Nudging Pathways: The Role of Teacher Recommendations as Strategic Interventions in Senior Mathematics and STEM Extension Choices

Hazel Tan
Monash University
Hazel.Tan@monash.edu

Janelle Hill
Charles Sturt University
jahill@csu.edu.au

This paper examines the role of teacher recommendations in shaping students' participation in advanced mathematics subjects and STEM extension programs. Such recommendations are often assumed to be influential but rarely theorised or empirically examined. Drawing on findings from two studies conducted in Victoria, Australia, and unpacked through the lens of Nudge Theory and Choice Architecture, the discussion highlights how teacher recommendations function as a part of educational choice architecture across both formal curriculum decisions and optional enrichment pathways.

Introduction

Concerns about student participation in advanced mathematics have been widely documented in mathematics education research, particularly regarding declining enrolments, inequitable access, and the long-term implications for STEM pathways (Department of Industry, Science and Resources, 2025). In senior secondary schooling, decisions about whether to enrol in advanced or intermediate mathematics subjects represent pivotal moments that can shape students' post-school options and identities as mathematical learners. These decisions are influenced by a range of factors, including perceived ability, future aspirations, institutional requirements and social influences (Hine et al., 2024; Holmes et al., 2025).

Within this decision-making landscape, mathematics teachers are frequently positioned as *significant others* (Henschel et al., 2023) whose recommendations are expected to guide students towards appropriate pathways. However, despite its presumed importance, the role of teacher recommendations has received relatively limited empirical examination. In particular, there is little clarity about the extent to which recommendations influence students' decisions relative to other factors, especially when it comes to significant and high-stakes choices.

This paper addresses this gap by examining teacher recommendations through the lens of Choice Architecture and Nudge Theory. Drawing on two empirical studies conducted in Victoria, Australia, the paper investigates the extent to which teacher recommendations function as subtle but powerful influences on students' engagement with higher-level mathematics and extension STEM opportunities. By conceptualising recommendations as nudges within the context of choice architecture, the paper offers a reframing with implications for equity, responsibility, and professional practice in mathematics education.

Literature Review

Research on senior secondary mathematics subject choice has identified a complex set of interacting influences, including students' self-perceptions of mathematical ability, enjoyment, future career aspirations, and institutional constraints such as university prerequisites (Hine et al., 2024; Holmes et al., 2025). Students' beliefs about whether a subject is 'for them' have been shown to play a particularly strong role, often shaped by prior achievement and classroom experiences (Hine et al., 2024).

Social influences also feature prominently in the literature. Parents, peers, and teachers have all been identified as important sources of guidance and information during subject selection processes (Holmes et al., 2025). Among these, teachers are often described as trusted experts

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with specialised knowledge of both the curriculum and pedagogy, and can influence students through their pedagogies and enthusiasm for mathematics (Holmes et al., 2025). The influence of teachers as significant others or socialisers (Eccles & Wigfield, 2024) encouraging female participation in mathematics is well-known in the mathematics education gender literature (Forgasz & Markovits, 2018; Henschel et al., 2023). However, much of the existing research treats teacher advice as one among many influences, rather than as a distinct phenomenon warranting focussed examination.

Importantly, there is limited theoretical framing of how teacher recommendations or advice exert influence in terms of mathematics and STEM pathways. Recommendations are often assumed to operate through persuasion rather than prescription. However, such explanations risk oversimplifying the subtle ways in which advice shapes students' perceptions of risk, suitability, opportunity, and challenges. This gap suggests the need for alternative theoretical perspectives that can account for the direct and context-dependent nature of teacher recommendations.

By including both senior mathematics subject selection and STEM extension participation, the nudging effects can be examined across differing choice environments. In mathematics, choices are constrained by prerequisites and university requirements (Hine et al., 2024), whereas STEM extension programs typically involve open access with minimal formal barriers (Ihrig et al., 2018). If teacher recommendations exert influence in both contexts, this suggests a robust nudging mechanism that extends beyond discipline-specific structures.

Nudge Theory and Choice Architecture in Education

Nudge Theory, originating in behavioural economics, describes how small changes in the way choices are presented can significantly influence decision-making without restricting freedom of choice (Thaler, 2018; Weijers et al., 2021). Nudges operate by shaping the psychological, social, and physical environment surrounding the decisions, the *choice architecture* (Weijers et al., 2021), often by making certain options more salient, normative, or cognitively accessible. Importantly, nudges do not charge individuals to act in a particular way. Instead, they steer behaviour while preserving autonomy.

