



**CENTRES FOR
EXCELLENCE IN MATHS**

Growth-mindset, motivation and positive effort beliefs for maths learners in Further Education

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OUR PARTNERS



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About CfEM

Centres for Excellence in Maths (CfEM) is a five-year national improvement programme aimed at delivering sustained improvements in maths outcomes for 16–19-year-olds, up to Level 2, in post-16 settings.

Funded by the Department for Education and delivered by the Education and Training Foundation, the programme is exploring what works for teachers and students, embedding related CPD and good practice, and building networks of maths professionals in colleges.

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Abstract

The current research consists of two cycles; Cycle 1 tests the implicit theory of intelligence amongst 16+ GCSE Maths re-sit students using the Blackwell et al. (2007) model. Within Implicit Theory of Intelligence exists Incremental Theory and Entity Theory. *Incremental theory* suggests that believing the brain and intelligence are malleable should help students to achieve better grades in Maths. On the other hand, *Entity theory* assumes that believing intelligence is a fixed trait will predict lower Maths grades.

Cycle 2 is an experimental study, tailoring interventions to teach growth mindset to the same groups of students in cycle 1. This will test the impact of these interventions on Maths achievements.

Background and Literature Review

As maths teachers in Further Education, we see a wide variety of personalities, behaviours and levels of engagement and motivation. As maths teachers we need to recognise the place Implicit Theories of Intelligence play in the motivation of our learners as posited by Ping et al (2017) “Empirical research suggest that the two beliefs of intelligence shape students’ achievement in different ways...” (p.2).

Implicit theories of intelligence fall into two main categories, Incremental and Entity, we will look at these in turn.

Incremental Theory is a belief that intelligence and ability are malleable, they can be shaped as we progress through study and life. A learner who believes their ability to be malleable is more likely to show a greater level of resilience when faced with setbacks and a **greater level of motivation** to correct and improve learning (De Castella and Byrne 2015). Possessing a **growth**

mindset allows the learner to have a performance approach, they look **to gain mastery** and to out-perform expectations (Smiley et al; 2016) and are more likely to achieve.

Entity Theory on the other hand is the belief that intelligence is fixed; you are unable to progress beyond the point of your IQ. Working within the scope of entity theory a learner is likely to show a **lower level of motivation** as they cannot see that effort will improve their outcomes. Smiley et al (2016) when looking at the place of performance goals, talk of learners working with a **fixed mindset potentially being performance-avoiders, they fear failure, and shame, in front of their peers, if they choose not to perform,** they can't be seen as failures, they didn't try. We have worked with several learners over the years who have exhibited this trait and when it has been discussed they agree this is the reason for their avoidance tactics.

Ping et al (2017) stated that results from their study showed that: “student's prior achievement predicted their **behavioural, emotional, and cognitive engagement...**” (p.1). Many maths learners in FE arrive in college having experienced failure, they did not achieve, even more so over the last 2 years with the restrictions Covid put on their education they feel cheated, either through not achieving the grade they were expecting or having the teaching experience they required. As such, we need to be mindful of these issues and ensure we support learners to build the growth mindset they require to achieve.

We also need to consider the wider influences of gender, culture and socio-economic status and the effect these have in shaping the mindset of our learners.

There were some studies that used **Growth mindset interventions** to achieve **mastery** by improving the following:

Positive effort beliefs

Motivation

Our aim is to investigate possible models for the our CfEM Action Research group to use **Design Thinking to Improve Psychological Interventions:**

The Case of the Growth Mindset During the Transition to High School, Yeager et al 2016

This Texas based large scale (3676 participants) study was carried out on students aged 14 to 15 years old, who were transitioning onto High School. Students not successfully completing 9th grade core courses have a dramatically lower rate of high school graduation and much poorer life prospects (Allensworth & Easton, 2005). GCSE re- sit students in the UK are transitioning from Secondary School to an FE College. Although the age comparison with the UK is not exact, it is within 2 years and UK students are also undergoing a change in education provider in their early teenage years.

In this study a user centred Growth Mindset intervention was used, so instead of asking,

‘What would make you adopt a growth mindset?’

