CriSTaL
CRITICAL STUDIES IN TEACHING & LEARNING

2019, Volume 7, Special Issue
DOI:10.14426/cristal.v7iSI.188

How do students' beliefs about mathematics ability change in their first year at university?

Anita Campbell
Academic Support Programme for Engineering, and the Centre for Research in Engineering Education, University of Cape Town
Corresponding Author: anita.campbell@uct.ac.za

(Submitted: 6 June 2019; Accepted: 2 October 2019)

Abstract

The affective dimension of students' transition into university is an area of development that has the potential to improve student success. Large-scale research suggests that developing a growth mindset belief – that academic ability can always be expanded – may be especially helpful for first generation students. A starting point for developing growth mindsets as one type of affective support for students is to investigate how we can position students on the fixed-to-growth spectrum of beliefs about academic ability. This mixed-methods study considers the changes during their first year of university in the mindset beliefs held by two representative first-year mathematics students, one who passed and one who had to repeat the second semester of mathematics. Without experiencing interventions aimed at developing growth mindsets, both students showed small shifts towards stronger growth mindsets over their first year. Limitations with assessing mindsets are acknowledged and recommendations for future research in this area are suggested.

Keywords: first year experience, mathematics, mindsets, social-psychology, student success, transition

Introduction

In South Africa, and particularly at the relatively well-resourced, research-focused university where I work, there is an ongoing drive to improve graduation rates and a recognition that student success is still racially skewed (Department of Higher Education and Training, 2019). Higher education is a key strategy to create social change through higher paying jobs (The World Bank Group, 2017). However, many students drop out of higher education, not only with broken dreams but often with debt.

Fataar (2018) provides insight into why the transition into university is especially difficult for first generation South African students. He describes how students use their pre-university paths, their activities at university, and their religious and cultural support to position themselves as learning agents who can achieve academic success. While this

positioning can be helpful, first generation students often narrowly focus their university activity on achieving good results in tests and examinations (performance goals) rather than improving ability (mastery goals). Performance goals are in turn associated with believing that failure is due to a lack of ability (Ames and Archer, 1988; Dweck, 1986) and with self-handicapping academic behaviour, such as not asking questions and not completing homework (Niiya et al., 2010).

Bangeni and Kapp (2005) claim that while universities focus on immersing students into academic discourses, teaching and learning activities neglect the affective dimension of students' transition. I go further and argue that an important aspect of the affective dimension of students' transition, particularly for first generation students, is developing the belief that academic ability is not fixed at birth but is always able to be expanded, a social-psychology theory based on the work of Dweck (2006). All students are likely to experience new academic struggles in their first year of university. These experiences may activate beliefs that lead students to question if they are the 'type' who can make it at university. If these beliefs are not challenged, perseverance decreases, academic behaviours are undermined, and the resulting poor performance reinforces the beliefs, forming a self-defeating cycle (Farrington et al., 2012).

Growth mindsets and fixed mindsets

Mindsets are self-beliefs that steer our behaviour by influencing motivation and self-regulation. A growth mindset, also called an incremental mindset, is the belief that our ability can always be developed (Dweck, 2006). At the other end of the spectrum, a fixed or entity mindset is the belief that our ability has a natural limit that we cannot do much to change. We may hold different mindsets about our ability in different fields (Scott and Ghinea, 2014); for example, we may hold a growth mindset belief that we can improve our mathematics ability with the right effort and enough time but also hold a fixed mindset belief that we could never master an unfamiliar language.

Over three decades of research have shown links between students' fixed or growth mindset beliefs and academic behaviour: fixed mindsets are associated with helplessness in the face of challenges (Dweck and Leggett, 1988), procrastination (Howell and Buro, 2009), and higher dropout rates from academic studies (Dai and Cromley, 2014; Heyman et al., 2002), while students with growth mindsets show higher achievement in the transition to high school (Yeager and Dweck, 2012), care more about learning than marks (DeBacker et al., 2018), and show greater persistence when challenged (Boaler, 2015; Yeager et al., 2013). A growth mindset encourages the behaviours that educators and employers wish for students to have, such as choosing to work on challenging rather than simple problems, collaborating, trying alternative methods when faced with failure. Fixed mindsets discourage effort, risk taking in new situations, exposing weaknesses, and reviewing errors to learn from mistakes.