Within educational contexts, nudges have been applied to understand how institutional structures, expectations, and messaging influence student behaviour (e.g., see a discussion on the application of nudges in education by Decuypere & Hartong, 2023). Various nudge strategies have been studied, such as apps and online platforms for career development (Lent, 2025), opting out of high school advanced courses instead of opting in (Austin et al., 2022), and student and parent interventions to increase female uptake of STEM subjects at UK's Advanced Level (Department for Education, Behavioural Insights Team, 2020). The "Nudging to STEM Success" project (O'Hara & Sparrow, 2019) uses a series of text messages to nudge students to re-enrol in STEM programs. The initial randomised controlled trial involving more than 2700 students and the subsequent implementation involving more than 9500 students found that nudges increased students' persistence in participating in STEM courses (Soricone & Endel, 2019).

Weijers et al. (2021) described two types of nudges. Type 1 nudges influence behaviour through automatic, low-effort cognitive processes (System 1 thinking). They alter the decision-making environment or context (choice architecture) so that students make better decisions without needing deliberate reasoning. Examples in the mathematics classroom might include having the default calculator mode set to exact values and degrees or radians, having a poster of key formulae or problem-solving steps placed at eye level on the walls, worksheets designed with sufficient space for students to write their workings, and beginning mathematics exercises with easy questions that are similar to worked examples to encourage students to participate. Type 2 nudges target reflective, deliberate thinking (System 2 thinking). They prompt students

to pause, think, plan, or reflect before making a choice. Examples include metacognitive question prompts and scaffolding prompts for students to explain their solutions, set goals, or analyse their errors. Printed exit tickets collected at the door could involve both Types 1 and 2 nudges. Nudges can have a positive or negative impact, depending on how they are framed and perceived (e.g., mathematics is hard versus this concept can be challenging, and that is why we will break it down together) (Sunstein, 2017; Weijers et al., 2025).

Teacher recommendations can be conceptualised as a form of deliberate and explicit/transparent nudge, in which trusted authority figures subtly signal what choices are appropriate, achievable, expected, or aspirational (Decuypere & Hartong, 2023). Such recommendations may influence students' perceptions of their own competence and the legitimacy of particular pathways, even when students retain the formal freedom to choose otherwise.

Viewing teacher recommendations as nudges through the lens of choice architecture shifts attention away from questions of persuasion or pressure, and towards the ethical and practical implications of choice design. This perspective is particularly relevant in mathematics education, where decisions about advanced mathematics study are often framed as difficult, high-risk and consequential. It also complements existing motivational theories, such as Eccles and Wigfield's (2024) Situated Expectancy-Value Theory, in that it provides a micro-lens to theorise the contextual processes and mechanisms of how teachers, as socialisers, impact students' expectancy for success. In the following two studies, we explore the potential of applying Nudge Theory as a lens to frame the role of teachers' recommendations and advice on students' mathematics and STEM pathways.

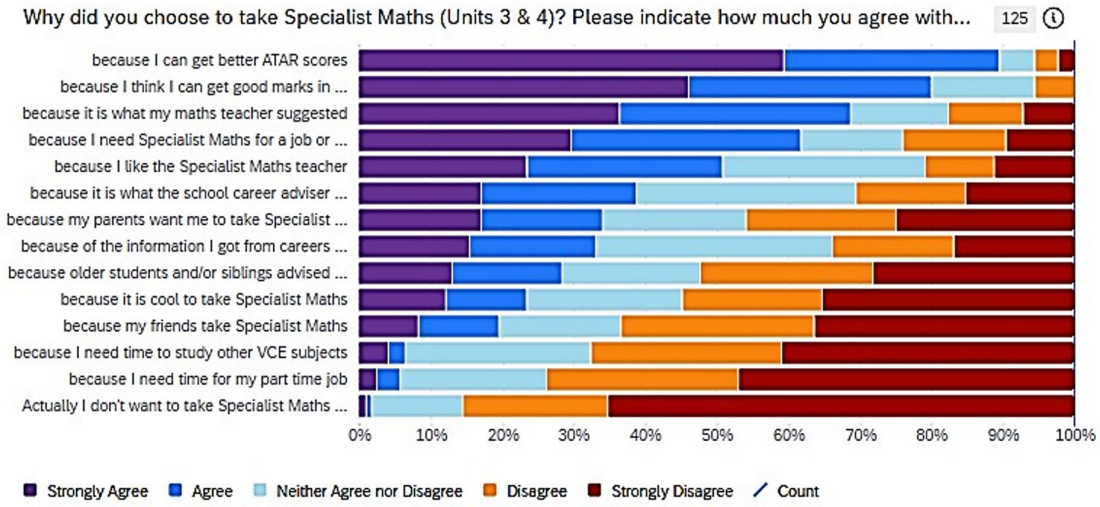
Study 1: Senior Secondary Mathematics Subject Choices

