the various voices, the transcription of the action loses something of the dynamic process in the translation from action into words, at least within the limited wordage of an article or book chapter. This thesis claims that filming human interaction, and particularly in the filmed-drama, where the actors are explicitly focused on interaction to come up with some form of dramatic piece, provides a window into exploring that dynamic. Moreover, in producing an aesthetic piece, to be watched by some imagined, external, generic audience, we are also reminded of the silent but active role of the audience as spectator and contributor to the collective storying. The audiences are explicitly and implicitly addressed by the actors who envisage what might make an

entertaining, or at least appropriate, performance to share with a wider audience.

Bakhtin's (1986) concepts of dialogism, and specifically, 'addressivity' are analytically useful here because we are dealing with story tellers, listeners/audience, past and present future self. An utterance (for Bakhtin) is always told in response to something/one, and in turn, it demands a response (in a dialogic discourse, but even perhaps in a monologue). Every word is 'half someone else's' and has generally been used by others a million times in the past. In performing for an unknown public audience the actors may increasingly gravitate to common stories about mathematics and mathematicians in order to find commonality, to 'make sense' through a shared understanding. Included in the 'others' is the researcher and my framing of the task to them would also be expected to be highly influential on the range of expectations they felt was expected of them. As the actor's stories are performed to these different audiences the stories they chose to perform might not be claimed as the most important personal story of mathematics for them, but rather the story which 'satisfies the group and the audiences. This continuum of more or less personally persuasive stories may be mediated by a compulsion to tell satisfactory stories regarded as 'tellable' by the listening audience thus positioning the listening audience as active storying participants. The listener asks 'so what', what is it about the story that is important? (Sacks, 1992; Ryan, 2005). In asking 'so-what' the 'tellability' of the story will be dependent upon the context of time, place and space (Bowles, 2010) and personal significance (Huhn and Sommer, 2013). *'Tense identity'* is such an example of the specificity of telling stories dependent upon context, time, place, space and personal significance.

In summary, storying is a dynamic and fluid process which involves both addressing and being addressed. There are a contextuality and historicity of the storying process whereby the significance of the story is determined by the time, space and place as well as the listening audience. How one goes about

constructing a satisfying story of identity for the self and an addressable audience must, therefore, be a site of tension. It is claimed here that this site of tension can be better described and explored in the filmed drama, as a window in to the process.

6.3.2 *'Tense Identity'*: Film clip and discussion

I closely examine how *'Tense Identity'* exemplifies the dynamism of storying identity amongst the other actors as co-storiers. This dynamism resulted in some tensions and difficulties for the actors in claiming the stories as their own and also some issues identity story authenticity. Whilst the main focus here is on the collective storying process, I must stress how the storying process is regarded in both sense as oral and embodied/.enacted storying. Whilst this clip assists the audience to engage in and learn something of identity through watching the film, I encourage the reader/audience to pay attention to the negative spaces, a moment of seeming inaction, and what is not said as much as what is. The clip below shows John, Claire and Rob working out how to dramatise John's identity.

Clip No 10. Performatics: Tense Identity
Timecode 12m 03s
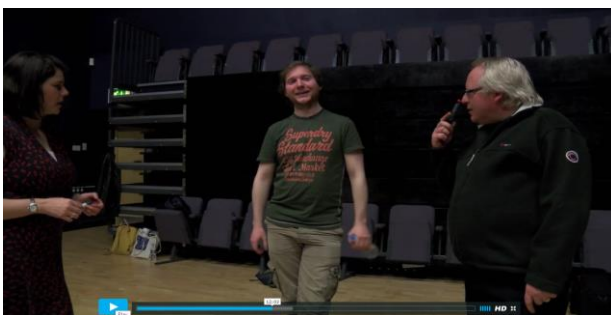
Claire: You wanted to be popular?

No sorry no. You were really good at maths and you quite enjoyed showing people and   [interrupted by John]

John: Yes, well yes…

Claire: and you'd have two different voices. One saying *"John you're great, you're our wonderful. Show everybody how good you are"*. And the other one saying *"no be modest"*

John: It's more like the er….

Claire: You could walk in and have the same indecision about whether you are going to answer or not but it's a different dialogue within your head.

And you're erm...Unless you are big and then your voice is; oh what about your mates? Oh, it's not a second voice because you're already big.

If we're using the symbolism of the size you are indicating your own perception or conception of your ability with maths. Does that make sense?

John: Er, er, [long pauses] I'm trying to sort of think about it. [long pauses]

It's hard. Whenever I think about it in terms of myself, I'm like no it's not perfect.

It's not exactly how it is but I need to sort of distinguish, sort of take myself out of that and realise it's just a story.

In this clip, the actors are collectively storying their understanding of John. Claire, quite forcefully, suggests how John should portray his experiences. In the clip, and also the film still image, John's body language speaks volumes about John's resistance to being storied, at least in this way. John is bodily disengaging from Claire's insistence of how to proceed and John becomes increasingly irritated by the actors' attempts to story him. John turns away from Claire, eyes averted, crossed legs and eventually sitting down on the floor. Through John's bodily expression and demeanour, and what he does not say, rather than what he does say (which is limited), the watching audience get some sense of the tension. Whilst this interaction could be and has been captured in the transcription, I would argue that the sense of tension is not as palpable and emotional in the written account because the intricacies of the body language and the tension of the silences and interruptions are difficult to

translate into writing. Moreover, whilst the film/action could be transcribed, the transcription of the emotions would be my interpretation. Whereas in the film (although edited) the action is perceived by the viewer direct, and so there is one less layer of interpretation of the emotional content of the action, which may carry greater conviction/persuasion for the viewer/interpreter. This is a matter of validity and conviction, whereby the ABR principle of beauty as validity, means the actor's drama can be appreciated for its original form. The purpose of the observational cinema style is to represent, as much as is possible, the action as it was recorded, and to limit editing in anything other than a realistic way. Whilst the researcher's subjectivity undoubtedly frames what action will make the final edit, the actors were included in those decisions and the film represents (as much as is possible) the work the actors undertook, rather than my interpretation of it. This visual method is a qualitatively different portrayal of the dynamism of collective storying as accounted for in written narrative approaches, e.g. Povey et al.'s (2006, 2016) inclusion of the other voices present in the storying of Joanne, and Solomon's (2016) account of the various voices (father and mother) who mediated her subjects mathematical identity. The visual account in Performatics gives the audience a window; to see how the storying occurs and what is lost in translation to written word such as bodily gestures, actions, and indeed silences and inaction which are evident in the storying of identity.

The tension comes more from what John doesn't do and doesn't say than what he does. What filming can do is to pay attention to 'negative' spaces in dialogue and action and privilege any seeming in-action and silence with the same gravitas as the action or dialogue. Negative spaces, in-action and silences, or the constraint of dialogue are elements of dramatic tension, encountered so frequently in theatre and film/TV media. Silence can speak loudly. Silence is resistance (Denzin, 2001).

However, De Freitas (2016) critiques how film has come to concentrate on exploring the mathematical body through gestures where the body is thinking,

embodied, a phenomenological body, with a rational goal of communication. Instead, De Freitas draws on Deleuze's[38] (1989), non–thinking body to go beyond bodily cognition, and to study the body without interpreting it as having rational actions. Deleuze's work on the time image considered the past and present together, in a jarring juxtaposition of image and movement. This gets to the crux of some of John's difficultly in expressing past memory and how film might be able to think of time and memory in relation to learning? (De Freitas and Ferarra, 2014).

In ethnofiction, the dramatic process which was integral to the methodology of this thesis, the non-thinking body is exposed through the observational cinema techniques.

> "Once you allow film subjects some freedom to improvise what they say, or do, you get the possibility that they will reveal values and feelings which they might otherwise not directly express, not because of repression or inhibition necessarily, but sometimes because they are "taken-for-granted"
>
> (Lazois, 2008 in Sjoberg, 2009, p. 2).

The beauty of the film is that it can present the intangibles, the taken for granted bodily communication which occurs without interpretation, or what I term 'cognitive-deliberance'- a deliberate action to act or be a certain way. The film is also able to trace the present John with previous depictions of him in the testimony footage and to overlay this with the drama footage. In the selected scene in this section there is a dance; a dissonance between John's cordiality, to provide Claire and Rob with some sort of understandable story, and his bodily giving away of / revealing the tension he finds himself in. John is in tension between making the story understandable but also authentic. Finally, sitting down, in a contemplative state, the tension is broken and a resolution is sought as John begins to reflect; *"I need to take myself out of that and realise*

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[38] Deleuze (1989) considers the filmed form of the body and the 'time image'.

it's just a story." There are a difficult balance and some trade-off for John between telling some personally satisfying versus some socially understood story for the group and also the wider public audience. John struggles with bringing his memory into the present tense. In storying their past experiences the actors are also in dialogue with their past self; performing as oneself, but beside oneself, through 'restored behaviour'. Schechner (1985) clarifies the difficulty of working with actors 'restored behaviour' whereby you revisit yourself in the past or in another frame of mind; it is you but it is also not you, there is a move to the subjunctive mood: *"even performing as self, if invoking the past they are performing as-if they were themselves."* (Schechner, 1985, p.37). Restored behaviour in drama, where you act as if you were yourself, is also a methodological apparatus with which to see, in real terms, Bakhtin's dialogism whereby social actors can hold more than one perspective about themselves. However, as we have witnessed, focused self- reflection is difficult and memory recall is not unproblematic.