Since academic behaviour directly impacts academic performance (Farrington et al., 2012), it is surprising that correlations between growth mindset and higher academic achievement (shown by, for example, Dweck and Molden, 2005; Eppler and Harju, 1997;

Elliot and Dweck, 1988) are not found consistently (Burnett et al., 2013; Bazelais et al., 2018; Li and Bates, 2017; Sisk et al., 2018; West et al., 2016). Despite the shortcomings in the research results regarding mindsets, and the paradox of change being theoretically impossible for someone who holds a fixed mindset (Kristjánsson, 2008), the validity of the mindset theories has been defended (Dweck, 2017) and research in this area continues to grow (Zhu et al., 2019).

Importantly, the impact of growth mindsets on academic achievement may be skewed in favour of students who are most at risk of dropout due to pressures from their low socio-economic status (SES). For example, a study of all grade 10 students at schools in Chile (Claro et al., 2016) showed that while low SES predicted lower academic achievement than high SES, low SES students who held growth mindsets achieved at the same level as high SES students. Furthermore, low SES students and low-achieving students in this nationwide study were more likely to hold fixed mindsets, and, compared to SES, mindset was a stronger predictor of academic achievement. The greater benefit of growth mindsets on achievement by low SES students and minority groups was confirmed in two meta-analyses by Sisk et al. (2018), although the effect of growth mindsets on achievement was overall small. This research suggests that fixed mindsets may be a factor perpetuating the achievement gap between low and high SES students.

Similarly, Kapp et al. (2014) found that religious and cultural support enabled South African students from low SES backgrounds to position themselves as learning agents. However, family, friends, or religious beliefs may reinforce fixed mindsets and performance goals, for example, "Your intelligence is a gift from God", "You are an A-student". Parents' fixed mindset reactions to failure have been shown to induce fixed mindsets in their children (Haimovitz and Dweck, 2017). Therefore, turning to their usual support systems when failing a test for the first time may push students towards fixed mindset beliefs. These beliefs discourage students from seeking help as they try harder to maintain an image of being a strong student who does not need support. In contrast, "What can you learn from your mistakes? Where can you get help?" is an example of growth mindset support that may encourage self-reflection and the use of feedback for self-development.

Aim

A starting point for developing growth mindsets as one type of affective support for first generation students is to investigate where students position themselves on the fixed-to-growth spectrum of beliefs about academic ability. In this paper, I consider the mindset beliefs held by two representative first-year mathematics students and how their beliefs do or do not change during their first year of university. If we find that students do not have strong growth mindsets, this would indicate that it would be worth doing further research on (1) how to develop growth mindsets, including through affective support such as the words and actions of lecturers, friends, family and support communities, and (2) how mindsets affect academic success.

Research question

The research question is: How do students' beliefs about academic ability in university mathematics shift in their first year of university?

Methods and methodology

The focus of this research was an in-depth exploration of the mindsets of first year students through interviews. Contextualisation of the interviewed students' mindsets in relation to their peers was provided by surveying first year mathematics students using an existing eight-item questionnaire freely available at http://blog.mindsetworks.com/what-is-my-mindset (Mindset Works, 2015). Four items aligned to growth mindsets (e.g. "No matter how much intelligence you have, you can always change it a good deal") and four aligned to fixed mindsets (e.g. "You can learn new things, but you cannot really change your basic level of intelligence"). Response choices were on a six-point scale from 'disagree a lot' = 1 to 'agree a lot' = 6 for growth mindset items. The fixed mindset items were reverse-scored, so that high scores represent a growth mindset. Following Dweck, Chiu and Hong (1995), weighted scores of 25 to 31 were classified as representing neither fixed nor growth mindsets. The five-section grouping of weighted scores shown in Table 1 was adapted from the Mindset Assessment Profile Tool (2012).

Table 1: Classification of mindset according to weighted score from mindset questionnaire

Weighted mindset score	**8 to 16**	**17 to 24**	**25 to 31**	**32 to 39**	**40 to 48**
Classification	Strong fixed mindset	Moderate fixed mindset	Neutral mindset	Moderate growth mindset	Strong growth mindset

The questionnaire was piloted using a sample of 49 students in a first year mathematics course at a South African university in 2017. As all eight items in the questionnaire were designed to measure mindset, the Cronbach alpha coefficient was a suitable measure of reliability (that is, the extent to which the questionnaire can be expected to return the same results when reused) and internal consistency (if the items are all measuring mindset). A Cronbach alpha coefficient value of 0.71 suggested that the questionnaire could be expected to give the same outcomes for the target population of students at a South African university.