The first study investigated senior secondary students' reasons for choosing or not choosing advanced and intermediate mathematics subjects in Victoria, Australia. Data were collected through an anonymous online survey with 838 respondents (after cleaning) enrolled in senior secondary schooling (Years 10-12), recruited via Facebook advertisement approach (Forgasz et al., 2018). The survey included items addressing a range of potential influences on senior secondary mathematics subject choices, including perceived suitability, university requirements, teacher recommendations, peer influence and personal interest, informed by the instrument used by McPhan et al. (2008).

Of the 164 students who reported taking the Victorian (Australian) Specialist Mathematics Units 3 and 4 (equivalent to senior secondary Year 12 advanced mathematics), 125 (60 males, 64 females, 1 missing) responded to an item in which they indicated their level of agreement with a list of potential factors (see Figure 1). The survey data indicated that teacher recommendations were the third most influential reason for choosing advanced mathematics (36% Strongly Agree and 32% Agree). The first two most influential factors were that students could maximise their university entrance score (59% SA + 30% A) with the high scaling of Specialist Mathematics and that they could achieve good marks in Specialist Mathematics (46% SA + 34% A). Notably, teacher recommendations ranked above peer influence and other social factors, and liking their Specialist Mathematics teacher was ranked fifth (23% SA + 27% A). This is different from the Western Australian context, where parental advice was the most frequently cited source of influence of the 20 students interviewed (Kirkham et al., 2020), and the scaling effect was only perceived by half of the 1633 students surveyed as adequate to motivate them to choose advanced mathematics (Hine et al., 2024).

Figure 1

Participants' Reasons for Enrolling in Advanced Mathematics



This finding suggests that teacher recommendations function alongside systemic factors relating to tertiary entrance, reinforcing students' perceptions of the suitability and establishing the legitimacy of their subject choice. From a Nudge perspective, teacher recommendations can be seen as expert advice and may help reduce uncertainty and perceived risk associated with enrolling in the higher-level mathematics subject, particularly for students who are ambivalent about their capabilities.

Study 2: STEM Extension Programs Enrolment

The second study examined students' enrolment in a suite of STEM extension programs in various STEM disciplines (e.g., nanotechnology, astrophysics, bioinformatics) delivered online during school hours. The programs are available at a subsidised fee to students from metropolitan, regional and rural government schools, and have been conducted for several years. An anonymous online survey was administered to alumni of the STEM extension programs, and of more than 500 alumni who were sent the survey, 65 responded (23M, 42F). One of the survey items was "What made you decide to join the STEM extension course?", with an open textbox for students to complete. The 65 qualitative responses were coded and analysed using thematic analysis (Braun & Clarke, 2019). Table 1 shows the types of reasons cited by the students, in total and according to subgroups (location during the time of study, and gender).

A high proportion of students, particularly females (2M, 14F), reported being recommended by their teacher or principal (16 out of 65 students, or 25%). This was the second most frequently cited reason (and the highest frequency for female students) for enrolling in the STEM extension, just behind having a strong interest in STEM (19/64 or 30%). This category excludes five students (4M, 1F) who said they were recommended but were not explicit in stating who recommended them. If we assumed that the recommendations were made by teachers and schools, then teacher/principal recommendations would also be the second-most frequently cited reason by male students. Several students' responses made reference to teacher or principal recommendation:

> My teacher broached the subject with a handful of students truly committed to school and who were fairly switched on when it came to science. (Male, Rural or Regional)
>
> My principal came to me hoping I would be one of the people to try it out and I gladly took up my own time to do this course. (Female, Rural or Regional)

Table 1.