In the end, John's drama story becomes a re-enactment indicative of his collective experiences with mathematics at secondary school rather than representative of a specific experience. The metaphorical re-storying was necessary for John to voice his experiences in light of his difficulty recalling and expressing to others exactly what the experience was like for him. The drama facilitated John to convey an understandable 'sense' of his experience. By interacting with the other actors, in collective storying, a sense of John's story emerges and merges with the stories of the others. Eventually, John's drama mirrors Claire's story by using the same premise of a mathematics classroom but where he is large in comparison to the board, to indicate his superior mathematical ability. John's drama is told in concert with Claire's frame of reference – thus, story begets story (Norris, 2000), as we mirror the stories and experiences of others.

In accounting for the dynamism of storying identity, the hard work of identity is palpable in the tension of the actors as they struggle to come to some shared

understanding of each other's stories. Sfard and Prusak (2005) claim that identity is a process of storying which includes those told by ourselves to ourselves, and to others, and those that others tell about us. Witnessing the drama underscores how a sense of shared understanding is important to deciding what stories can be shared and how, in the case of John, we might permissively allow the stories that others tell about us - even though we may not feel they are authentic. Identity can, therefore, be easily given away and is not always something which we understand about ourselves but rather what others understand about us. The story transfers from the story conveyer to the listener/audience to be made sense of, through their frame of reference (i.e. the mirroring of John's story to Claire's).

 I would contest that stories are told with us rather than about us or to us; we understand ourselves through the 'other'. Even when we are storied by another, they use some sense of us as a resource (amongst other things i.e. wider social stories for example); we are referenced in accordance to stories of the 'other'. Whilst the drama is a contrivance, it is argued (Schechner, 1985, 2003) that drama is a means to reflect social life and so we can expand what we have learnt about the dialogic storying process to generalise that similar storying practices would be accounted for in everyday interactions. However, this reflection, in the drama was a difficult process and issues with authenticity and presenting more realistic accounts of memories of past experience proved troublesome.

This example of *'Tense Identity',* is a scene focusing on the construction of storying, but was a contrivance. However, based on performance theory, that contrivance can be considered as reflecting social actions we can imagine that the actors would engage in similar forms of storying in everyday life, outside of the drama. Filming the process of the drama enabled the audience to witness the dynamism of the storying process and how identities can be 'given over' to the more forceful storying by others and how creating a shared understanding of a sense of a story can somehow merge stories so that experiences can even

be told through another's frame of reference, which may be different to our own. Crucially, the film allowed the viewer to see, and so gave equal importance to, what was not said, the 'er's' and the pauses and the bodily disengagement of John from the conversation. The spaces of inaction are often also spaces of tension and dissent. These spaces are arguably more difficult to portray in written accounts, which demand words and can be heavily interpreted to express emotions. In the case of *'Tense Identity'*, the absence of words expressed something more interesting about the dynamism of storying identity. The 'emotional' element is important: the point is that words tend to be good representations of the cognitive, but emotions are less easily language, more identified with expressions of the body/hands/face, e.g. the grimace of disgust etc.

6.4 *'Math Therapy'* reads the body as both a sign of identity and for its dramatic intent

The final claim attends to how film and drama facilitated an examination of the imaginative aspects of storying and reading the body as a sign. This imaginative 'act' of being and acting as some kind of mathematics person, be it the identities which were identified in the literature review –'professional mathematician' or 'Just plain-folks' are bound up with ideas about the gendered and pathologised body of the mathematician. The body as a sign also ties into the discussion in both the literature review and the conceptualisation of identity, whereby the body is a way to story conflict as drama in order to make a particularly entertaining and tellable story. Firstly, this section grounds *'Math Therapy'* in the literature on the mathematical body before moving on to discussing the scene as parody.

6.4.1 Sum body in the literature: The mathematical body as a site of storying

Revisiting the literature about mathematicians as *'sum body'* usefully grounds the *'Math Therapy'* scene in the literature in order to understand 'Story 2', where

the actors draw on the media and common, stereotypical notions of mathematicians as a resource, and site of shared understanding about being mathematical.   In addition, the body is viewed as fundamental to the storying process, whereby the body, read as a sign, becomes integral to the tellability, and dramatic intent, of mathematical identity story. I revisit literature which describess the gendering of the mathematical body, the embodiment of cognition and the dramatic, narrative function of the body. More specifically, how the mathematical body is read as mental illness, as substance misuse and finally, sexualised.

Mathematicians as the mad genius consumed by their subject have long since been ingrained in public consciousness and media (Csicsery, 1993; Doxiadis, 2003; Andreasen, 2014; Gadanidis, 2010; Mendick et al, 2010 p.4). Studies exploring images of mathematicians are overwhelmingly negative, citing how students often rely on these stereotypical images of mathematicians to guide what or who mathematicians are (Rock and Shaw, 2000; Picker and Berry, 2000), whilst the media are implicated as a resource drawn on when imagining images of scientists and mathematicians (Moreau, Mendick and Epstein, 2010 and Allen and Mendick, 2013). Mathematicians depicted in theatre and films are often portrayed for the dramatic elements such as the mathematicians struggle against the mathematical problem, or against personal difficulties and relationships (Csicsery, 1993; Doxiadis, 2003; Gadanidis, 2010; Mendick et al, 2010; Andreasen, 2014; Abbot, 2015). Conflict, as drama, is entertaining, making stories of paradox and dichotomy particularly compelling and tellable and therefore reproducible and durable (Doxiadis, 2003). Mathematicians' lives are read through their mathematics as through it is their identity (Mendick et al, 2010, p.5). Mathematics as obsession alludes to mathematics as a vice, an addiction, which in itself is also a mental illness. What Mendick et al argue as problematic is the mind-body dichotomy, where madness is a way to perpetuate this dichotomy by locating mathematics in the body as a way to contrive mathematics as 'natural ability'.

The naturalisation of a mathematical body also has implications for how the body is read as mathematical and what a mathematical body might be like. The literature (Chapter 2) pointed to an attractive/mathematics dichotomy for both men and women, were mathematicians are most usually portrayed as unattractive, socially inept, and beset by romantic issues. These are media generalisations of course. The media, in a general sexualisation of the body as attractive viewing content, has been a somewhat unlikely ally in the attractive/mathematics dichotomy by depicting mathematical women in TV and film (and in particular the maths quiz show format) as highly attractive and sexualised (Paasonen et al., 2007; Redfern and Aune, 2010; Allen and Mendick, 2013). However, Allen and Mendick (2013) point to the problem of sexualisation where one is known for their body rather than mind and this becomes evident in the 'Math Therapy' scene where the male mathematicians are discussed for their intellectual contribution to the field and the women are discussed for their bodies.

In summation, obsession, addiction and sex are all highly emotive subjects, which speak to human experience and conceiving mathematics and mathematicians in such ways, humanises them somewhat. Additionally, for the media at least, these subjects are also seemingly, and inherently, dramatic. It is not beyond plausibility that the mathematical body receives such unlikely interest because of the dramatic narrative function attributed to it – rightly or wrongly. There are very few occupations which receive such dramatic and media interest. Understanding the dramatic function of the mathematical body, and how it is represented in the media is an important foregrounding for understanding some of the media representations which the actors explicitly draw on, or allude to, in their performance of 'Math Therapy'. However, before some final conclusion of this section, there is some necessary discussion on the way in which these media (or common) notions of mathematicians are represented in this selected scene and how the mathematical body comes together, or can be understood as a site of narrative function.

6.4.2 Parodying sum-body

The scene *'Math Therapy'* is an improvisational parody. Some sense is given here to how I conceptualised parody so as to understand it as a conceptual and also a methodological tool in the drama. I explain my understanding by briefly outlining two selected chapters from the works of Holland, Lachiotte, Skinner and Cain's (1998) *'Figured Worlds',* which is influenced by Bakhtin, Vygotsky and others of a socio-cultural, anthropological and performative persuasion. It is a complex theoretical proposition which suggests cultural production and heuristic development (the facilitation of self-discovery) as intimately tied to identity making. However, this is not to suggest a Figured World's reading of the scene will ensue, but rather to explain how parody might be useful in understanding, and then replaying in drama, the ways in which mathematical bodies can be come to understood, and misunderstood.

Holland et al. outline how parody is a means to ventriloquate actors with the voices of others. Bakhtin's position on ventriloquation and the taking of others words are that it is akin to parody; a dialogical dimension of the relation between one text and another. Parody, taken on by the other can also be a means of dissent, a means to subvert the teller's original meaning. In the quote below, Bahktin explains his understanding of the use of parody and how parody can be meaningful and also superficial.

> "Analogous to parodistic discourse is ironic, or any other double-voiced, use of someone else's words; in those instances too another's discourse is used for conveying aspirations that are hostile to it…one speaker very often literally repeats the statement of the other speaker, investing it with new value and accenting it in his own way–with expressions of doubt, indignation, irony, mockery, ridicule, and the like. … One can parody another person's style as a style; one can parody another's socially typical or individually characterological manner…one can parody merely superficial verbal forms, but one can also parody the very deepest principles governing another's discourse."