After obtaining ethical clearance from the university where the study took place, first year mathematics students were asked to complete the questionnaire on an online learning platform used for regular homework tasks, in the first term of the 2018 academic year. Students voluntarily participated and were incentivised with a bonus homework point if they completed the questionnaire. They were assured of their anonymity in research publications. A total of 265 students submitted responses to the questionnaire in the first term. The analysis of responses on Excel was used to ensure that the selection of interviewed students

for in-depth analysis were representative. Due to a low response rate of only 27 students in the end-of-year questionnaire, comparisons between the questionnaires were not made.

Interviews of up to thirty minutes were held with students who had completed the questionnaire and who volunteered to be interviewed. These interviews took place in the first year, within the first month of university (n = 16) and in the second semester (n = 15). The interviewer was not involved in the teaching or assessment of the course. No incentives were offered for participation in the interviews.

Interviews were recorded and analysed by identifying responses that matched characteristics of fixed and growth mindsets described in Dweck (2006), namely how students dealt with challenges, feedback, criticism and the success of others; how they viewed effort, mistakes, and marks. After a comparison of interview data, two representative students were selected to describe in detail.

Results and discussion

The questionnaire results completed in the first term of 2018 by mathematics students at a South African university are summarised in Table 2. For the 248 students who provided consent for their results to be used for research, a Cronbach alpha coefficient was calculated as 0.62, below the recommended minimum value of 0.7 but within the range of 0.6 - 0.7 that is commonly, but not contentiously, referred to as acceptable (Taber, 2018).

Table 2: Classification of mindset according to weighted score from mindset questionnaire

Weighted mindset score	**8 to 16**	**17 to 24**	**25 to 31**	**32 to 39**	**40 to 48**
Classification	Strong fixed mindset	Moderate fixed mindset	Neutral mindset	Moderate growth mindset	Strong growth mindset
Number of students (Total: 248)	2	15	64	139	28
Percentage	1%	6%	26%	56%	11%

Using to the classification from Table 1, only 7% of students identified as having fixed mindsets, 26% had indeterminate or 'neutral' mindsets and 67% of the 248 students had growth mindsets.

In interviews, there were no students who consistently gave responses that matched only-growth or only-fixed mindsets. Assessments of students' mindsets were guided by the breakdown of mindset characteristics as fixed, low growth, mixed, growth and high growth according to The Mindset Continuum (Anderson, 2019). Questionnaire and interview data were analysed in conjunction to make mindset assessments.

I will focus on the academic mindsets of two students I will call Pearl and Khalil. At the start of the year, Pearl's responses to the eight-item mindset questionnaire indicated a moderate growth mindset, with a weighted score of 34 on the scale from 8 (strong fixed

mindset) to 48 (strong growth mindset). Khalil's responses at the start of his first year showed an overall neutral mindset, with a weighted score of 29. The items in the questionnaire, together with responses from Pearl and Khalil and the interpretations of their responses are presented in Table 3.

Table 3: Interpretation of two students' responses to Mindset Assessment Profile Tool (2012) items from strong fixed mindset (1) to strong growth mindset (6)

Items in eight-item mindset questionnaire	**Pearl's responses**	**Interpretation**	**Khalil's responses**	**Interpretation**
No matter how much intelligence you have, you can always change it a good deal.	Agree (5)	Growth	Agree (5)	Growth
You can learn new things, but you cannot really change your basic level of intelligence.	Disagree a lot (6)	Strong growth	Disagree a little (4)	Weak growth
I like my work best when it makes me think hard.	Agree a little (4)	Weak growth	Agree a little (4)	Weak growth
I like my work best when I can do it really well without too much trouble.	Agree a lot (1)	Strong fixed	Agree a little (3)	Weak fixed
I like work that I'll learn from even if I make a lot of mistakes.	Agree a lot (6)	Strong growth	Agree a lot (6)	Strong growth
I like my work best when I can do it perfectly without any mistakes.	Agree a little (3)	Weak fixed	Agree a lot (1)	Strong fixed
When something is hard, it just makes me want to work more on it, not less.	Agree (5)	Growth	Disagree a lot (1)	Strong fixed
To tell the truth, when I work hard, it makes me feel as though I'm not very smart.	Disagree a little (4)	Weak growth	Disagree (5)	Growth
Mindset Classification from Table 1	**Score: 34**	**Moderate growth mindset**	**Score: 29**	**Neutral mindset**

The value that Pearl placed on learning from mistakes is consistent, evident in her questionnaire responses and both interviews. When asked if she believed that people are born as 'maths people,' she strongly disagreed:

> No, no, no, I don't think so. 'Cos I didn't like maths for a very long time in my life. ... It doesn't matter whether you like it or not. It makes it easier if your heart is there, but if you put your mind to something I feel that you can do it, it doesn't matter if you're a

> maths person or you were born with it, I don't believe that. ... I feel like if you just put your mind to something, to make it work, it does work.

