Maths Self-Concept Change in Makerspaces

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Makerspaces are learning environments with the potential to engage students in STEM and broaden their career aspirations. This explanatory mixed-methods study investigated how students' academic self-concept in maths and their future possible selves changed after participating in a high school makerspace subject. The analysis indicated no self-reported change in students' academic self-concept in maths, with students finding makerspaces and maths classrooms and pedagogies very different. However, participation in a maker space subject decreased the number of students who feared a future that included maths, reducing the effect of maths as a gatekeeper subject.

Introduction

Australia is one of many countries experiencing a long-term decrease in enrolments in "maths-intensive" subjects like advanced mathematics, physics and chemistry (Department of Industry Science and Resources, 2025; Marchent & Kennedy et al., 2025). There are many factors driving this participation issue, including societal influences, factors within schools, and the Australian university entrance system (Cook, 2025; Finkel et al., 2020). While this is true for all students, the underrepresentation of girls in maths has remained stubbornly consistent since the early 90s, despite numerous interventions (Marchant & Kennedy, 2025).

The maker movement in education has the potential to engage students in STEM learning (Kidman & Tan, 2025), particularly for underrepresented groups (Fasso & Knight, 2019). Maker education provides a context where learning occurs through design and construction with physical and digital tools. Grounded in the principles of constructionism (e.g. Papert & Harel, 1991), and popularised by the maker movement (Dougherty, 2012), makerspaces have proliferated in schools as well as in universities and public settings such as libraries. Makerspaces, unlike more traditional spaces for making in schools such as art and woodworking rooms, are not constrained by connection to a defined curriculum, and instead focus on integrating knowledge, project-based learning, collaboration and community.

While makerspaces have obvious applications in the science, technology and engineering aspects of STEM (Kidman & Tan, 2025), the role and prominence of maths within makerspace initiatives can vary significantly (LeBlanc et al., 2022). Integrating maker practices and pedagogies can augment maths learning and teaching (Namukasa et al., 2023) and, specifically in maths, makerspaces have been proposed as a means to move beyond the focus on procedural techniques and support the development of critical and creative problem-solving skills (Doorman et al., 2019).

This paper explores how participation in a makerspace elective in high school can affect students' academic self-concept in maths and their perceptions of how maths relates to their future possible selves in terms of hope for and feared careers and work characteristics.

Literature review

Researchers have employed various approaches to understand what factors influence students towards and away from STEM careers, including examining attitudes, identity, goals,

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attainment value, self-efficacy and self-concept (Wigfield & Eccles, 2000). This study selected self-concept as a predictor of participation in maths. Self-concept was chosen for the normative standards it uses and its long-term predictive links to career choices, as opposed to self-efficacy which is goal- referenced and measured in relation to a specific task; e.g. "how confident are you that you can solve this specific equation?". These task-specific scales allow researchers to establish a causal relationship between self-efficacy and achievement behaviours, but reduce the predictive power for broader outcomes like course selection and career aspirations (Bong & Clark, 1999). In contrast, self-concept is a multifaceted construct encompassing students' perceptions of their abilities as well as their desire to engage in specific activities (Brunner et al., 2010), thus self-concept is similar to self-efficacy, but also includes affective factors such as enjoyment of a subject (Bong & Skaalvik, 2003). Self-concept has been shown to correlate with academic engagement and motivation (Green, 2012) and is a precursor to attainment value in maths (Arens et al., 2019). Self-concept is also normative; e.g. "compared to others my age I am good at maths classes". This relates to feelings of enjoyment, interest and pride (Bong & Clark, 1999) resulting in self-concept being a better predictor of future aspirations than self-efficacy (Marsh et al., 2019).

Self-concept is a multifaceted construct encompassing students' perceptions of their abilities as well as their desire to engage in specific activities (Brunner et al., 2010). In this way self-concept is similar to self-efficacy, however self-concept also includes affective factors such as enjoyment of a subject (Bong & Skaalvik, 2003). Self-efficacy is goal referenced, measured in relation to a specific task; e.g. "how confident are you that you can solve this specific equation?". These task-specific scales allow the researchers to establish a causal relationship between self-efficacy and achievement behaviours, but reduce the predictive power for broader outcomes like course selection and career aspirations (Bong & Clark, 1999). In contrast, self-concept is normative; e.g. "compared to others my age I am good at maths classes". This relates to feelings of enjoyment, interest and pride (Marsh et al., 2005), resulting in self-concept being a better predictor of future aspirations than self-efficacy (Marsh et al., 2019).

