STEM Higher Education and Mature-Aged Students: Building a Model for Well-Being and Institutional Support

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ABSTRACT

Aim. As the global demand for Science, Technology, Engineering, and Mathematics (STEM) graduates continues to rise, ensuring the well-being of diverse student groups, including mature-aged students (ages 30 and above), is increasingly recognised as essential for fostering inclusive and sustainable higher education systems. This study explores the well-being dimensions of mature-aged students in STEM programmes through a case study of Riga Technical University (RTU) in Latvia.

Methods. Adopting a mixed-methods approach - combining a systematic literature review, a survey, and semi-structured interviews with mature-aged STEM students - the research investigates five key well-being dimensions: academic, financial, physical, psychological resilience, and relational.

Results. The findings reveal that mature-aged STEM students' well-being is shaped by three interrelated factors: academic–relational climate, resource strain and well-being burden, and academic skills and literacies. Faculty engagement, respectful communication, and inclusive learning environments significantly support academic and relational well-being. However, financial and psychological challenges - often linked to work-study-family tensions - require coordinated institutional and policy-level responses.

Conclusions. The results underscore the need for flexible academic structures, accessible faculty, and integrated support services. A conceptual model is proposed to guide institutional support, highlighting how systemic interventions across all five

well-being dimensions can foster inclusive and sustainable engagement for mature-aged learners in STEM education.
Keywords: STEM, higher education, mature-aged students, well-being, model, diversity

Introduction

The increasing diversity of student populations in higher education (Ward et al., 2025) and demographic challenges in various regions (Grawe, 2021) have highlighted the importance of understanding and addressing the specific needs of mature-aged students, particularly those enrolled in Science, Technology, Engineering, and Mathematics (STEM) programmes (Jekabsone et al., 2025). Mature-aged students – in this study defined as individuals aged 30 and above - bring unique experiences, perceptions, motivations, and challenges to their academic pursuits. Promoting inclusive and sustainable higher education systems necessitates interventions that extend beyond individual institutions. Policy-level frameworks, national strategies, and cross-institutional collaborations are critical to ensuring equitable access (Filippou et al., 2025), supporting diverse learning pathways (Gianoutsos et al., 2021), and addressing the structural barriers (Heffernan, 2024) that mature-aged students often encounter. As lifelong learning becomes essential, higher education worldwide must also become accessible to people of all ages (Zeide & Kalvane, 2023). To reduce the dropout rates especially related to student adaptation, personality, teacher-student relationship, and quality in university education (Lorenzo-Quiles et al., 2023; Slišāne & Rubene, 2021), this study seeks to explore these aspects in the Latvian context by addressing two interrelated research questions:

- What institutional support mechanisms do universities implement to promote the wellbeing of mature-aged STEM students?
- What institutional and policy-level interventions are necessary to promote inclusive and sustainable support systems for mature-aged students in STEM education?

The aim of the research is to investigate the institutional support mechanisms and necessary policy-level interventions to enhance the well-being of mature-aged students in STEM education in Latvia.

Methodology

The study is grounded in the premise that well-designed institutional and policy-level interventions - particularly those targeting academic-relational support, resource-related pressures, and the development of academic competencies - play a critical role

in enhancing the well-being and educational success of mature-aged students enrolled in STEM programmes.

At the same time, the study responds to a persistent gap in empirical research concerning the ways in which such institutional and policy frameworks effectively support the well-being and retention of mature-aged STEM students. Although this group represents a growing segment of the higher education population, their specific needs and challenges remain underexplored and insufficiently addressed within existing student support structures.

To investigate this problem, the following research objectives were defined:

- To analyse the profile and characteristics of mature-aged students in higher education;
- To identify good practices and institutional support mechanisms implemented by universities to enhance the well-being of mature-aged STEM students;
- To explore the needs, perceptions, and challenges related to existing support systems for mature-aged STEM students, using the case of Riga Technical University;
- To propose evidence-based institutional and policy-level interventions that strengthen support systems and promote the well-being of mature-aged learners in STEM programmes.

To achieve these objectives, a mixed-methods research design was employed, integrating both quantitative and qualitative approaches. This design was chosen to allow for a comprehensive examination of the research questions: the quantitative component provides generalisable insights into patterns and trends in student well-being, while the qualitative component offers deeper understanding of lived experiences and context-specific challenges.

The research methodology, including all instruments and data collection procedures, was reviewed and approved by the Riga Technical University Research Ethics Committee (Decision No. 04000-10.1-e/17, dated 3 April 2025).

Data Collection

The data collection for this study involved a multi-faceted approach, combining quantitative surveys, in-depth qualitative interviews with students, and desk research to gain a comprehensive understanding of support mechanisms.