Researchers asked for positive and negative reactions to Growth Mindset material. Responses to these questions formulated changes to the Growth Mindset material which was then used as the intervention. The intervention described scientific facts about the brain. The intervention material described what neurons are and how they form a network in the brain. It described how the brain can get smarter the more it is challenged, like a muscle getting stronger when it is exercised. Students were then asked to write a letter to future students who might struggle and feel stupid. This is a “saying not believing” exercise, (Aronson, E, 1999). By asking the students to communicate the message to a third person it can feel less controlling and avoids implying the students are deficient. The CFEM AR project could use this approach.

Informal qualitative, and quantitative methodology was used. For quantitative methodology direct and indirect framing was used. It was found that direct framing led to smaller changes in mindset and hence correspondingly lower effectiveness, compared to indirect framing. Participants were encouraged to replace thoughts about between person comparisons (they are smarter than me) with within person comparisons (I can become even smarter). In other words, saying to a third person, and not necessarily applied to themselves. Strategy is emphasised not just hard work. Results showed that a fixed mindset was associated with thinking that difficulty means you are ‘not smart’. Therefore, to avoid looking stupid hard problems are avoided (Dweck, 2006).

Data was analysed by a third-party government backed organisation. A control activity was used, which might be difficult to replicate for the CFEM action project. However, baseline data from a control GCSE group could be used. That is, grade on entry to college and grade achieved in June 2022. It is important to have the graded data as one theme from this study is a disconnect between self-reports and actual behaviour.

Methods

Implicit theory of intelligence has been tested on school students in America, China and recently on young children in England (Yeager et al. 2016; Jiang et al.; 2020; Garnett, 2020). Cycle 1 will be testing implicit theory of intelligence on 16+ re-sit GCSE Maths students; seeking to find whether what was true for a different group of students of varying ages or from a different educational system, is true for our group of students. The beliefs of the students taking part in the research are held at the centre of the research. Precisely worded questionnaires, using a Likert scale set answers, will measure students’ beliefs regarding theory of intelligence. Each student holds a certain theory of

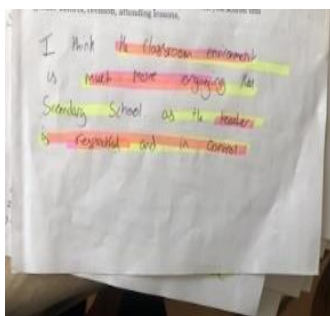
intelligence (entity theorist versus incremental theorist) where the students' views will be transferred into quantifiable data to uncover it.

Cycle 2 is an experimental study to teach incremental theory; growth mindset interventions, using online programme called Brainology, for 16+ GCSE Maths re-sit learners to investigate the impact of learning implicit theory of intelligence on Maths motivation and resilience. Three colleges took part in this study: Carlisle College, Kendal College and Lancaster and Morecambe College. Sixty Students took part in Cycle 1 of the study while Thirty two students took part in Cycle 2.

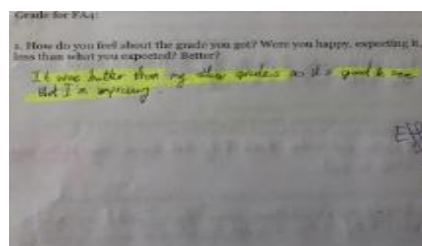
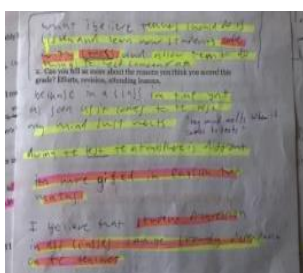
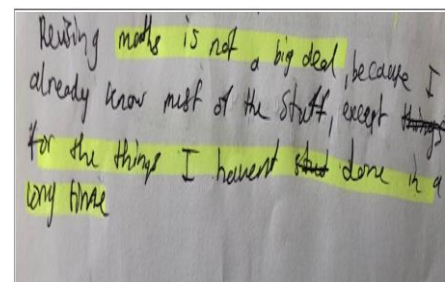
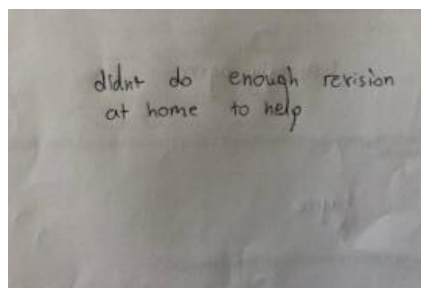
Results and Discussion

Cycle 1- Thematic Analysis

We conducted **Thematic Analysis for Cycle 1**, the following codes originated from the first level coding:



Some students answers

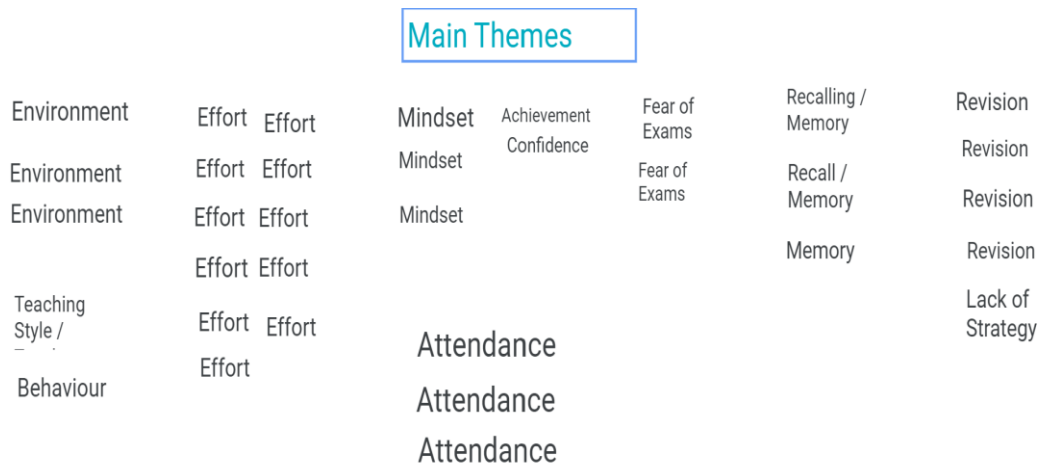


First level coding showed some interesting result: There certain words that learners kept repeating in their answers like:

- Environment,
- Effort
- Mindset
- Revision

We looked at themes that appeared strongly from students answers, the following Main Themes emerged:

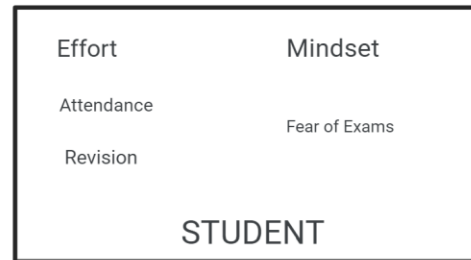
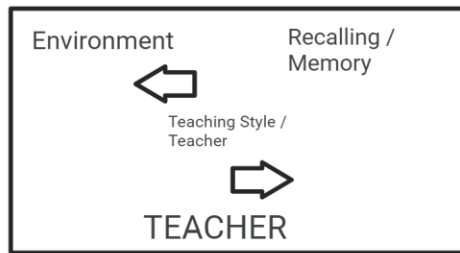
Coding the data using jam board



Following the main Themes, I narrowed them to 4 final main Themes:

2 Related to **Teachers** and Teaching styles: **Environment & Memory**

2 Related to **Students**: **Effort & Mindset**



Main Themes Linked

Cycle 2 - Thematic Analysis

Two focus groups were conducted, one before Brainology and one after Brainology.

Focus groups before Brainology

How did you feel when you received your GCSE Result?

Shocked
Annoyed
Upset
Disappointed
Felt alone
Let Down
Not Fair
Not Fair
Not surprised
Didn't look
What's the point?

How did you feel when you received GCSE results other than maths?

I wasn't surprised
Passed everything else
Wasn't as disappointed as I was with maths
More disappointed at maths
Felt the same

What was the reaction of the people you live with?

Still happy
They weren't annoyed
Annoyed because I couldn't show my full ability
Not surprised encouraged to keep going
Understanding, they were encouraging

How do you feel having to attend re-sit classes?

Groan Stressed. Keep thinking I am going to fail.
Groan it's the motivation I miss out ...as I have to be at maths
Missed out on a lot, not enough time
Feel resentful, interferes outside of college. I had to come in for maths.
Groan
Groan. Didn't think much

How did covid affect your Maths learning?

Enjoyed working from home.
More distractions. Instant help. Didn't have to be around other people.
Missed out on a lot, not enough time.
Not like online, I need help. Dyslexia and dyscalcula
It's hard to ask online cos don't get an immediate response.
I liked online learning better
Happy online, liked it. Didn't do much maths. Distracted
Hard to work at home, Distracted
Lack of motivation. No desk, no equipment, no help!