Maths self-concept serves as a gatekeeper for STEM career aspirations (Goldman & Penner, 2016). Students with lower maths self-concept are less likely to aspire to STEM careers, even in fields that are not maths-intensive (Ceci et al., 2014). There are also gendered aspects (Sax et al., 2015), with girls reporting significantly lower perceptions of their maths abilities than their boy counterparts, despite demonstrating equal or better academic performance (Shapka et al., 2007). Additionally, Watt et al. (2016) found that for Australian girls, perceived maths ability was a much stronger predictor of STEM-related career aspirations than for boys, so girls both underestimate their maths abilities, and this lower self-perception has a disproportionate influence on their career aspirations. While previous research has explored the development of self-concept in traditional single subject disciplines, self-concept development in newer non-traditional learning areas such as makerspaces has been less studied. Maker education could offer an alternative pathway into higher level maths through the development of different aspects of self-concept.

Lyons and Quinn (2015) found that the most common reason Australian students gave for not choosing science was that they were unable to picture themselves as a scientist. For all students, having an accurate perception of who a STEM professional is and what they do is an important step towards seeing themselves in such a role in the future. Thus, it is necessary to capture this future oriented aspect of the students' self-concept, called Future Possible Selves (FPS). FPS provides a link between an individual's self-concept and their future orientated motivations (Molina et al., 2017). These possible selves encompass various dimensions of an individual's potential future, such as personal characteristics, professional roles, lifestyle choices, and desired future achievements. Examples might include working with maths, owning a house, or being well-travelled. FPS can be further categorised based on their desirability: hoped-for possible selves (highly desirable outcomes), expected possible selves (anticipated outcomes), and feared possible selves (undesired outcomes). It is important to note that the term "feared possible selves" does not necessarily imply dread or horror, but rather refers to possible selves that individuals simply wish to avoid (Molina et al., 2017).

This study aims to determine the influence participation in a makerspace has on students' mathematical self-concept and the career-orientated aspects of future possible selves.

Methodology and Data Collection

This study, which was part of a larger study exploring eight subject areas, employed a mixed-methods, quasi-experimental design, comparing data from students taking makerspace electives (n=76) to those in control classes (n=71) across four schools. Quantitative data measuring academic self-concept and future possible selves was collected through pre- and post-surveys. Qualitative data from teacher interviews and student focus groups was used to triangulate the quantitative data and provide deeper insights into the findings.

Academic self-concept was measured using the Academic Self-Description Questionnaire (ASDQ) (Marsh, 1990), which uses an eight-point Likert scale to measure eight subject specific items. The ASDQ-2 was used, as it has been tested for validity for years 7-10, across different genders and within the Australian context (Byrne, 2002). The survey statements for this study are:

- Compared to others my age I am good at maths classes.
- I get good marks in maths classes
- Work in maths classes is easy for me
- I am hopeless when it comes to maths classes
- I learn things quickly in maths classes
- I have always done well in maths classes
- It is important to me to do well in maths classes
- I am satisfied with how well I do in maths

The survey instrument for Future Possible Selves provided options for students to select career groups from the thirty-three listed on the Career Bullseye posters (one of which was maths). Career Bullseye is a resource used with students in all the participating schools as part of their careers education and are well regarded by careers teachers and used widely in Australia (Firth, 2020). Students were asked to drag and drop the careers into boxes labelled either "I want a job in" or "I don't want a job in". This questionnaire was used with schools 2,3 and 4 but not school 1.

To triangulate with the two quantitative surveys, qualitative data was also collected in the form of student focus groups conducted after the subjects had been completed.