> (Bakhtin 1981, p.194)

Parody, as a distinct narrative form, has its own function and purpose to present dissenting voices. Voloshinov articulates how parody has the purpose *"of focusing on the 'referential object of speech, as in ordinary discourse, and simultaneously at a second context"* (Voloshinov, 1986, p. 196); that is the speech refers to wider social discourse. Hutcheon (1989) tells how parody references history and a tension in the changing of old forms of expression, into new; it subverts the iconic. But the second context of parody can also indicate tension and contradiction. Kleberg (1991) elucidates how parody is a way to translate experience which exists simultaneously, where comedy and tragedy, for example, exist "*from the beginning, as two sides of the same coin, as the two aspects of dialogue* (Kleberg, 1991, p. 101). Parody is therefore also a device which is able to drive the narrative of 'conflict' and 'contradiction' as necessary for the tellability of a good mathematical identity story. Parody exemplifies the *"double-voicedness"* (Voloshinov, 1986, p. 197) of speech; the words of the speaker and a reference to wider discourse and speak across time for dramatic effect and to reference tensions. For example, in the literature review, Solomon (2016) presented an interview where her research subject adopted a 'Skaz' voice, dramatically ventriloquating parodied voices of her family members, who were complicit in her identity storying. Whilst revelatory, for understanding how the research subject positions the 'other voices', the skaz or parodic speech was happenstance, whereas drama can purposefully provoke such interactions.

Although, story is not solely a discursive practice and Holland et al go beyond the discursive to consider identity narrative as being bodily performed through "*Dialects, genres, styles of dress, ways of holding and moving the body"* (Holland et al, 1998, p.235). Holland et al present two cases which exemplify how the body can be understood as a cultural artefact which mediates and indexes identities; Alcoholics Anonymous (AA) and Mental Disorder. In '*Math Therapy'*, the actors (through their own design) decided to draw on the context of a self- help group (like the AA) to create a space to talk about mathematics as anxiety making and culturally unpalatable –through the discourse of mental health, addiction and vice. Holland et al.'s exposition of the medicalised view of

addiction as a 'disease', illness or malady made apparent by an observable set of 'deviant' behaviours (Holland et al., 1998, p.69) is a useful comparison to understand the framing of mathematics as addictive, deviant and madness making. Holland et al describe how the psychiatric classification of mental disorder is derived from a phenomenological, descriptive system where disorders are categorised according to observed sets of symptoms or syndromes that are different to what is designated as normal behaviours (Holland, et al., 1998, p.198). Whilst psychology maintains that patients are distinct from their illness, patients are most often identified by their diagnosis and thus for Holland et al, the words of the psychiatrised identifications become semiotic devices. Mathematical addiction is, therefore, indicative of mathematical madness, mathematics becomes embodied, and the body becomes a sign through which personal stories are voiced (Goffman, 1961; Butler, 1990, 1993; Langellier, 1989). In the mathematical identity literature the body is variously discussed as indicating who can be legitimately considered as mathematical such as the female mathematician (Mendick et al, 2008; Betz and Sekaquaptewa, 2012; Herzig and Bowitch, 2012,), race and being mathematical (Katz-Buonincontro and Foster, 2012) and geek identities (Renold, 2001; Csicsery, 2008).

The literature has pointed to how the aesthetic/dramatic performances of mathematics and mathematicians are a powerful resource for mediating mathematical identity. The body, as a sign, can also reference stories of who and what are mathematical, and in that same way, parody can be used as a means of dissent, to reflect another's words and make them ridiculous, or at least critiqued and open for discussion. It is not only words which can be parodied but also the body, and through our gestures, stance and dress etc, we can also take on the words of another. Crucial to the reading of 'Math Therapy' are the body as a site for storying and the body as possessing dramatic intent.

6.4.3 *'Math Therapy'*: Film clip and discussion

The relationship between the body and the actor's performance in *'Math Therapy'* are drawn out in this final section to evidence how the body is read as mathematical and also as a sign; a means of dramatic intention. I closely examine how, through parody, the actors make common stories about mathematics and mathematicians ridiculous; so as to critically question their authority.

'Math Therapy' is the longest whole scene depicted in the film. It was shot without breaks, to account for the observational cinema style for the camera to be guided by the subject. The use of improvisation by the actors meant that the scene had to 'play out' to a point that was a natural end for them. This more naturalistic way of performing meant that the action often dipped in places, but the ebb and flow of the conversations, whilst still dramatic, were less contrived and more realistic. *'Maths Therapy'* is also a move between fact and fiction, offers new routes to exploring self through imaginative practices such as parody and characterisation. Whilst the other scenes have concentrated on one instance, *'Math Therapy'* is a whole longer scene, which, for the purposes of this discussion, I have broken down into smaller scenes, which play on the different kind of therapies the actors parody. The overarching premise of 'Math Therapy' is that of mental wellbeing therapy, which includes addiction as a mental illness. The first scene begins with psychiatry and therapy for *'mental health'*; the following two scenes are related to addiction as mental health and are entitled *'substance abuse'* and *'sex therapy'*

6.4.3.1 *'Math Therapy'* - mental health

The climax of scene 2, and indeed the film, begins with Claire's proposal that the performers improvise a scene about the mathematics anxieties which surfaced in the scripted performances. Below, in clip number 11, Robert becomes a more central character when his personal story about the anxieties of needing to *"get good"* at mathematics caused him some anxiety.

Clip No 11. Performatics: 'Math Therapy' - mental health

Timecode 18m 8s

Rob: Maths anxieties, I have many of them, maths anxieties. [odd walk and voice]

…This is my first time here [high pitched voice, holds head]. Yeah I've been referred by my psychiatrist.

The improvisation was given only a few minutes thought as to a general theme (Maths Therapy). Largely unplanned and unscripted the roots of the performance were laid down in the earlier drama practice sessions where the actors discussed shared feelings of anxiety and identified emerging themes across each other's stories. This developed some ideas about mathematicians as mentally ill and a need for therapy (see Chapter 4). Moreover, the actors did not act out specific memories of experiences with mathematics but more a bricolage of personal and general ideas about mathematics. Whilst the actors played 'themselves', using their own names, and drew on personal experience of mathematics, overall, these were caricatures; in the subjunctive mood, the actors played alternative versions of self. The anxiety theme is brought into the present day rather than recounting specific personal and historical experiences with mathematics. The anxiety theme of mathematical experience is re-visited through 'Maths Therapy', a confessional self help group for mathematicians. Whilst not intentional, the therapy session framed the behaviours and language of the actors around that context and they spoke of mathematics in a therapy 'genre' so-to-speak, as an effective method to parody various mathematics anxieties and stereotypes of mathematicians for their perceived ridiculousness.

Additionally, the therapy session, as a confessional space, spoke to concerns about mathematics as something invisible and an aspect of identity to be kept hidden –shameful.

The scene begins with Rob telling his mathematics anxiety story in the practice 'collection stage' drama session. We then see how this practice session translates into the compilation drama in the theatre space. The therapy begins with therapy for mental wellbeing and the use of psychiatry for overcoming anxiety towards mathematics. Afterwards, the scene moves through substance addiction and then finally sex therapy. The scene unfolds thus.

The opening scene sets out a caricature or stereotype of the 'mad' mathematician, the tortured genius or the idea that you have to be crazy to like mathematics or getting good at mathematics can make you anxious or mad. Rob's strange walk, high pitched voice and head holding is an early indication of how both mental illness/madness and mathematics are regarded as residing within the body as the parodies stereotypical images of the mad mathematician. This embodied aspect of an imaginary, albeit common allusion of a mathematical character is brought to life and made more real and more ridiculous in the dramatic performance, evidencing how parody also includes the body as a system of signs which can be read. The actor's portrayed mathematics as medicalised, psychiatrised mathematicians, as requiring therapy. Earlier in this section, I had addressed the problem of the commonly held view that mathematics is something natural, that mathematical bodies and minds are distinct. Mathematics within the body and mind and mathematicians as a distinct kind of biological entity translates to how mathematicians are construed in the popular media as physically performing themselves in unusual ways. Importantly, the film provided an alternative means to sense mathematical bodies, beyond a simple stereotype, to consider the problem of embodied mathematics, to discredit this account through parody, and instead to show how the body can have a dramatic, narrative function. What this means is that rather than depictions of a pathologised mathematical body being a means

to embody mathematics, the body can be understood instead as a narrative device where we understand mathematicians in terms of the story plot which is contradictory and driven by paradox.

6.4.3.2 'Math Therapy' - substance abuse

In the movement to drug and alcohol therapy, mathematics is framed as an addictive drug, which opens one's eyes to another kind of reality, a different way of seeing things. The language of addiction very clearly frames perceptions that mathematician's lives are lived through mathematics (Mendick et al, 2010).

Clip No 12. Performatics: 'Math Therapy' - substance abuse

Timecode 24m19s

John: Have you tried ignoring it? Living life without maths?

Rob: You can't live life without maths, unfortunately. It's in everything, It's everywhere, you can't get away from it.

Claire: So how do you live a normal life [open arm gesture/questioning]

If you're addicted to maths?

        ...

Claire: [looking to John] So when did your issues with maths begin?

John: I think was whenever I realised that it was everywhere and you couldn't escape it. And I've been trying to escape it ever since.

Claire: So have you found any methods to…keep it in, keep it in check?