What made students decide to join the STEM extension program

Reason*	Total number and percentage of students (*n*=65)	No. (%) of Males (*n*=23)	No. (%) of Females (*n*= 42)	No. (%) of students from metropolitan areas (*n*=31)	No. (%) of students from rural or regional areas (*n*=33)
Strong interest in STEM	20 (30%)	8 (35%)	11 (26%)	10 (32%)	10 (30%)
Recommended or selected by teacher or principal	16 (25%)	2 (9%)	14 (33%)	7 (23%)	9 (27%)
Interest in specialised subjects	14 (22%)	6 (26%)	8 (19%)	9 (29%)	4 (12%)
Wanted extension in science/maths	13 (20%)	3 (13%)	10 (24%)	5 (16%)	8 (24%)
Preparation for future studies or career	12 (18%)	2 (9%)	10 (24%)	5 (16%)	6 (18%)
Recommended (by unknown)	5 (8%)	4 (17%)	1 (2%)	3 (10%)	2 (6%)
General interest	4 (6%)	2 (9%)	2 (5%)	2 (6%)	2 (6%)
Challenge myself	3 (5%)	0 (0%)	3 (7%)	1 (3%)	2 (6%)
New learning experience	2 (3%)	1 (4%)	1 (2%)	0 (0%)	2 (6%)
Recommended by friend	2 (3%)	0 (0%)	2 (5%)	0 (0%)	2 (6%)

Note. Reasons are not mutually exclusive and thus column percentages add up to more than 100%. Percentages are calculated within gender and location categories in the respective columns.

Other reasons included interest in specialised subjects (as opposed to mainstream science or mathematics subjects), preparation for future studies in senior secondary or university, general interest, a desire to challenge themselves, or a combination of these factors. These findings indicate that teacher and principal recommendations played a vital role in students' (particularly females) awareness of and participation in the STEM extension program. This influence may be pronounced in rural and regional contexts, with students reporting few alternative sources of information about extension opportunities (consistent with Ihrig et al., 2018) ("living in a rural area it is quite difficult to learn more about science", Female, Rural or Regional). In this setting, school leaders and teachers appeared to function as key information channels to opportunity.

The findings highlight the role of recommendations not only in shaping choices among known options, but also in determining which options become visible to students in the first place. From a Nudge perspective, this represents a powerful form of choice architecture, where the availability of options is itself mediated through institutional actors. Unlike mathematics subject selection, participation in the STEM extension program was not constrained by curriculum sequencing or formal prerequisites (such as the need to maximise university entrance scores). The prominence of teacher and principal recommendations in this context suggests that nudging effects operate even in the absence of systemic or structural limits, underscoring the broader influence of educators as choice architects.

Discussion: Teacher Recommendations as Educational Nudges

In the context of senior secondary subject selection, students face a decision characterised by high stakes (future career options) and imperfect information (uncertainty about their own capacity for advanced work). This is a classic scenario where cognitive biases thrive and where a well-placed nudge can be highly effective and strategic (Weijers et al., 2021). The teacher has a *messenger effect* of nudging (Weijers et al., 2025). A teacher's recommendation acts as a

powerful **informational nudge** due to their expertise and epistemic authority (Fried, 2020). This leverages the **authority heuristically** (Weijers et al., 2025), where individuals rely on the judgment of an expert to simplify a complex decision (Fried, 2020). For the student, the cognitive load of evaluating their own aptitude, comparing it to peers, evaluating risks of loss or failure, and projecting future success, is significantly reduced. The teacher's advice effectively transforms the decision from an open-ended question (e.g., Which mathematics subject should I take at senior secondary level?) into an easier confirmation (Should I accept my teacher's recommendation?). The high level of trust students place in their teachers, which is a prerequisite for the nudge's effectiveness, is a critical element of the choice architecture.

In senior secondary mathematics subject selection, students face a high-stakes choice under imperfect information about their own readiness for advanced work, a context that heightens reliance on heuristics and susceptibility to cognitive biases (Weijers et al., 2021). In such conditions, well-designed nudges can structure the choice environment without limiting autonomy, and education studies increasingly document their promise and design considerations (Weijers et al., 2025). Within this choice architecture, the teacher functions as a high-credibility messenger: qualitative evidence from vocational and higher education shows teachers routinely, and often implicitly, deploy nudges that shape students' learning behaviours and choices (Decuypere & Hartong, 2023), while mathematics education research has long observed the salience of teacher authority in classroom interactions (Fried, 2020). This reduces cognitive load by shifting the task from open-ended complex decision-making to a confirm-or-decline evaluation of the teacher's recommended option, which is precisely the kind of cognitive streamlining seen when individuals use heuristics under uncertainty (Weijers et al., 2021). The effectiveness of this nudge depends on trust: students' willingness to treat teachers as legitimate authorities, recognised in mathematics education as a field with distinctive authority dynamics, underwrites the persuasive force of the recommendation (Fried, 2020). Importantly for senior secondary enrolment patterns, Australian research indicates that mathematics teacher leaders' attributions and actions measurably influence students' uptake of higher-level mathematics, aligning with the messenger-effect account of teacher recommendations guiding subject choice.