Results

Participant demographics

Table 2

Characteristics of participating schools and classes

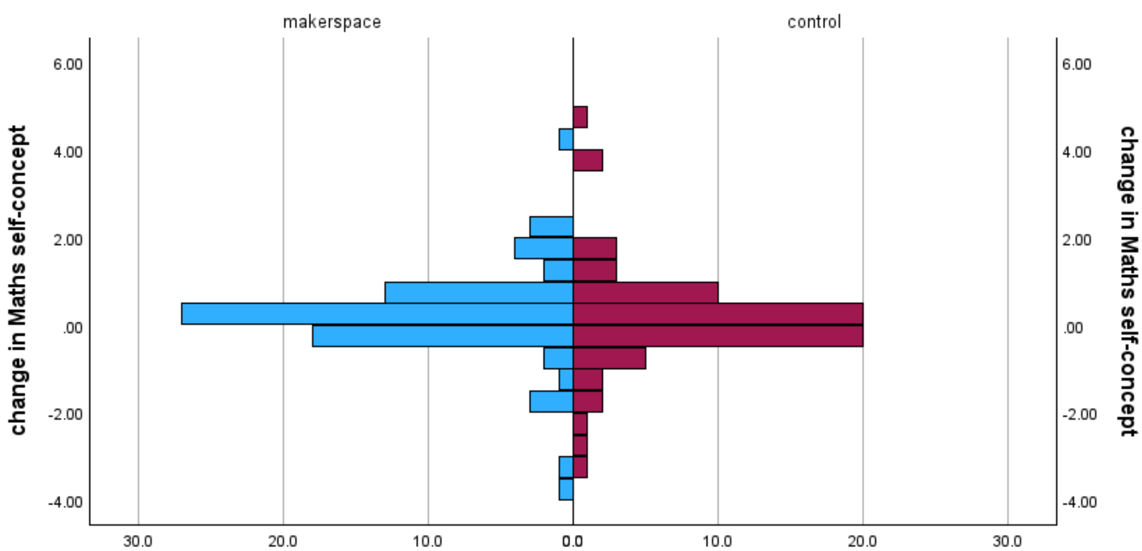
Characteristic	School 1	School 2	School 3	School 4
Sector	Independent	Independent	Catholic	Independent
Gender	Co-ed.	Girls' school	Girls' school	Girls' school
Year level	Year 9	Year 10	Year 10	Year 10
Control Class	Science	Drama	Creative Writing	Printmaking
Control participants	23	22	18	8
Makerspace participants	18	27	21	10

Academic self-concept

Academic self-concept change was calculated by subtracting students' average initial score from their average final score. To determine if there was a difference in self-concept change between makerspace students, an independent t-test was conducted. The 76 students in the makerspace classes (M = 0.15, SD = 1.08) and the 71 students in the control classes (M = 0.09, SD = 1.23), did not demonstrate a significant difference in performance (t[145] = -0.32, p = .77). The majority of students in both classes did not have a change in their self-concept from the start of the semester to the end of the semester, as can be seen in the back-to-back frequency chart in Figure 1.

Figure 1

Comparison of academic self-concept change in maths for students in makerspace (left) and control (right) classes.



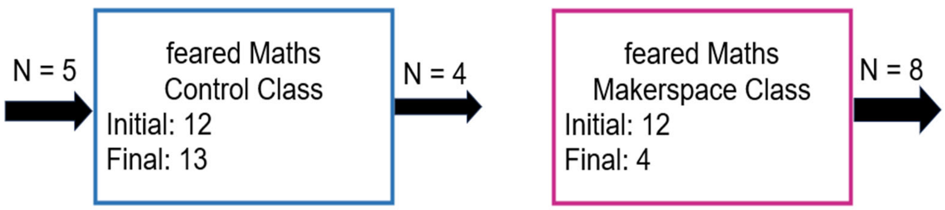
The analysis showed that there was no significant change in maths self-concept before and after participation in a makerspace subject compared to the control classes.

Future Possible Selves

The control class students consisted of 48 participants, while the makerspace students had 58 participants as school 1 was not included in the analysis. Among the 33 career group options available, maths emerged as by far the most frequently chosen feared career group in the pre-intervention data in both makerspace and control groups, with 24 out of 106 students saying they did not want a job involving maths. The next most common option was selected by only four students, so the other subjects were not included in further analysis as due to low numbers. Figure 2 shows how the number of students choosing maths as a feared future career changed after participating in a makerspace subject, with eight fewer students selecting this option, and no students adding maths to their list of feared future careers. In comparison, four students in the control classes removed maths from their feared list, but five added it, leading to an overall increase of one student selecting this option post intervention.

Figure 2

The change in numbers of students selecting maths as a feared future career.



Despite small sample sizes preventing any statistical significance in these results, participation in a makerspace subject appears to have had an effect on reducing the fear of maths compared to other creative electives, even though it did not increase students self-reported self-concept in maths.