Focus groups after Brainology

id you find rainology ?	Give me an example of how it helped you	Do you feel Comfortable to attempt more difficult questions?	Would you be able to explain the method to another students?	Did Brainology encourage you to attend revision lessons?	Do you feel able to tackle longer/wordier questions now?	Do you feel more comfortable in your Maths classes now?	Goal Orientation-level of hard questions
	it helped to cope with stress	would use in an exam	would give it a go	(all answered) "no"	would give it a go now	"same" x 3 responses	Gold x 4 responses
	(liked) the one on revision and coping with stress	would try in an exam	I think so yes		"yes" x 6 responses	"yes" x 3 responses	silver x 2 responses
	learning about different parts of the brain helped	yes and no	yes				
	liked TED talk about reinforcement						

Coding the data

Maths Feelings

Let down Not fair Annoyed Shocked	Not my fault
Upset Disappointed Felt alone	Accepting responsibility
What's the point Didn't look	Resigned
Stressed Fear of failure Missing out	Mindset

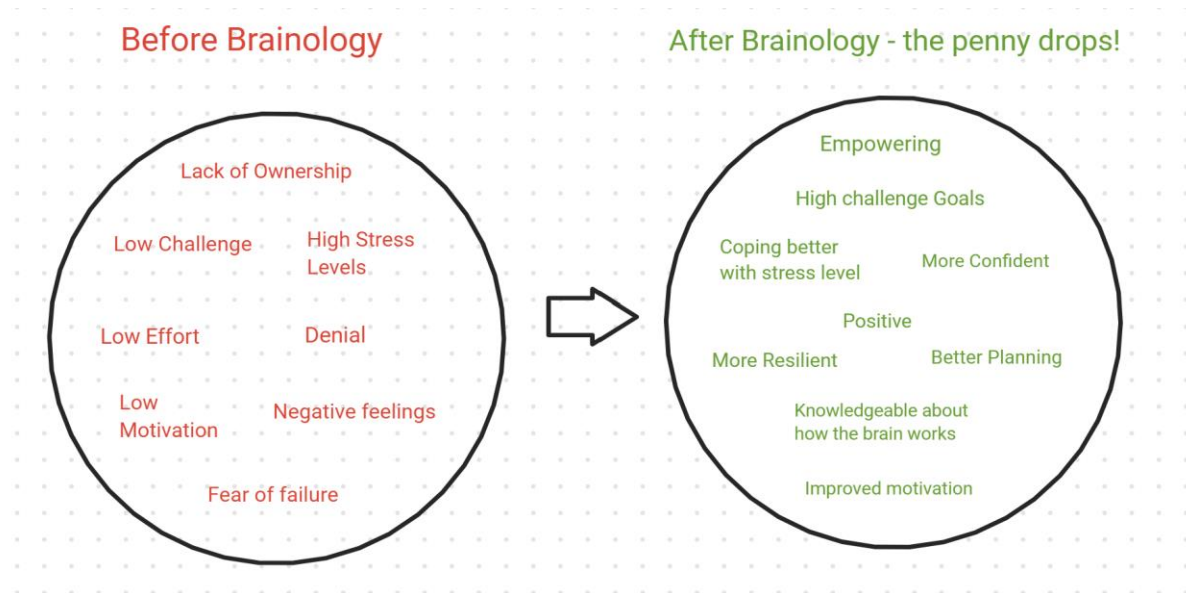
Challenge

Maths < Lower challenge No choice/Ownership
Vocational > Greater challenge Choice/Ownership

Covid Influences

Liked online Liked online better Instant help	Low Effort Lack of time Lack of motivation
Environment No help Lack of equipment	More distractions

Themes



The Thematic Analysis yielded some strong findings :

Before interventions : there was lack of ownership, high stress levels, low challenges, low effort, negative feelings and fear of failure.

After interventions: Empowering, mastery-goals, coping with stress levels, more resilience, knowledge about how the brain works and improved motivation.

From Cycle 1 & Cycle 2: we concluded that students mindset is very powerful theme, it is affected by the whole classroom atmosphere, and impact both teachers and students, and having a GM leads to a positive learning culture.

There are great benefits to teaching GM, it improves students' experience in the classroom, they become more resilient and less anxious, some of the students said they will be happy to tackle difficult questions they were not able to do before.