Overcoming Cognitive Biases: Status Quo and Loss Aversion

The teacher's nudge is particularly effective because it helps students overcome two key cognitive biases that often lead to sub-optimal educational choices:

1. ***Status Quo Bias*:** Students often prefer to stick with the familiar or easier option, which in this context may be a lower-level mathematics subject or simply not applying for an extension program. The teacher's recommendation disrupts this inertia by creating a new, expert-endorsed status quo.
2. ***Loss Aversion***: The decision to take a higher advanced level mathematics subject is often framed by students as a potential loss (e.g., loss of free time, loss of a high grade if they struggle). The teacher's recommendation can reframe the decision, emphasising the **gain** (e.g., access to university courses, a challenging and rewarding experience) and providing a form of **risk mitigation** by assuring the student of their capability.

The data from Study 1, in which the recommendation by mathematics teachers was cited more often than recommendations from other sources (friends, career advisors, family), suggest that the teacher's recommendation exerts a powerful influence. This nudge might steer them toward a logically advantageous choice, helping to overcome possible risks or confidence issues related to selecting the advanced mathematics subject.

The Role of the Nudge in Equity and Access

The findings from Study 2, which highlighted the critical role of recommendations in rural and regional schools (and for females), underscore the importance of teachers' or principals' nudges in promoting **educational equity**. In rural and regional areas, the institutional and informational infrastructure for advanced STEM opportunities is often weaker than in metropolitan schools (Ihrig et al., 2018). A teacher's personal recommendation serves as a **compensatory mechanism**, ensuring that students who might otherwise be unaware of opportunities or unsure of their capabilities are actively guided towards them.

A principal's recommendation, often cited by students from rural or regional schools, acts as a powerful **institutional nudge**. This top-down endorsement provides a strong signal of the program's value and the student's suitability, which can be particularly persuasive in smaller, tightly-knit school communities. This demonstrates that the choice architecture can be manipulated at multiple levels, the personal, relational level (teacher) and the institutional level (principal), to achieve the desired behavioural outcome of increased participation in advanced STEM pathways.

The Ethical Dimension of the Nudge

A key ethical consideration in Nudge Theory is the concept of **libertarian paternalism** (Decuypere & Hartong, 2023). The intervention must be non-coercive and preserve the individual's freedom of choice. A teacher's recommendation meets this criterion, and the strong influence observed across both studies highlights the responsibility teachers hold as choice architects. This influence makes it essential that recommendations are well-informed, equitable, and tailored to individual students, particularly given that in Study 1 the recommendation aligns closely with the student's perceived suitability for the subject.

Across both the mathematics and STEM extension contexts, teacher recommendations acted not simply as supportive advice but as nudges shaping how students interpreted their readiness and the legitimacy of particular pathways. In the mathematics study, they reinforce decisions at key transition points, while in the STEM extension program study, they open opportunities that might otherwise be invisible. Rural and regional data suggest ethical concerns: uneven access to information can make the lack of recommendations act as gatekeepers, foreclosing opportunities even when formally available. Viewing recommendations as nudges foregrounds their ethical impact. They can expand access but also reinforce inequities if influenced by biases related to gender, background, ability, or likelihood of success. Since nudges are not inherently positive and may backfire (Sunstein, 2017; Thaler, 2018), thoughtful and transparent recommendation practices are essential. This framing positions teacher recommendations as a significant yet under-acknowledged mechanism shaping participation and access across mathematics and STEM education systems.

Conclusion

We have argued that mathematics teacher recommendations play a significant and under-examined role in shaping students' participation in advanced mathematics and extension STEM opportunities. Drawing on two studies from Victoria, Australia, and using Nudge Theory and Choice Architecture as an analytic lens, the paper highlights how recommendations operate as subtle but powerful influences on student decision-making. Recognising recommendations as nudges invites renewed attention to their ethical, pedagogical, and policy implications, particularly in relation to equity and access in mathematics education.

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