At the end of the year, when asked about behaviour that might lead to not being successful in mathematics, Pearl spoke about a friend who had placed great pressure on herself to achieve high marks (grades):

> Sometimes people pressure themselves too much. I have a friend, ... actually she likes maths, and she does maths all the time and she wants to get like those h-i-g-h marks, so then now she puts pressure so much on herself that I feel like it's also affecting her marks ... and it's affecting her mentally as well.

From her first to second interview, Pearl shifted from a desire to achieve a high mark to achieving a pass without worrying about what mark she obtained:

> ... you can do work and work hard but not pressurise yourself to a point where, 'I need to get a certain mark, I need to get 90.' ... So, I'm just working on my progress right now. If I get 90, I'll be happy but if it happens, it happens, I'm not going to pressure myself, as long as I'm passing that's what matters to me.

Pearl's de-emphasis on achieving high marks indicates a move away from performance goals, associated with fixed mindsets, towards mastery goals, which are associated with growth mindsets (Eppler and Harju, 1997). Pearl suggested that her friend's focus on marks may have come from a desire to be recognised in class as a top achiever:

> I feel like, people in our class, people are smart (laughs), I won't lie, people are smart, some people just get 100% and .... usually last semester our lecturer would say people are getting 100% and he'd congratulate them, which is a good thing, and now I feel like people pressurise themselves into getting those good marks maybe to be recognised as well, or, I don't know.

Growth mindset characteristics that Pearl displayed in the second interview are the beliefs that you do not need to be quick to be able to achieve in mathematics, and that mistakes give valuable opportunities to learn:

> That's how I think I learnt at school. I'd write homework and then I'd get them wrong, coming to corrections I'd get probably 90% of my homework wrong... and then, like, there are silly mistakes, 'cos I'm like, it takes me a long time to understand something... So it takes, like, I won't get everything right but I'll get 90% of the questions wrong but then I go back, I look at the answers, or the teacher explains

> again, like step by step what happens, so then I'm able to rectify, 'Ok, this is what happens.'

Fixed mindsets encourage students to hide their difficulties to prevent being judged as weak. Pearl displayed a growth mindset by making use of mentors throughout the year. At the end of the year, she identified time management as an area of weakness for her and explained how she was getting help with this:

> I still feel like time management, hey, *time management*! is bad. Um, but I'm working with my mentor, my physics one and my maths one and they're helping a lot. I'm going to stick with them again 'cos I feel like having them in my life ... makes a huge difference, so I'll keep on going to MLC [Mathematics Learning Centre][1] ... and organise my time.

Like Pearl, Khalil showed a shift towards a stronger growth mindset in the context of mathematics over his first year. At the start of the year, Khalil disagreed strongly with the statement 'When something is hard, it just makes me want to work more on it, not less,' – a strong fixed mindset response. At the end of the year, he seemed to hold contradictory views regarding challenges, both enjoying a challenge and trying alternative methods (growth mindset traits) but also feeling frustration when challenged, which is more of a fixed mindset characteristic:

> If you can see where you have to go, like, even if it's difficult, the process that has to happen, it's like okay, cool, so this is an integration problem, for example, then the challenge will be to integrate but like as long as we can see where we have to go. It's frustrating not knowing what to do. I'll try a few methods.

While Khalil started the year strongly agreeing that he preferred working without any mistakes, he shifted towards being more comfortable with making mistakes, although this seems to be in the context of being able to resolve the mistakes easily.

> Generally, I just fly through everything. If I make a mistake I'll be like 'Cool, how do you fix it? I fixed it. Great.'

However, at the end of the year, Khalil was more endorsing of the fixed mindset idea that working hard may go together with not being very smart, as seen in his procrastination tactics (shown by Howell and Buro (2009) to predict fixed mindsets) and labelling himself as lazy.

[1] The Mathematics Learning Centre, or Maths Hotseat is a space where students can work individually or in groups during free times. Tutors assist students with specific questions from lectures or tutorials.

> I feel like I'm personally the laziest student in the world that you will find in your life. With the degree that we're doing [engineering] you can't be lazy so, [I do] the bare minimum, but you still have to put in the effort. I guess it's more like how long can you leave it until you start putting in the effort, and if it is an effort then you go through the process of figuring out what to do and afterwards its easy or you decide to leave it and focus on the rest of the coursework.