John: Well there was the alcohol and the drugs but then I have to go to AA and now   I'm back here…

Rob: Yeah I don't find replacing one addiction with another helps

During this exchange, the three actors remain partially ventriloquated by the social voices that doing mathematics is something to be ashamed of and to distance you from. However, John and Rob are able to see the humour in wider social stories; parodying the notion that mathematicians can only be read through their mathematics (Mendick et al, 2010). The 'abuse' of mathematics is not really troubling for John and Rob. Rather they are presenting a parody of how those with a wider knowledge of mathematics are privileged to be able to see and use mathematics. In contrast, Claire, who has positioned herself as someone not good at mathematics, is limited in her contribution to the improvisation and takes on a facilitating role as a questioner in the confessional of John and Rob. Claire asks many questions such as how John and Rob *"live a normal life?"* and *"when did your issues with maths begin".* Claire re-asserts the mad mathematician idea invoked earlier, whereby mathematicians are 'not normal' in some way. Claire further questions John about his self-control over the mathematics he 'uses'. The addiction metaphor was useful for John and Rob to display their mathematical prowess (voicing all the ways they 'use' mathematics) whilst still holding to the premise that the use of mathematics is somehow undesirable.   This displays a contradictory mathematical identity where mathematics is both within and without the body. Something ingrained in the body and also something you take into the body. However, what Holland et al, (1998) does for this reading, with regard to this seeming duality, is to place mathematics in the body through addiction. That mathematics is an addiction of some sorts, ties in to notions of mental illness and therefore it is still something about the body, an addictive personality, which is aligned to mathematics. The body of the mentally ill or the addict can be subject to descriptive systems which delineate how they look and act.

There are many tensions evident in this exchange and mostly the actors are able to switch between their various mathematical identities with relevant ease, indicating how switches in mathematical identity can be somewhat perfunctory, the switch in identity does a job of being a certain person in a certain context and that this is and not always necessarily difficult work of the act is to parody. Parody, it seems, comes easier to the actors than re-imagining their own experiences. When the actors are critiquing common stories about them (as mathematicians) their storying flows more freely. The methodology claimed that drama can assuage difficulties with self-reflection. However, it was the act of improvisation, which doesn't allow the same space for reflection, where the actor's engaged more freely in the drama. Freed from self-reflection the actors became less hung up on performing some sort of authentic story. With limited pause-for- thought I suggest that in improvisation expressions of intuitions are not filtered by reflection and that some portrayals maybe express emotional content and, even prejudice, that a more thoughtfully reflective production would have filtered out (e.g. the expression of a Tourette's syndrome type of mathematical-expletives as a symptom of madness). It could be claimed that the improvisation is more authentic because the actors are not participating in the same kind of filtering and censorship which was evident in the scripted drama, tailoring their stories to suit some form of audience and to make sense to each other. In the improvisational parody the actors 'act out', although drawing on wider social and media stories of mathematics and mathematicians, act out much more through their own frame of reference rather than getting hung up, or frustrated in creating some form of an authentic and understandable story.

6.4.3.3 'Math therapy' –sex therapy

The final 'vice' for the Math therapy group is sex therapy. Sex becomes a metaphor within a comic framing of innuendo and double entendre to enlighten the gendering of being mathematical. Rather than play down issues about the gendering of mathematical identity, this discussion highlights how the frivolity of innuendo and double entendre quite powerfully draws attention to these

difficulties with uneasy parallels between the actors' personal experiences and wider societal stories about the gendering of mathematics.

This section begins with double entendre in an exchange about the use of mathematical tools and moves on to discussing the attractiveness of the female presenter of the TV mathematical quiz show 'Countdown'. The accompanying text is selected from an exchange which takes place over the course of a few minutes but is distilled here for the purposes of exploring the scene. The scene can be viewed in its entirety via the film link attached in this thesis, at the timecode indicated.

Clip No 13. Performatics: 'Math Therapy' - sex therapy

Timecode 25m50s

Claire: [whispering] Do you ever use a calculator?

John: [long pause, furtive glances to each side] Do you want me to get it out?

Rob: [excited voice, smiling] Yeah show us your calculator.

Group: laughs...

John: It's quite big!

Claire: I imagine it would be!...

Claire: Who's your favourite mathematician?,

Claire: I'm more of a Carol Vorderman person myself

John: Her replacements pretty good

Rob: I like Rachel Riley's legs I have to say

Claire: Well she has two of them

John: Two is about as much as I can handle

The scene has many layers, but first and foremost, conversations of a sexual nature are more often judged as salacious and scandalous. And so the scene is foreground in the scandal of sexual inequality in mathematics education.

To begin, the calculator is inferred, indirectly through jeers, glances and laughter, as a phallic symbol; a rude, salacious joke that the group begin to laugh along with. It is common for comical effect or derision to make these sexual innuendos between prized objects or belongings as a symbolic extension or expression of manhood and male sexuality. Parody quite often draws on these absurd or comical notions. The group join in the innuendo asking to *"show us your calculator", "it's quite big"* and the body language of laughs, smiles, knowing glances draws the performers and audience deeper into the joke, deeper into the scandal. The irony of this joke is that whilst the performers parody mathematics as something as sexy and desirable, mathematics is very rarely discussed in this way, as desired or an attractive proposition. Mathematics is more usually viewed as perfunctory, for its use and exchange value (Williams, 2012) rather than for any love of mathematics (Davis, 2008). There is rarely a romance story to be told.

However, at this historical point, sexual desirability is entering the public consciousness as a way to engage women in mathematics and also into popular culture as the popular media increasingly look to attractive viewing content. The actors are portraying these sexual innuendos when the zeitgeist of 'geek chic' is very much of the moment. The stereotypical image of the old mathematician in glasses, with poor dress sense and a lab coat or the 'mad', physical tick, kind of mathematician discussed earlier, are being joined by their

antithesis of impossibly attractive men and women. Suddenly the arena of the various, competing, and often contradictory mathematical identities are becoming increasingly densely populated. Whilst there may be some attempts by broadcasting to resolve a perceived mathematics and femininity dichotomy (Archer, et al., 2013; Macdonald, 2014) the performance intimates how female mathematicians might be objectified for their bodies rather than appreciated for their mathematical ability. It seems that women in mathematics might be more palatable to other women and men and mathematics might be more desirable if more attractive women did mathematics.

I would argue that discussions about mathematics and sex would not usually be the stuff of research interview, and only in a dramatic piece, with the proclivity towards fiction and fancy could such conversations be had in this parodic way. What Abbott (2005) claimed (see Chapter 2) was that mathematics and theatre both have grand human narratives in mind (life, death, sex), and indeed Abbott draws on a scene from the play 'Arcadia', and the comparison between mathematical and human procreation to elucidate his point. Because mathematics and the male body have been conflated it makes sense to ascribe and make fun of mathematical objects and tools as if they were male members, with which to go forth and procreate - mathematically. What the drama does is to distil, quite succinctly, the gender conversation and in trivialising it, making it ridiculous and scandalous (through sexual innuendo), a means to democratically, through the media and drama, address inequality in mathematics education and through the film, put mathematical education research into conversation with, and influence storylines about, mathematics education alongside the media, who Herbel-Eisenmann et al. (2016) attest are key influencers of mathematics education.

6.4.4 *'Math Therapy'* conclusion

In conclusion, dramatic parody is an aesthetic way of knowing; a powerful means to understand the body as a site of narrating mathematical identity. It is not beyond imagination to suggest that in an interview situation that research

subjects would begin, without provocation, to make such elusions between mathematics, mental illness, substance misuse and sex. However, theatrical wisdom has it that mathematics and theatre are both concerned with grand narratives of life and death and therefore mathematics as vice humanise the actor's experience.

The use of ethnofiction, playing oneself as a fictional caricature in the parody of *'Math Therapy'*, was a means to directly position the personal experiences of the actors amongst the social stories of what it means to be mathematical. *'Math Therapy'* contributes new knowledge on how anxious mathematical identities are mediated by reading the body as a sign. Where cultural production and heuristic development (the facilitation of self-discovery) is intimately tied to identity, signalling what can legitimately be voiced about the body's mathematical potential. Phenomenological descriptive systems where disorders are categorised according to observed sets of symptoms or syndromes that are different to what is designated as normal behaviour become semiotic devices (Holland et al., 1998, p.198). Being mathematical has been played out in *'Math Therapy'* as indicative of mathematical madness. As such the problematic nature of embodied mathematics is addressed through reading the body for a dramatic purpose – as a site for entertainingly tellable stories about mathematics. The therapy setting became a performative convention for the way mathematics is still considered as something problematic. In using this convention of medicalised madness in an Addiction Therapy setting akin to Alcoholics Anonymous the performers are in almost a confessional space and the drama shifts to almost parodying itself m where the drama also becomes therapeutic. Whilst not intended to be drama therapy the methods of using drama in research in this sense facilitated the actors to 'exercise' feelings about wider societal and cultural attitudes towards mathematical ability and negative associations of the genius/madness dichotomy discussed in the literature (Moreau, Mendick and Epstein, 2010; Epstein, Mendick and Moreau, 2013).

Where the actors brought their experiences into the present day, rather than looking back at past experience, an increasingly dichotomous vision of mathematicians arises. The introduction of sexualised mathematics (attractive mathematicians and geek chic) enters the already overpopulated arena of visions of mathematicians. How all these competing notions of mathematics stand together in one coherent whole can be explained by the narrative function of what makes a good mathematics identity story. A good mathematics identity story is in contradiction. If we allow contradiction as the narrative driver for mathematical identity then we live with a tension and difficulty of what it actually means to be mathematical. Representations of mathematicians are so contrary and over populated as to make the notion of 'mathematician' schizophrenic, constituted by contradictory and competing entities. There is little wonder why anxious or tense mathematical identities emerge as a result. Rather than provide any solutions to this identity problem, the film has illuminated the contradiction by caricaturing mathematicians in parody. The function of drama as pretence makes explicit the narrative function of the body, as a site for drama and tension. In viewing the mathematician as a character, some perspective is gained and the issues of the disparity of vision of what mathematics is and who mathematicians are (Brown et al., 2016) helps us to understand some of how this disparity might have come about by illuminating the mathematical body as a site for dramatic narrative, which can be problematic for identity making. If one positions them self in relation to competing and often contradictory images of what a mathematician is or could be – mathematics for somebody (a critique levelled at the framing mathematics for STEM careers)[39], mathematics for everybody remains difficult to imagine.