Qualitative Data

Mathematical Content

When asked what subjects the students associated with the makerspace, art was most frequently mentioned, with maths used as a counterexample: "Not maths. Maybe art is probably like the closest". While students recognised the presence of maths in their makerspace activities, they perceived it as different from the maths encountered in traditional classrooms. This was exemplified in this quote from a student in school 3: "I think the maths we were doing, wasn't like maths-maths, because it's kind of different to what we're obviously doing in maths class. I found I was doing much better in the maths here than in our other normal class."

This differentiation suggests a difference in how the context and application of maths influences students' perception and experiences of maths. This was also seen in school 2: "I suppose I use maths in here. Maybe in a much less "using brain" type way, more using my common knowledge… What I already knew. And then also learning new things along the way." Her characterisation of the maths used in the makerspace as "common knowledge" suggests that it may be more relevant or practical than the maths of the traditional classroom. These students made it clear that the maths they were doing in the makerspace was different to the maths in the maths classroom, and that they can more easily do the maths in the makerspace. It might be expected that this ability to apply maths in the makerspace would result in an increase in the students' maths self-concept, yet this was not the case. One explanation for this is that, as the students see the maths used in the makerspace as being a different kind of maths they do recognise their abilities and development as being related to “maths maths”.

Pedagogies, Engagement and Mistakes

When describing why the makerspace is different to their other classrooms, one student describes the levels of active participation, “science and maths aren’t that hands-on”. Another difference was their engagement in the learning and the value they placed on the work: “Sometimes I don’t even check if I got the answer right. I just don’t care really [in maths class]. But with my project [in the makerspace] I really wanted it to work”.

One feature that students discussed as being different in the makerspace, particularly in relation to science and maths classes, is the way mistakes were handled. In the makerspaces, mistakes were viewed as constructive and as a natural part of the design process. For example: “In the Makerspace the feedback seems more for change” (school 2), and “I think we found the mistakes kind of good because we could change for next time, for our next class, so our mistakes were kind of helpful” (school 3). Both these students recognise the role that mistakes played in moving their design forward. Students again used maths as a counter example: “I think in maths and science like there’s less room for error” (school 2), and “I feel like [mistakes are] not as helpful as in maths.” (school 3).

The contrast of mistake making was more than procedural, students also described an emotional component. “In math class if you’ve got something wrong, you might feel a bit discouraged. Like, oh no, I did it wrong or I don’t know what to do now” (school 2). Again, this is contrasted to the makerspace. “I know [mistakes] happen for everyone so I just fixed them, but in maths it means I wasn’t paying attention.”. This suggests that mistakes made in maths classes are perceived as a deficit, rather than the learning opportunity they are viewed as in a makerspace.

Conclusion

Maths classrooms were seen by students as being different from makerspaces, with maths often being used as a contrasting example when describing their experiences in makerspaces. Students were able to identify that they used maths knowledge used in the makerspace, but made a distinction between maths in the makerspace and maths in their maths classroom. Differences in “makerspace maths” compared to “maths maths” included increased persistence when the correct answer led to an improvement in project, a reduced fear of failure and a shift from mistakes being perceived as a result of lack of attention or ability to being accepted as a natural part of the design process. This indicates a desired shift from fixed a mindset towards a mathematical mindset (Boaler, 2015). Pedagogies also differed, with the makerspace being seen as “hands-on” compared to maths classrooms.

The effects of participation in makerspace subjects were mixed, with no significant change apparent in students’ academic self-concept in maths, but with a clear reduction in fear of careers containing maths. The lack of gain in self-concept may be due to students not connecting maths with what they did in the makerspaces, as the classroom experiences were so different. What is interesting is that, despite not connecting maths explicitly to making or improving their self-concept, students who had participated in the makerspace classes grew much more open to careers that included maths compared to the control groups who had taken other elective subjects. This indicates makerspaces have the potential to present maths as a subject with real-world applications, making it less daunting for students.

These results highlight the nuanced relationship between academic self-concept, future possible selves, and educational experiences in makerspaces, with makerspaces potentially helping students to see maths as less of a barrier to future careers, even if their perceived math abilities remain unchanged. Noting the small sample numbers in this study, this connection between maths and makerspaces requires future exploration.

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