At the end of the year, Khalil still identified himself as a procrastinator, but his reasons appear to be linked to rejecting performance goals.

> I'm not one to study on Monday for a tut test on Friday. It also becomes a thing of what's more important, learning or marks? It's like 'I know these two questions are going to come up in the test, let's just learn these two questions,' and then nothing is really learnt.

Khalil's rejection of performance or even strategic learning goals (Biggs, 1979) match the strengthening of his growth mindset. However, by the end of his first year, Khalil does not yet appear to have developed the necessary work habits that will support mastery goals. When asked why some students have high achievement in university learning, he identifies helpful behaviours – diligence and consistency – but seems to view diligence as a fixed trait rather than something he could develop.

> I think it's maybe just diligence. Because that's the one thing that I would … if I could be a diligent student then I think I would do a lot better than I'm doing right now.
> *Interviewer*: And what would that entail?
> Being consistent. 'We're going to class, we're coming home, we're doing this.' As opposed to 'Ok, maybe tomorrow we'll do all the things we need to.'

While a fixed mindset may prevent a student from even trying to achieve an academic challenge, having a growth mindset is not enough for academic success. Academic improvement does not happen unless students actually engage in effective practices. This was confirmed in the case of Khalil. His openness to learning from mistakes, rejection of performance goals, and comfort with challenges are growth mindset characteristics, however recognising that his work habits did not include enough diligence or consistency did not translate to effective action and he had to repeat the second semester mathematics course.

Limitations and directions for future research

A focus on mindsets may lead a researcher to fall into the trap of 'fundamental error attribution' - giving attention to attitudes and personality but overlooking 'how profoundly the social environment affects what we do and who we are' (Kohn, 2015: p.3). Pairing growth mindset development with effective strategies to manage issues such as procrastination, as

suggested by Job et al. (2015), may result in better academic achievement. Further research linking growth mindset development with effective learning habits, as suggested by Yan et al. (2014) and Anderson (2017) but aimed at higher education is suggested.

The effect of mindset on achievement may be eclipsed by the larger impact of institutional and course features, including lecturers' assumptions of students' prerequisite knowledge (Solina, 2019) and a focus on competitive achievement of marks rather than learning (Kohn, 2015). Future research could look at how course design features – assessment practices, reward systems, lecturers' speech and actions – can promote growth mindsets in lecturers and students, and what impact this could have on student success. I suggest that setting assessment at the right level and developing students' understanding of what they are expected to do, and how to achieve it if they are underperforming, supersedes the effects of mindset orientations.

The low percentage (7%) of students identified with fixed mindsets according to the questionnaire used in this study may be an indication that the questionnaire is not being interpreted as intended by students in a South African university. Validation of the questionnaire, or alternative versions with personalised and domain specific items (De Castella and Byrne, 2015; Nelson, Gee and Hoagler, 2016; Pembridge and Rodgers, 2018) would increase confidence that the questionnaire results are reliably measuring mindsets.

Fixed mindsets can be triggered by ego-threatening situations (e.g. failing a test, Burnette et al., 2013). The nuances of situation-dependent changes to mindset and the timing of these in relation to study time, test time and times when students took the mindset survey or were interviewed, may skew our understanding of what is actually the connection between students' beliefs, actions and behaviours. Gilbert (2007) points out how our recollection of past experiences is strongly influenced by our present circumstances. So, if a student is interviewed soon after performing well in a quiz, they may forget how difficult it may have been when they were struggling.

The impact of not addressing the affective needs of students through promoting growth mindset beliefs is likely to have a greater impact on students from low socio-economic backgrounds. A study involving 150 000 students and 150 lecturers from STEM courses (Canning et al., 2019) found that, compared to classes with growth mindset lecturers, students in classes with fixed mindset lecturers had lower motivation and the racial achievement gaps were double. Raising awareness in lecturers, students' supporters, and universities broadly of the damaging impact from fixed mindset beliefs is strongly recommended as an area for further research and action.

Conclusion

Bangeni and Kapp (2005) suggested that a lack of affective support from teaching and learning activities at universities may contribute to student under-achievement. Since students with fixed mindsets are most at risk of dropout from university studies (Dai and Cromley, 2014; Heyman at al., 2002), developing growth mindsets is one form of affective support that can benefit students with a history of high achievement at school but who

experience academic struggles in their first year at university. While the link between growth mindsets and grades has not been established for mathematics students at a South African university, the characteristics of a student holding a growth mindset match with desirable graduate outcomes, such as persistence in the face of difficult challenges, being willing to put in effort to achieve goals, seeking and accepting help when necessary.