Conclusion and Recommendations

Prior research claimed that one's belief system in one's own capabilities is key to showing how people react to challenges and how far they can go in life. This research discusses the interaction between the motivational variables and their impact on academic achievement in a real-world environment. It aims to establish if 16+ re-sit GCSE mathematics learners who endorse an incremental theory adopt higher learning goals. The research tests whether the growth mindset intervention changes students' beliefs towards effort, builds better studying strategies and enhances mathematics results.

Finally, This study has illuminated basic motivational processes, though debate surrounds their nature and impact. It showed that the impact of growth mindset depends on how it is utilised in the environment. Growth mindset yielded active learning goals which predicted active coping, sustained motivation, and higher achievement in the face of challenge. It is crucial to embed growth-mindset interventions in classroom environment and weave it in mathematical learning and teaching. Mathematics is a challenging subject and students tend to give up easily when facing tricky questions. Embedding growth-mindset interventions helps learners to become more resilient and increases motivation.

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Appendices

Appendix 1

Measuring Students' mindset

The scale consists of six statements : with the latter three belonging to incremental theory while the first three belong to entity theory (Dweck, 2000, p.177).

1. *"You have a certain amount of intelligence, and you really can't do much to change it."*
2. *"Your intelligence is something about you that you can't change very much".*
3. *"You can learn new things, but you can't really change your basic intelligence".*
4. *"No matter who you are, you can change your intelligence a lot".*
5. *"You can always greatly change how intelligent you are".*
6. *"No matter how much intelligence you have, you can always change it quite a bit".*

Answers will be 6-point Likert-scale ranging from *strongly agree* to *strongly disagree*.

Appendix 2

Measuring Learning Goals versus Performance Goals

It is similar for the items on teacher scales which are anchored at 1 = "Strongly disagree," 3 = "Somewhat agree," and 5 = "Strongly agree."

The following three statements are used from Grant and Dweck (2003) construct to capture **performance goals**:

1. *"It is very important to me to do well in my classes."*
2. *"I really want to get good grades in my classes."*
3. *"A major goal I have in my courses is to perform really well."*

Participant will respond in six-point scale (Strongly disagree=1, Disagree=2, Slightly disagree=3, Slightly agree=4, Agree=5, Strongly agree=6). The code is reversed so that higher score indicate incremental theory.

The following three statements are used from Grant and Dweck (2003) construct to capture **Learning goals**:

1. *"I strive to constantly learn and improve in my courses."*
2. *"In school I am always seeking opportunities to develop new skills and acquire new knowledge."*
3. *"In my classes I focus on developing my abilities and acquiring new ones."*

As above, a 6-point scale will be used.

Appendix 3

Mastery goals statements (PALS, Midgely et al., 2000):

1. *"I like class work that I'll learn from even if I make a lot of mistakes."*
2. *"An important reason why I do my class work is because I like to learn new things."*

3. *"I like class work best when it really makes me think."*
4. *"An important reason why I do my work in class is because I want to get better at it."*
5. *"An important reason I do my class work is because I enjoy it."*
6. *"I do my class work because I'm interested in it."*

The following three statements are used from Grant and Dweck (2003) construct to capture **Mastery** goals:

1. *"I seek out courses that I will find challenging."*
2. *"I really enjoy facing challenges, and I seek out opportunities to do so in my courses."*
3. *"It is very important to me to feel that my coursework offers me real challenges."*

The above three-item construct also assess if learners enjoy challenges.

As above, a 6-point scale will be used.

Appendix 4

Helpless response towards setback

Unpublished research carried out by Blackwell et al. (2002) presented students with a fictional failure scenario:

"You start a new class at the beginning of the year and you really like the subject and the teacher. You think you know the subject pretty well, so you study a medium amount for the first quiz. Afterward, you think you did okay, even though there were some questions you didn't know the answer for. Then the class gets their quizzes back and you find out your score: you only got a 54, and that's an F."

After reading the above scenario, the participants will be asked to evaluate the four statements with the 6-point scale (Strongly agree=1....Strongly disagree=6).

- *"I wasn't smart enough."*
- *"I am just not good at this subject."*

- *“The test was unfair.”*
- *“I didn’t really like the subject.”*

Students' responses to this scenario will help assess their characteristics patterns to academic helplessness. The lower the scale the rating, the greater inclination towards helplessness.