What I am claiming has been done by this scene, and how it contributes towards the thesis and its significance, is that a very different, improvised,

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[39] Herbel-Eisenmann et al. (2016) comment that the influential storyline ' mathematics is for producing a STEM workforce' can be counterproductive to engagement in mathematics education when the goals of economics can be in tension with the goals of education; particularly mathematics as status and aiding social mobility, through employment in contrast to a democratic equitable goal of collective benefits of education.

subversive, take on mathematical stereotypes potentially challenges them. What we know of stereotypes is that they serve to story identity. What the parody made more evident is the way those stereotypes mediate identity, by conceiving the body as a site of dramatic intent. The mathematical body, as depicted in popular media images depict mathematics as embodied, for certain kinds of people. In parodying those accounts we come to see the body for its dramatic intent, a site of drama, and an interesting tale. The pathologisation of the body, which makes it for certain kinds of people, becomes ridiculous and we see the mathematical body for what it is - an entertaining story. The function of parody in theatre, as a potentially creative and subversive medium, shows that once we can understand that the body has a dramatic and entertaining intent, we can begin to separate the fact from the fantasy.

6.5 The final curtain or a franchise?

This conclusion is the final curtain of this thesis and I synthesise the value of '*Performatics*', and filmed-drama research methodology, as useful to mathematical identity research and educational research more widely. I detail what '*Performatics*' can bring to mathematical identity research, limitations of the study and some implications for further research (where ABR filmed-drama could take research next, to move the field forwards).

6.5.1 How *'Performatics'* moves the field of mathematical identity research

This chapter put '*Performatics*' into conversation with the literature review, conceptualisation of identity and the methodology to discuss the value of the film as research. The chapter was structured around three claims that '*Performatics*' has allowed us to sense mathematical identity differently to written research texts. Through the actor's expression of emotions and the brining into the open how the actors imagined their past experiences with mathematics the dynamism, complexity and affective properties of storying (including oral and embodied/enacted story –including silences and in-action) became more apparent. I concur with Darragh's (2016) proposition that performance approaches to mathematical identity research can offer some

conceptual coherence by attending to the range of phenomena which constitute identity; thus accounting for, and embracing, the approaches already existing in the literature. I argue that through ABR mathematical identity reveals features that may include a wider grasp of emotions and cultural semiotics. Emotions were linked to the affective property of storying the self through past memory, whereby the memory can often be felt and rather than orally expressed. That film allowed an exploration of the dynamism of storying identity. We came to know the collective endeavour of storying which slipped between the tensions of authoring a story which is both authentic yet draws on some shared understanding of what makes a tellable mathematical identity story. In this dynamic the film was able to explore what was not said, as much as what was said. In this way, the film could give gravitas to silence and inaction, which is arguably more difficult to pay attention to in writing –which demands words.

There are features of dramatic and filmic research methodology which facilitated the exploration of intangible, inner aspect of identity. More usually in ethnofiction, the drama is incorporated into the film more seamlessly so that the audience cannot distinguish between fact and fiction. I purposefully brought together the testimony, observation and drama in order to learn about identity at the intersect between fact and fiction. The dialogic filmmaking principles of Jean Rouch positioned the film as useful to understanding human lives in a social context but also that life, as it really is, must also include one's own dreams and imaginations. The film gives an 'eye' into the imagination that human experience can't always see (Vertov, 1984), to get deeper into how cultural ideas embed into the person and how the person then expresses those ideas. Additionally, the eye of imagination captures embodied aspects of mathematical identity performance missing from textual accounts; emotions, thoughts, feelings and the sensing of mathematical identity as embodied and bodily performed.

Finally, 'aesthetic knowing' is contributed to mathematical identity research as productive for generating and knowing alternative senses of mathematical

identity. 'Aesthetic knowing' was evidenced for its two understandings. Firstly, an in-the-moment, perceiving, feeling, sensing of a situation in constructing the drama. secondly, 'aesthetic knowing' through beauty using Arts Based Research (Levy, 2015); where '*Performatics*' explored embodied aspects of mathematical identity more difficult to capture in purely verbal or written accounts such as bodily gestures, memory, inner speech, imagination, thoughts and feelings. Through the filmed drama the actors became aesthetic objects, their lives interpreted through their performance on film and the audience were drawn into a visceral experience, invited to make sense of and provoked into thinking about mathematical identity. What these contributions bring to mathematical identity research are methodological, theoretical and practice based. I have summarised the contributions below, with some commentary on how the field could move forward: drama as useful for investigating identity and emotions; ABR as useful to exploring past experience; film as a means to research and represent the richness of identity as story; the potential of mathematics drama pedagogy*; 'Performatics'* as a provocation for mathematics educators to explore the emotionality of learning mathematics, from teacher and student perspectives and influencing the storylines of mathematics education.

6.5.1.1 Drama as useful for investigating identity and emotions

I suggest drama is a useful means to investigate identity and emotions. The dramatic process of aesthetic knowing became a means to locate mathematical identity in relation to mathematics anxiety. Since it has been claimed that most mathematical identity research has been *"quite detached from studies dealing with emotions (e.g., mathematics anxiety), attitudes or beliefs"* (Heyd-Metzuyanim, et al., 2016, p.25). '*Performatics*' can be claimed as a novel study examining the intersection of these related concepts. I suggested *'Tense Identity'* as a new definition of mathematical identity which could be productive for understanding identity storying 'in action' as a tense experience, and therefore closely related to the concept of anxiety. The drama research method of 'Playbuilding' could prove particularly productive for mathematical identity and mathematics education research because as it stands identity is more

usually researched in a qualitative paradigm and mathematics anxiety in a quantitative paradigm. The structure of 'Playbuilding' allows a systematic approach to the study of the inter-relationship between identity, anxiety and tension, which begins from the perspective of the research subjects. *'Performatics'* is a qualitative study with a systematic approach.

6.5.1.2 ABR as useful to exploring past experience

The many positions, voices, and responses evident in the actor's identity in practice revealed a *'modulating identity'*; an identity in flux. Uncovered were the actor's often contradictory mathematical identity which oscillated between ambivalence, anxiety and joy as their stories were mediated in response to the stories of others (including their past selves). Memory and imagination became integral to an aesthetic knowing of mathematical identity. Stories grounded in the actor's memory and imagination was successfully represented in the filmed drama because the filmed drama was able to represent visual aspects of the actors' identity story. Additionally, phenomenological descriptive systems, which narrated and mediated mathematical identity in relation to common stories about mathematicians and mathematical bodies, elucidated how the body can be read as a sign of identity. Through the body, parallels were drawn between mathematics and mental health and specifically anxiety, madness and addiction.   The body in its physical and psychic form is read as a sign of mathematical identity through the film, conveying the subjects lived experience (including imagination). Ethnofiction or ethnodrama as ethno-mimesis plays to an audience to provoke thinking at an individual, group and societal level in order to *"undercut identity/identitarian thinking and in the process facilitate a space for the viewers to approach a genuinely felt involvement (see Nicholsen, 1993: 12) which demands critical reflection"* (O'Neil, et al., 2002, p.84-85). Whilst critics declare that narrative research panders to the dramatic, the dramatic becomes a lens to consider how dramatic narrative constructs (such as drama, dichotomy and paradox) are fundamental to the storying of identity. The affective property of story becomes more evident. The literature review (Chapter 2) revealed how mathematical identity research of a narrative persuasion loos to the subject's stories for indications of identity. However,

there is some critique of looking towards social influences, for example, concentrating on gender and stereotypes in mathematics anxiety research (Dowker et al, 2016). '*Performatics*' considers social stories and influences in concert with the influence of narrative –what makes a good story; potentially revealing something new about identity.

6.5.1.3 Film as a means to research and represent the richness of identity as story

Increasingly, new, experimental forms of narrative are seeking ever more expressive ways to represent the lived experience of the research subject, from monologue to experimental and fictional texts. The richness of such data can be constrained by words. Film is no panacea and is subject to the same constraints of being bound by its limits (word count or duration). However, film is a more judicious means to represent the richness of narrative research which can be expeditiously presented in or through the use of cutting together scenes and overdubbing action with dialogue. I encourage researchers of mathematical identity to consider film as research. In addition, film and drama can be considered an equitable research method, unconstrained by the word. When words escape the research subject, or the subject finds difficultly in verbally expressing themselves, you can find an alternative means of expression through drama and film. Drama and visual methods are, therefore, another way of enriching narrative research when words limit expression. For this reason drama and visual methods could be especially productive for researching with children, young people and any other group for whom verbal communication presents some difficulties.

6.5.1.4 The potential of mathematics drama pedagogy

The intention of this research was not to specifically address mathematics pedagogy. However, drama is increasingly being adopted in mathematics education as a means of instruction or expression of mathematical thinking. Drama may, therefore, be productive for cognitive development and as a means to 'come unstuck' from stories about, or feelings the students may have about difficulties with being mathematical. Whilst the research was not a traditional

psycho-socio drama, these techniques could be useful in the classroom for students to express their feelings about their mathematical learning. As was made evident in the methodology, self-reflection is a difficult process and concretising reflective practice through methods such as drama can assist this process. Drama, therefore, has a secondary application in pedagogy, as metacognition. Metacognition has been reported as having a strong evidence base for improving student attainment (EEF, 2016).