This research provides two examples of how students' beliefs about ability in university mathematics shift in their first year, without any targeted intervention to develop growth mindsets. Pearl began her first year as a student with a moderate growth mindset. She believed that her efforts would lead to success in mathematics, but she also focussed on achieving high marks as a measure of her ability – a trait that Fataar (2018) noted is typical of many South African students. Towards the end of her first year, Pearl had developed practices that indicated a shift to a stronger growth mindset, such as asking for help and putting in effort to achieve learning. She saw that focussing on achieving high marks harmed a friend's test performance and mental well-being, and she had dropped the goal of achieving high marks in favour of mastery goals. At the end of her first year, Pearl considered herself as a learner who needs more time to fully understand problems but was confident that she could succeed by working hard and seeking help when stuck, which indicate a strong growth mindset.

Khalil's statements at the end of the year that he can 'fly through everything,' but that he is inherently lazy and not 'a diligent student' indicate fixed mindset beliefs. Yet he also displayed antipathy towards chasing marks rather than learning and rejected performance goals, which is characteristic of a growth mindset (Eppler and Harju, 1997). A growth mindset defends against overconfidence by making students more open to try more difficult problems, thereby developing a more accurate assessment of current ability (Ehrlinger et al., 2016). While Khalil passed the first semester mathematics course, he had to repeat the more challenging second semester course. With the habit of working fast, it is possible that Khalil avoided struggling on problems, and that this avoidance was due to fixed mindset beliefs.

This in-depth study showed that mathematics students at a South African university held fixed mindsets alongside growth mindsets, and that even without a targeted intervention, mindsets shifted slightly towards growth mindsets over their first year. Future research on the role that universities and communities could play in supporting growth mindsets development in first year students is highly recommended and may help students to avoid self-defeating cycles and to realise the academic success hoped for by all stakeholders.

Acknowledgements

Thanks to all students who generously gave their time to be interviewed and to complete questionnaires. Excellent guidance from my PhD supervisors, Tracy Craig and Brandon Collier-Reed, and from the anonymous reviewers was gratefully received.

The financial assistance of the National Research Foundation (NRF) of South Africa and the Research Office at the University of Cape Town towards this research is hereby acknowledged. Opinions expressed, and conclusions arrived at, are those of the author and are not necessarily to be attributed to the NRF.

Author Biography

Anita Campbell is an enthusiastic Senior Lecturer at the University of Cape Town with a passion for teaching first year university mathematics students. Her PhD study on growth mindsets sparked a new research interest in applying the findings from positive psychology to help university students achieve success, using design-based research.

References

Ames, C. & Archer, J. 1988. Achievement goals in the classroom: Students' learning strategies and motivation processes. *Journal of Educational Psychology*, 80 (3): 260-267.

Anderson, J. 2019. *The Mindset Continuum: How to Implement Growth Mindsets and Increase Learner Agency*. [Available at: https://www.jamesanderson.com.au/books].

Anderson, J. 2017. *The Agile Learner: Where Growth Mindset, Habits of Mind and Practice Unite*. Victoria, Australia: Hawker Brownlow Education.

Bangeni, B. & Kapp, R. 2005. Identities in transition: Shifting conceptions of home among “Black” South African university students. *African Studies Review*, 48 (3): 1-19.

Bazelais, P., Lemay, D.J., Doleck, T., Hu, X.S., Vu, A. & Yao, J. 2018. Grit, mindset, and academic performance: A study of pre-university science students. *EURASIA Journal of Mathematics, Science and Technology Education*, 14 (12): 1-10. DOI: 10.29333/ejmste/94570

Biggs, J. 1979. Individual differences in study processes and the quality of learning outcomes. *Higher Education*, 8 (4): 381-394.

Boaler, J. 2015. *Mathematical Mindsets: Unleashing Students' Potential Through Creative Math, Inspiring Messages and Innovative Teaching*. San Francisco: Jossey-Bass.

Burnette, J.L., O’Boyle, E.H., Van Epps, E.M., Pollack, J.M. & Finkel, E. J. 2013. Mindsets matter: A meta-analytic review of implicit theories and self-regulation. *Psychological Bulletin*, 139, 655-701. DOI: 10.1037/a0029531.