6.5.1.5 'Performatics' as a provocation for mathematics educators to explore the emotionality of learning mathematics: from teacher and student perspectives

An additional implication of the study could be using the film within teacher education courses. For example, Boylan's (2009) employ of drama as a means for university lecturers to put themselves into the shoes of their students, to reflect on how those students might think or feel as they undertake their studies. 'Performatics' could prompt a similar reflection for lecturers and teachers to promote the development of empathy and to draw their attention to student's negative emotions, which may not be immediately evident to, or are overlooked by, their teachers (Bibby, 2007); such as a student's sense of shame (Bibby, 2002) from being 'critiqued' in the classroom (Boaler, et al., 2000). Moreover, the film could assist teacher's to reflect on their own emotional responses and anxieties to mathematics, like Claire and Rob, who reflected on their anxieties as they developed their own teaching practice. This could be useful for new teachers and particularly some primary teachers, who the literature identify as often being disaffected from mathematics, which could prompt some maths anxiety.

6.5.1.6 Influencing the storylines of mathematics education

Finally, Herbel-Eisenmann et al. (2016) comment that influences on mathematics education are outside of the realm of mathematics education researchers. To remedy this they suggest they call for new forms of wider engagement through the media. '*Performatics*', as a media artefact, intends to provoke a wider debate about mathematics education and mathematical

identity. The film has been circulated via Vimeo (an online film platform), Facebook and Twitter. So far it has been estimated (through social media statistics provided by the various site hosts and conference attendee numbers) that the film has engaged a varied audience of approximately 300 academics, policy makers, educators, employers and members of the general public. As academics, finding new ways to engage and disseminate research is important if we are to move with technological advances of how knowledge is produced and disseminated and also to enliven the academic debate by speaking to a wider audience. As Gerofsky put it earlier in the literature review,

> "As our everyday society becomes a culture of collaborative makers and players rather than passive consumers and audiences, the Modernist separations (high from low culture, mathematics and science from arts and humanities, expert performers from reverent audiences) can no longer hold. As performance (both live and digital) becomes a predominant mode of being and communication for everyone, performance takes on a far more democratic, empowering and playful character. If everyone can take on the roles of actor, spectator, producer and critic in quick succession, then everyone is involved, actively and in-depth."

> (Gerofsky, 2010, p.8)

Performance offers a democratic possibility to make new meaning and images of mathematics.

6.5.2 Limitations of the study and recommendations for future research.

Limitations of the study are discussed in relation to the impact that access difficulties had on gathering observational data, how this limitation ultimately shaped the final thesis and, therefore, what could then be said about mathematical identity. Throughout this discussion, the limitations of the study are countered with ways further research may assuage any difficulties, as well as take up further opportunities from undertaking ABR.

The ethnographic aspect of observational cinema, where the filmmaker captures the actors' in social action (undertaking a mathematical activity), was the most difficult aspect of the filming. Access to filming was denied in some areas of the University. Access difficulties meant that the observational aspect of the film was less developed than the drama and this limited the study somewhat. The difficulty with access was frustrating because the observations and testimony were more productive in eliciting alternative stories to the dismal, anxious mathematical identity. Acts of 'romance' rather than 'tragedy' emerged in this observational data. This was particularly evident in John and Rob's talk about, and demonstration of, connections between mathematics and music, mathematical puzzles and how mathematics was an enjoyable hobby. Even Claire and Maddy unwittingly enjoyed using mathematics in everyday life (in drama and even when shopping etc). These observational stories were embodied in the actions of the actor as they undertook mathematics as part of their everyday life and university studies. In this space, the actors reflected on their mathematical practice in the present and divulged a very different mathematical identity to the biographical stories of past experience which were performed in the drama. Through reflection on these activities, the actors related how mathematics, for them, was enjoyable and something which enhanced their pleasure. This was particularly true of the artistic nature of mathematics which began to resonate with the artistic endeavour of the Arts Based Research.

Focussing on observations, in the present, is a potential means to generate alternative stories of mathematical identity which are different to the default mathematics anxious school story. Bringing research into the present has implications beyond mathematical identity work because observations happen in real time, giving a sense of how things are for the research subject in the here and now. When we ask research subjects to share an experience we are already asking them to share a past moment, whether that moment was five minutes ago or five years ago, or further. They take the subjunctive form. The research subject would find it very difficult to frame an experience in the present sense - what I am doing now because they need to reflect and process that

experience. As we have learnt through the film, and through the conceptualisation of identity, identity is in a constant state of flux, so researching identity- in the moment, can be a productive way to uncover new meanings, before a layer of reflection has filtered them.

The testimony and observational footage became a useful counterpoint to the stories told in the drama, evidencing identities in flux, between the dismal, anxious mathematical identity storied through past experience to the pleasure of performing a mathematical activity in everyday practice. However, the thesis is bound somewhat by the word allowance so these contradictions did not have the space to be explored in the written account. The focus of the written thesis was narrowed to concentrate on the intersection between personal and social stories of mathematics and therefore on the drama as a means to explore the actor's identity in relation to the more usual dismal stories about mathematics so as to question why this story is so easily narratable. Whilst on the surface the narrow focusing in of the written thesis may appear a limitation of the study it also affords opportunity to: (i) appreciate the film as an academic text in its own right and not to undermine its importance by reducing the film to a written description; and (ii) the rich data the film gathered affords opportunity for many readings of the film text and many possibilities for analysing identity by focusing on different aspects of the filmed data. There is an opportunity to work the filmed data in many different ways and to focus on different aspects. Moreover, there is an opportunity to exploit the observational cinema approach to get to know the individual through the social (and vice versa) by concentrating on fewer research subjects, to explore individuals in their surroundings, rather than when engaged in contrivances such as drama (although drama was useful to this particular study). In looking for dismal common stories, that is what was uncovered. When the actors were engaged in testimony, with me as a researcher who has an interest in mathematics, their more positive, mathematical romance stories came to the fore. When editing the film it was the positive stories that captured my imagination and said something beyond the usual. For this reason, these positive stories were heavily represented in the film as counterpoints to the dismal social stories and as an indication of how,

when focusing on one aspect of a research question, you may (intentionally, or unintentionally) close yourself off to other more interesting possibilities.

Heyd-Metzuyamin, (2016) identify that most studies on identity are framed by socio-cultural theories and that psychological studies have been less important. Similar was found in the literature review (Chapter 2). However, the literature did point to a move towards a broader conceptualisation and investigation of identity as psycho socially and culturally produced. The drama was design to attend to this broader conceptualisation of identity and guided by dismal stories of mathematical identity. As such the drama was constructed by the actors to attend to the affective properties of identity, which the actors framed as 'shared feelings'. The issue of emotions emerged from the drama and the phenomenological approach of exploring identity through the actors' lived experience. The drama evoked and portrayed such emotions but the actors still experienced some issues with recalling past memory. Whilst this research explored emotions in relation to mathematical identity the intention was to show the affective property of the storying process. This could be considered a shallow approach to emotions. Exploring emotions, through psychodrama as therapeutic could offer a fuller account of the actors' emotions but it could be considered unethical to record such deep explorations for a general viewing public. Should a traditional psychodrama approach be adopted, it may only be ethically possible to use film within the therapy for the sole use of the actors to reflect, rather than use film as a research process.

Finally, *'Performatics'* does not make discussion of existing literature, the conceptual framing of identity, and the methodological debate explicit. However, it is constructed in reference to these things. The cinematic approach to observational cinema does not usually adopt, or condone providing, some sort of meta-narrative through voiceover or subtitles. Therefore the film may be considered limited because no grand narrative is provided; it is for the audience to make sense of the data. It is, therefore, important that a written thesis accompanies the film, and as a filmmaker, this left an uneasy sense of the

writing undermining the intention of the film. There is an uncomfortable compromise to be made between the ABR and written thesis; I cannot say everything I want to about the film in the writing and the film cannot say everything I need to on screen. Whilst this is true of much ethnographic research, it is uncommon to provide anything beyond the transcription of the data and the researcher's interpretation of that data, in more traditional research. As a filmmaker you are often providing more detail, more data than you have words to convey and this is a limit and a risk. By putting the data out there, on screen, inviting provocation and open-ended discussion without a meta-narrative; you are inviting many alternative interpretations. And whilst this may be the intended purpose it is risky none the less. However, it is a risk with rewards as these possible alternative interpretations are other ways to know the data, to triangulate meaning and provide rigour and validity.

The film offers the opportunity to undertake further work on the data, to explore the observational and testimony footage in more depth. A proposal for a paper in the special edition of '*The Disorder of Mathematics Education: Challenging the Socio-Political Dimensions of Research'* has been accepted. This paper will focus on the parody of 'Math Therapy' and how this section of the drama relates to the observational and testimony footage. Further, as a Research Associate on the British Academy review of mathematics anxiety research, I intend to explore how emotions and mathematical identity, particularly *'tense identity'*, have been researched in respect to mathematics anxiety and how ABR might have been used in that respect.

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Appendicies

Appendix 1. Participant Information Sheet

You are being invited to take part in a research study as part of my PhD. Before you decide to participate it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this

Title of Research: 'Perform-atics': A digital video ethnography of ways University students perform their mathematical identity.

Researcher: Kelly Pickard-Smith. Manchester Institute of Education. University of Manchester.

Research aim: To use dramatic performance as a means for participants to reflect on their mathematical identity.

Why have I been chosen? You have been chosen because as a University student you will be engaging with and reflecting on your own learning and would be expected to reflect in similar ways on your experiences, thoughts and feelings about mathematics.

If you take part you will be: Videoed conducting the following activities: All dates, times and durations are flexible to be arranged with the participants.

Being observed in your usual daily activities at University of Manchester. Approximately 2 hours but flexible to student availability.

Give a 'testimony' of your mathematics experiences, thoughts and feelings about mathematics and the research project at various relevant points in the research

Participate in drama sessions with the other participants enacting stories/events about your mathematics learning/experiences with at least 2 other students from your course.

Review edited data from interview, observation and drama with an audience (of your choosing) to make comment on how you felt the process went and any other observations you have.

What happens to the data collected?

Data is used in 3 key ways. (1) In a PhD Thesis; (2) For academic review as journal articles and conference presentations; and (3) An ethnographic film (made publically available with your permission).

All data will be video recorded, edited as a film and downloaded to disc. Through this process the technical crew (University of Manchester affiliates) and my Supervisory team of Pauline Prevett, Julian Williams and Michael O'Donoghue will review the data in my company.

With your permission (via a signed video release form) the final documentary will be publically available as a DVD and/or downloaded to streaming service e.g. Youtube, researcher blog and as a disc and video stills to be examined with the written Thesis.

You will have the following opportunities to review the data (3 of which opportunities will also be videoed to form part of the film and Thesis). Reviewing the data helps to reflect on mathematical identity and assist your decisions about what data can (1) be used for the PhD thesis and academic articles/conferences and (2) enter the public realm,

Observation and initial testimony reviewed in the first and subsequent drama sessions as provocations for the drama.

Observation, initial testimony and drama data reviewed together in final testimony.

First rush (edit) of the film containing the observation, interviews, drama and data reviews showcased to the cast for comment. **This screening is not recorded. It is a closed screening where a mutual confidentiality agreement is signed agreeing that data and individual contributions will not be talked about or data taken away from the session and shown or discussed with outside sources.**

Final (edit) reviewed with the cast and invited audience of your choice (which may just be the cast) but is hoped might include your colleagues, course lead, other academics, family, friends, students? Written comments made about the film will be collected.

* At any point in the research I can arrange to review your data with you to change, edit or delete at your request. After 'first rush' a waiting period of 2 weeks gives you time to decide if data can be used or amended before a hard copy is produced for dissemination. Data can be removed or amended in the following ways:

-Removal/deletion of that section or all of the data.

- Removal/deletion of that section or all of the data but retaining the right to use the data as anonymous quotes in the PhD thesis and any academic articles and conference material resulting from the thesis.

-Pixilation of the face/voice modification.

How is confidentiality maintained? See above section.

Additionally, data not used in the documentary will be secured on disc and not released. I reserve the right to use this remaining data in the PhD thesis and in academic articles in the form of anonymous written quotes.

What happens if I do not want to take part or if I change my mind?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time without giving a reason.

For your participation

Reasonable expenses for any travel to the Drama venue (if this is outside of your normal University attendance).

Water available in drama sessions. For any lunchtime sessions sandwiches are provided.

Final screening reception with small buffet/refreshments.

Contribution to academic knowledge on how mathematical identities are shaped.

You may experience benefits to your own learning and understanding about mathematics from thinking about and reflecting on your own and others ways of thinking, feeling and doing mathematics.

What is the duration of the research? The research is conducted throughout the duration of one academic year from October 2014 until June 2015. Observation, testimonies, drama sessions and screenings arranged at times convenient to the group. Final screening will be shortly after your course finishes.

Where will the research be conducted? University of Manchester.

Will the outcomes of the research be published? Research will be used for a PhD Thesis, journal articles, conference presentations and posters and DVD/download.

Criminal Records Check (if applicable) N/A

Contact for further information and to confirm participation: Kelly Pickard-Smith. PhD student Office. Ellen Wilkinson Building. University of Manchester, Oxford Rod, Manchester. Email: Kelly.pickard-smith@postgrad.manchester.ac.uk

What if something goes wrong?

It is unlikely that you will feel any harm from participating in this research. You may recall negative memories/feelings about your past experiences with mathematics or an altering in your mathematical identity in some way but this risk is expected to be low. You may feel harm from being filmed that have been covered in data confidentiality. In the unlikely event that you will feel harm may I refer you to your course lead responsible for student welfare or University of Manchester Counselling services and careers guidance officers who can offer independent advice/support.

If there are any issues regarding this research that you would prefer not to discuss with members of the research team, please contact the Research Practice and Governance Co-ordinator by either writing to 'The Research Practice and Governance Co-ordinator, Research Office, Christie Building, The University of Manchester, Oxford Road, Manchester M13 9PL', by emailing: Research-Governance@manchester.ac.uk, or by telephoning 0161 275 7583 or 275 8093.

Appendix 2 Consent Form

'Perform-atics': A digital video ethnography of ways University students perform their mathematical identity.

CONSENT FORM

If you are happy to participate please complete and sign the consent form below

Please
Initial Box

I confirm that I have read the attached information sheet on the above study and have had the opportunity to consider the information and ask questions and had these answered satisfactorily.

I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving a reason and that there are various levels of participation that I can agree to if I wish as an alternative to full withdrawal.

I understand that I will be recorded using digital video for a final film to be publically available and will sign a Video release form.

I agree to the use of quotes from the data that can be anonymous at my request.

I agree that any data collected may used for the purposes outlined in the Participant information sheet.

I agree to take part in the above project

Name of participant	Date	Signature

Name of person taking consent	Date	Signature

Appendix 3 PhD Technical set up: Notes for video recording of PhD data collection.

Event date: TBC. Sessions to take place over the period OCT 14 – JAN 15

Location: University of Manchester. Room TBC

Rehearsal: TBA, provisional schedule in section 6.

1. General.

This filming schedule is for the purpose of capturing digital video data of a PhD study. The digital video will record a group of approximately 3-5 students performing a drama piece about their thought/feelings/experiences of mathematics teaching and learning over a number of sessions. Number of sessions TBC dependent upon student timetable but are expected to be 3 sessions in total (this is to be arranged with participants after recruitment and dates set in the diary to give adequate notice to the technical crew. Each session will be no longer than 3hrs duration.   This is a closed session attended only by the invited research participants and will be filmed in a suitable room (TBA when dates are set) in the University of Manchester.

On the day pre-recorded video of these students testimonies and observations will be played back to them at the start of the session as video clips via a large screen as provocations to initiate a drama piece. On each session a student will be put forward as a 'focus student' whose story will be enacted by themselves and the rest of the group.

The sessions will be recorded and later edited, with testimony and observation footage into an ethnographic film. Recording the sessions are a single camera set up requiring a sound recording assistant.

Camera - Kelly Pickard-Smith (Researcher)

An additional video and audio source for playback to the session room will be a computer hosting the video recorded testimonies/observations. These will be played by the researcher KPS.

Rehearsal of positions, framing and cueing is required and this is expected to take place on the afternoon prior to the event.

2. Equipment:

MIE   1   x   JVC   camera   kits   and   tripod
MIE 1 x Sennheiser tie clip microphones & receivers (incl. in JVC camera kits)

Room with a whiteboard and PC deck to be available.

Audio mixer (MIE source).

Computer / Tablet with individual pre-recorded video footage.

Cabling as appropriate.

3. Allocation (provisional):

Production coordinator and Camera operator – Kelly Pickard-Smith (PhD researcher)

Sound recordist (University of Manchester affiliate to be recruited such as MIE Technician Peter Leigh)

Computer video source – Kelly Pickard-Smith

4. Preparation schedule:
Room set-up review: Date TBA

Production team meeting time: Time and location TBA
Rehearsal and MM set-up schedule: details to follow.

Figure 2 - Camera positions & allocation

5. Suggested/ Approximate framing:

Testimony – 3 shots:

Wide – whole body and environment

 Medium head and shoulder

Class observations and drama (process shots) 3 shots. 'Triangle of activity'

Wide –whole environment

Medium **–** closer to the person, into the process

Close – into the action and details of the process e.g. hands, facial expressions, tools used.

6. Schedule – Date/time and location TBC with participants.

Production team meeting

Preparation / planning / schedule review;
review recorded data for provocations

7. Planning notes:

I will arrange for the room to be accessed prior to session start time on the day.

KPS will be moving around the action.

Video recorded testimony and observation will have previously been offered to be previewed before showing in the session.

The video recorded testimony and observations will be reviewed for 15 minutes maximum.

Video/audio from the pre-recorded and edited testimony and observations shown on a whiteboard screen with pc station and loaded up by KPS prior to the start of the session.

KPS will ensure the whiteboard and pc has an adequate power supply and that the clips are available to play easily from a folder or from the desk-top.

In case computer breakdown, a second computer (laptop) will be prepared with the video clips.

Camera operators should note that all action in the session is to be recorded, e.g. on stage enactments, prior discussions, any other discussion outside of the drama but occurring in the room at the time of the session.

Camera operators to use agreed subject framings as described.

The session recording should commence at least 30s before and continue for at least 30s after the end of the session - this is for editing purposes.

Talkback is not available (unless we can access a studio) - camera and sound operators to agree start/stop etc signals for the recording.

Camera and sound operators to check adequate power supply (mains or battery) and sufficient recording time on the capture cards. During recording cameras should operate from battery rather than mains supply where possible.

In the event of a main camera failure (CAM 1 or 3), a replace camera will be available.

CF cards from cameras are kept by KPS at the end of the events.

After the session equipment needs to be checked and packed-up for return to the Ellen Wilkinson Building (EWB).

Pre-recorded data are available for preview by KPS and PGCE's. These will be available via appointment between KPS and PGCE's. Data will be refined/enhanced in pre-session processing.