Canning, E.A., Muenks, K., Green, D.J. & Murphy, M.C. 2019. STEM faculty who believe ability is fixed have larger racial achievement gaps and inspire less student motivation in their classes. *Science Advances*, 5 (2): eaau4734. [Available at: https://advances.sciencemag.org/content/advances/5/2/eaau4734.full.pdf]

Claro, S., Paunesku, D. & Dweck, C.S. 2016. Growth mindset tempers the effects of poverty on academic achievement. *Proceedings of the National Academy of Sciences*, 113 (31): 8664-8668. [Available at: http://www.pnas.org/content/113/31/8664.full]

Dai, T. & Cromley, J.G. 2014. Changes in implicit theories of ability in biology and dropout from STEM majors: A latent growth curve approach. *Contemporary Educational Psychology*, 39 (3): 233-247.
[Available at: https://pdfs.semanticscholar.org/0699/ffb17cd60bd96e83df191d8f487b5565e396.pdf]

De Castella, K. & Byrne, D. 2015. My intelligence may be more malleable than yours: The revised implicit theories of intelligence (self-theory) scale is a better predictor of achievement, motivation, and student disengagement. *European Journal of Psychology of Education*, 30 (3): 245-267.

DeBacker, T.K., Heddy, B.C., Kershen, J.L., Crowson, H.M., Looney, K. & Goldman, J.A. 2018. Effects of a one-shot growth mindset intervention on beliefs about intelligence and achievement goals. *Educational Psychology*, 38 (6): 711-733. DOI: 10.1080/01443410.2018.1426833.

Department of Higher Education and Training. 2019. *2000 to 2016 First Time Entering Undergraduate Cohort Studies for Public Higher Education Institutions*. Pretoria: Department of Higher Education and Training.

Dweck, C.S. 2017. Growth mindset is on a firm foundation, but we're still building the house. *Mindset Scholars Network*, 18 January. [Available at: https://mindsetscholarsnetwork.org/growth-mindset-firm-foundation-still-building-house/]

Dweck, C.S. 2006. *Mindset: The New Psychology of Success.* New York: Random House Publishing Group.

Dweck, C.S. 1986. Motivational processes affecting learning. *American Psychologist*, 41 (10): 1040-1048.

Dweck, C. S., Chiu, C. Y. & Hong, Y. Y. 1995. Implicit theories and their role in judgments and reactions: A word from two perspectives. *Psychological inquiry*, 6 (4): 267-285.

Dweck, C.S. & Leggett, E.L. 1988. A social-cognitive approach to motivation and personality. *Psychological Review*, 95 (2), 256.
[Available at: https://mathedseminar.pbworks.com/f/Dweck+%26+Leggett+(1988)+A+social-cognitive+approach+to+motivation+and+personality.pdf]

Dweck, C.S. & Molden, D.C. 2005. Self-theories: Their impact on competence motivation, and acquisition. In Elliot, A.J. & Dweck, C.S. (eds.) *Handbook of Competence and Motivation*. New York: The Guilford Press, 122-140.

Ehrlinger, J., Mitchum, A.L. & Dweck, C.S. 2016. Understanding overconfidence: Theories of intelligence, preferential attention, and distorted self-assessment. *Journal of Experimental Social Psychology,* 63: 94-100. DOI: 10.1016/j.jesp.2015.11.001.

Elliot, E.S. & Dweck, C.S. 1988. Goals: An approach to motivation and achievement. *Journal of Personality and Social Psychology*, 54: 5-12.

Eppler, M.A. & Harju, B.L. 1997. Achievement motivation goals in relation to academic performance in traditional and nontraditional college students. *Research in Higher Education*, 38 (5): 557-573.

Farrington, C.A., Roderick, M., Allensworth, E., Nagaoka, J., Keyes, T.S., Johnson, D.W. & Beechum, N.O. 2012. *Teaching Adolescents to Become Learners: The Role of Noncognitive Factors in Shaping School Performance--A Critical Literature Review*. Consortium on Chicago School Research: Chicago. [Available at: https://files.eric.ed.gov/fulltext/ED542543.pdf]

Fataar, A. 2018. From the shadows to the university's epistemic centre: Engaging the (mis)recognition struggles of students at the postapartheid university. Think Piece at Higher Education Close-Up Conference, Cape Town. 15-16 November 2018. [Available at: http://www.hecu9.co.za/images/Aslam_Fataar_ThinkPiece.pdf]

Gilbert, D. (2009). *Stumbling on happiness*. London: Harper Perennial.

Haimovitz, K., & Dweck, C. S. 2016. Parents' views of failure predict children's fixed and growth intelligence mind-sets. Psychological Science, 27 (6): 859-869.