Lighting will be room based (natural) for the session, unless a studio is available.

Appendix 4 Visual Release form

<u>Audio Visual Release Form</u>

I consent and agree that Kelly Pickard-Smith as a researcher at the *University of Manchester* has the right to take photographs and record audio/video of me (and/or my property) and to use these in the ways outlined in the Participant Information sheet, knowing this data can be kept for a period of 5 years.

I do hereby release all rights to Kelly Pickard-Smith and the *University of Manchester* to exhibit this work in print and electronic form publicly or privately.   I wave any rights, claims or interest I may have to control the use of my identity or likeness in the images and agree that any uses described in the Participant Information sheet may be made without compensation or additional consideration of me.

I am at least 18 years of age, have read and understand this statement, and am competent to execute this agreement.

Name: _____

Email address: _____

Telephone/Mobile: _____

Faculty/School/Discipline: _____

Course: _____

Signed: _____

Date: _____

Appendix 5 Confidential Disclosure:

<u>CONFIDENTIAL DISCLOSURE AGREEMENT</u>

This CONFIDENTIAL DISCLOSURE AGREEMENT is made the .... day of .... between:

Kelly Pickard-Smith as a Researcher at THE UNIVERSITY OF MANCHESTER of Oxford Road, Manchester, M13 9PL, United Kingdom (hereinafter referred to as "the University") and (student name)... of University of Manchester.

WHEREAS

A   Kelly Pickard-Smith as a researcher of the University and the Student agree that any discussions and exchanges of the information shall be governed by the following conditions:

NOW IT IS HEREBY AGREED AS FOLLOWS

1   "Confidential Information" shall mean any and all knowledge, know-how, information and techniques disclosed in connection with this Agreement but not limited to all research data, discussions as part of the research, the drama performances and the viewing of video data until as such time the video data has been reviewed by all research participants who agree on any video data can be made publically available.

10   Any communications under the Confidential Disclosure Agreement including but not limited to telephone conversations correspondence memoranda facsimile communications shall be protected under the terms of this Agreement as Confidential Information.

11   This Confidential Disclosure Agreement is made under the laws of England and shall be subject to the non-exclusive jurisdiction of the English Courts regardless of place of execution or place of performance.

12   Nothing in this Agreement shall obligate either party to enter into any further agreement relating to this matter.

7   This Agreement shall come into effect on …………….. for a period of …………………..

For and on behalf of The University of Manchester.

Authorised to sign on behalf of The University of Manchester

Name

Role

For and on behalf of the Company

Authorised to sign on behalf of _____ (Company name)

_____

Name

Authorised Signatory

The Student

Signature: _____

Name: _____

Date: _____

Appendix 6 VASTRA

Manchester Institute of Education

Research Risk and Ethics Assessment

Video and Still Image Recording Declaration

This form should be completed by all research students who seek to utilise still image capture or video recording of prospective research participants. This form should be completed and by the researcher in discussion with their supervisor and submitted with the current Manchester Institute of Education Research Risk and Assessment (RREA) and other relevant documentation. Please read the guidance document available prior to completing this form.

Name of researcher:

Title of research study:

Degree programme and unit:

This study seeks to utilise: Tick one		Still image		Video recording	x	Still image & video recording

This project intends to make use of the following type(s) of still image and/or video recordings for research purposes (please tick):

	1. Still image or video resources available from a library or archive;
x	2. Still image or video recorded independently by the researcher using their own or local available resources;
	3. Still image or video produced by the researcher within an independent production team;

4. Still image or video production initiated by the researcher and recorded independently by research participants.

The researcher should complete the following declaration (Please tick):

x	I have read and understood my responsibilities as a video ethnographer as outlined in 'Video recording and still image capture for research purposes in the MIE, University of Manchester'[40]
x	The use of still image and/or video for this study has been discussed by the researcher and supervisor and the manner in which still image or video recordings are to be used have been agreed as indicated.
x	All aspects of information provision to participants, consent, and related health and safety issues, as outlined in the current MIE Research Risk and Ethics Assessment documentation, have been discussed and are made available with this form.
x	The researcher will provide an unedited copy of all original still image and/or video recorded materials for the above research activity for archive to the School of Environment, Education and Development Ethics and Fieldwork Administrator for archive and audit or inspection purposes.

Signed (researcher)	K. Pickard-Smith	**Date: 24/06/14**
Approved:		**Date:**

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[40] Available from .http://www.education.manchester.ac.uk/intranet/ethics/

Appendix 7 Pilot Study

Pilot April – May 2014 'Performatics' Performing mathematics (Digital footage)

Sampling and access: Purposive sampling for a small study testing methods. MSc students were chosen for their attendance at a quantitative analysis class. 5 students contributed in two sessions.

Method 1: Videoed class observation – 2 hour duration in a Qualitative analysis class.

Method 2: Videoed Performance – Participants began with 'practice' discussion about stories to be explored in performance. Class observation was discussed for differences/similarities between socially and performed mathematical selves. Student feedback from session on wanting more guidance was adopted in session 2 (Example B) to have 1 student as the focus to direct other students in the drama.

Data recording: Digitally recorded with video.

Analysis: Drama as analysis. Researcher and participants interrogate the drama problem set in the flow of the action working out what the scene may look like. A Secondary analysis re-visited class observations and initial drama session for contrasts and similarities. Final dramaturgical analysis of the video data looking at how dialogue, props, movement, facial expression etc can convey markers of identity.

Data presentation/discussion:

Example (A): Session 1. Participants: 3 females and 1 male

Part 1 – Class observation. Students were videoed in a quantitative analysis class. The class observation shows 2 female students confidently working

through the maths task. They collaborate to solve the problem. At the next desk a male student struggles and approaches the female group for assistance who welcome him.

Part 2 –Videoed performance. The video observation findings prompted discussion and drama. The females from the observation want to act a piece about them not being confident mathematicians and how men are better/more confident – the setting is an upcoming university social event. There are anxieties amongst the female students because they don't want to look foolish when talking at the social to professors with what they consider 'better' mathematical skills than them. The male in the group is shocked and defensive when confronted with the female's assertions that males are better at mathematics. A debate about male and female mathematics skills ensues.

Example (B): Session 2. Participants: 3 females.

Part 1 – Performance. A student acted their realisation that Triangle angles total 180o. Almost a silent video the 'bodily emotions' evident in facial expression and bodily movements would have lacked clarity and depth capture or represented by other means, an ethical injustice to the data and participant. Dramatised were stages of *confusion,* scratching head, looking quickly at an imaginary book and confused facial expression when looking at the triangle; *Excitement*, Open mouth, aghast, quickening of movement walking around the triangle, shouts of joy; *elation* in problem solving, punching the air with arms, wide eyes, open mouth, smiles, shouts of joy, punching the air, excitable quick movements around the triangle, taking the triangle to the parent in a hurried excited manner; *dejection* from lack of praise, slowed movements, head down, rounded shoulders; and *disappointment* that their discovery wasn't unique, hugging the triangle, crying sounds.

Part 2 –Performance. The same student enacts a test situation where they came second. In planning the scene she talks about how it was a very important event and one that started to turn her off mathematics. She is 9 years old and it is an 'Olympiad' test at school. She is excited to do something

different in the usually boring mathematics class. She re-creates the classroom and positions the teacher as relatively inactive and to the side of the action. The desk and her own individual work are positioned centrally, highlighting their own agency and responsibility for educating herself about mathematics. She emotes through gesture and various grunting sounds the difficulty of the test. After the test the scene moves to them checking results where she declares *"second....second is also good".* But the shifty side glance to their desk partner who came first, betrays that second is not 'also good', despite the vocal demonstration to the contrary.

Conclusion of value of filmed drama method:

Example A begins with a typological mathematical identity story of men being better at mathematics. Re-visiting observation data in performance shows participants the converse was true. A change in thinking begins with participants performing how they would converse with mathematics lecturers at the social event, imagining themselves otherwise.

Example B highlights how mathematical identity was performed and conveyed using set design, props, movement, gestures and facial expression. Taken for granted and uneasily seen bodily gestures, sounds and movements conveyed how those emotions contributed to a disengaged mathematical identity for that person and how embodied data can contribute stories different to those told. A picture of mathematical identity related to emotions, excitement, praise, and competition materialises across the participant's historical enactments.

Pilot participant feedback

I really enjoyed being a participant in your pilot study. I had fun while role-playing. I felt comfortable during it. I tried to act just as I would behave in that situation. You asked us to how we would feel in a maths exam, but it was a bit difficult for me to recall these memories. Also, we had different math exams in

the past, such as mid-term, finals and standardised national exams. I would behave differently in each of them because they did not have the same weights in determination of my final degree or grade.

Here is my feedback of your drama study: First, it was an innovative and excited experience for me to participate in your study. Drama is an often used pedagogy in classrooms but not yet commonly applied in research studies. So I did think that your study was a very brave trail to see how this method could potentially work. Secondly, I think it was very clever to recreate the scenes of our mathematical-related experience. The dramatic form of study could have allowed the participants to intentionally reveal and highlight the things which were important to us in our real experience for your study. Because it is an initial trail I guess, I felt confused while participating in your study. It would be better if you give some more introductions at the beginning to explain how this drama study will work, or even let us have a 'practice-play' instead of having us 'jump' into the drama straight. Also, sometimes, I felt that the drama we performed for you wasn't really fluent with clear individual roles. It would be better if you could tell us what kind of drama play you are expecting from us to that we as participants may able to perform more precisely towards the aim of your study. Overall, I enjoyed your drama study