Heyman, G.D., Martyna, B. & Bhatia, S. 2002. Gender and achievement-related beliefs among engineering students. *Journal of Women and Minorities in Science and Engineering*, 8 (1): 41-52.

Howell, A. J., & Buro, K. 2009. Implicit beliefs, achievement goals, and procrastination: A mediational analysis. *Learning & Individual Differences*, 19 (1): 151-154. DOI: 10.1016/j.lindif.2008.08.006.

Job, V., Walton, G.M., Bernecker, K. & Dweck, C.S. 2015. Implicit theories about willpower predict self-regulation and grades in everyday life. *Journal of Personality and Social Psychology*, 108 (4): 637-647.

Kapp, R., Badenhorst, E., Bangeni, B., Craig, T.S., van Rensburg, V.J., Le Roux, K., Prince, R., Pym, J. & Van Pletzen, E. 2014. Successful students' negotiation of township schooling in contemporary South Africa. *Perspectives in Education*, 32 (3): 50-61.

Kohn, A., 2015. The perils of 'Growth Mindset' education: why we're trying to fix our kids when we should be fixing the system. *Salon*, 16 August.

Kristjánsson, K. 2008. Education and self-change. *Cambridge Journal of Education*, 38 (2): 217-230.

Li, Y. & Bates, T.C. 2017. Does mindset affect children's ability, school achievement, or response to challenge? Three failures to replicate. Unpublished manuscript. [Available at: https://osf.io/preprints/socarxiv/tsdwy/download]

Mindset Works. 2015. *Take the Mindset Assessment to Learn More about your Mindset.* [Available at: http://blog.mindsetworks.com/what-is-my-mindset]

Mindset Assessment Profile Tool. 2012. [Available at https://achieve.lausd.net/cms/lib/CA01000043/Centricity/Domain/173/MindsetAssessmentProfile.pdf]

Nelson, M., Gee, B. P. & Hoegler, S. 2016. The role of domain-specific non-cognitive variables in postsecondary academic success. *International Journal of Innovation Education and Research*, 4 (11): 1-11.

Niiya, Y., Brook, A. T. & Crocker, J. 2010. Contingent self-worth and self-handicapping: Do incremental theorists protect self-esteem? *Self and Identity*, 9 (3): 276-297.

Pembridge, J. J. & Rodgers, K. J. 2018. Examining self-efficacy and growth mindset in an introductory computing course. *Proceedings of the 48th ASEE/IEEE Frontiers in Education Conference*. San Jose, CA. October 3-6.

Scott, M. J. & Ghinea, G. 2014. On the domain-specificity of mindsets: The relationship between aptitude beliefs and programming practice. *IEEE Transactions on Education*, 57 (3): 169-174.
[Available at:
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.689.7943&rep=rep1&type=pdf]

Sisk, V.F., Burgoyne, A.P., Sun, J., Butler, J.L. & Macnamara, B.N. 2018. To what extent and under which circumstances are growth mind-sets important to academic achievement? Two meta-analyses. *Psychological Science*, 29 (4): 549-571. DOI: 10.1177/0956797617739704

Solina, D. 2019. Personal communication by email, 4 September 2019.

Taber, K. S. 2018. The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, 48 (6): 1273-1296.

The World Bank Group. 2017. *Higher Education*. 5 October 2017. [Available at: http://www.worldbank.org/en/topic/tertiaryeducation]

West, M.R., Kraft, M.A., Finn, A.S., Martin, R.E., Duckworth, A.L., Gabrieli, C.F. & Gabrieli, J.D. 2016. Promise and paradox: Measuring students' non-cognitive skills and the impact of schooling. *Educational Evaluation and Policy Analysis*, 38 (1): 148-170.

Yan, V.X., Thai, K.P. & Bjork, R.A. 2014. Habits and beliefs that guide self-regulated learning: Do they vary with mindset*? Journal of Applied Research in Memory and Cognition*, 3 (3): 140-152. DOI: 10.1016/j.jarmac.2014.04.003.

Yeager, D.S. & Dweck, C.S. 2012. Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist*, 47 (4): 302-314. DOI: 10.1080/00461520.2012.722805.

Yeager, D., Walton, G. & Cohen, G.L. 2013. Addressing achievement gaps with psychological interventions. *Phi Delta Kappan*, 94 (5): 62-65.
DOI: 10.1177/003172171309400514.

Zhu, P., Garcia, I. & Alonzo, E. 2019. An Independent Evaluation of the Growth Mindset Intervention. *MDRC: Building Knowledge to Improve Social Policy*. New York: MDRC.