Survey Research

A structured survey questionnaire was developed as the primary research instrument, drawing on established frameworks of student well-being (Khatri et al., 2024; Eloff et al., 2021) and adapted to the context of mature-aged students in STEM programmes.

The instrument aimed to measure five well-being dimensions: academic, financial, physical, psychological resilience, and relational well-being. It consisted of 28 items, grouped across these domains, and employed a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

To ensure content validity, survey items were aligned with the theoretical constructs from the literature and were reviewed by two independent experts in educational psychology and STEM pedagogy. Face validity was further confirmed through a pilot test with 10 mature-aged students not included in the final sample, who assessed the questionnaire for clarity, relevance, and comprehensibility. Minor wording adjustments were made based on their feedback.

The survey was administered electronically using RTU's internal student communication system from 20 April to 25 May 2025, targeting all mature-aged STEM students (aged 30+) enrolled at the university (N = 1228). A total of 119 valid responses were collected, representing approximately 10% of the population, with a margin of error of ±8.5% at a 95% confidence level. This quantitative data offered a general overview of student perceptions across well-being dimensions and served as a foundation for triangulation with qualitative findings.

Semi-Structured Interviews

For the in-depth exploration, semi-structured interviews were conducted with a purposive sample of mature-aged STEM students who had previously participated in the survey and expressed willingness for follow-up. Of the 24 students who volunteered, 6 were selected to ensure diversity in terms of gender, study level (Bachelor/Master), and study mode (full-time/part-time). This sample size aligns with qualitative research practices for achieving thematic depth rather than generalisation (Patton, 2014; Guest et al., 2006). Interview questions, developed from initial survey results and literature insights, focused on personal experiences related to well-being, perceived institutional support, and suggestions for improvement. All interviews were conducted online via MS Teams, lasting up to one hour, with informed consent obtained and minutes prepared and harmonised with interviewees. This qualitative component is crucial for understanding the nuanced perspectives and lived experiences of mature-aged students.

Desk Research

To map existing support systems within Latvian universities, comprehensive desk research was conducted. This involved reviewing official university websites, policy documents, student handbooks, and publicly available reports related to student

services, academic support, financial aid, and career development. The objective was to identify the formal and informal mechanisms in place to support mature-aged students, including specific programmes, resources, and initiatives designed to address their unique needs.

To ensure the credibility and comprehensiveness of the findings, data triangulation was implemented by integrating quantitative results from the survey with qualitative insights from the in-depth interviews and staff discussions, complemented by findings from the desk research.

Data Analysis

For quantitative data analysis descriptive statistics (mean, standard deviation, mode, median) were calculated for the survey indicators to assess mature-aged STEM students' evaluations of various well-being dimensions and faculty influence. Further analysis involved identifying statistically significant differences across programme levels (College, Bachelor, Master) and age groups using appropriate statistical tests (e.g., chi-square tests) where applicable.

The qualitative data - semi-structured interview from students - underwent a rigorous inductive qualitative analysis process, primarily following the principles of thematic analysis (Braun & Clarke, 2006). This process involved three main stages to systematically derive meaning from the rich textual data:

- Data reduction and coding - initial codes were generated directly from the data, reflecting an inductive approach;
- Data representation and organisation. This involved searching for patterns, relationships, and connections among the various codes. The aim was to condense the extensive interview data into a more compact and coherent set of information, allowing for the identification of overarching concepts and narratives related to mature-aged student profiles, institutional support mechanisms, and perceptions of well-being. This stage is crucial for reorganising the detailed codes into a structured framework that facilitates deeper interpretation (Miles & Huberman, 1994);
- Conclusions and ensuring scientific strength: The final stage involved drawing conclusions from the organised themes and sub-themes. This required interpreting the meaning of the analysed data in relation to the research questions, assessing the relevance of the identified themes, and cross-referencing findings.
- The integration of qualitative findings provides a deeper context and explanation for the quantitative results, leading to a holistic understanding of mature-aged students' well-being and the role of institutional support. Findings from the desk research will provide contextual information regarding existing formal support structures in Latvian universities, complementing the qualitative insights from students and staff.

Triangulation of Data

To enhance the credibility, reliability, and depth of the findings, data triangulation was applied by integrating data from multiple sources and methods. Specifically, quantitative survey results capturing broad trends in mature-aged STEM students' well-being were combined with qualitative insights derived from semi-structured interviews to provide contextualised, lived experiences. These findings were further complemented by desk research that mapped institutional support systems across universities, enabling the comparison of formal structures with students' perceptions. This multilayered approach allowed for cross-validation of results, identification of converging or diverging patterns across data sets, and the development of a more comprehensive understanding of how institutional support mechanisms influence the well-being of mature-aged students.

Literature Review

Mature-Aged Student Profile

Mature-aged students in higher education are generally defined as those who begin their studies at approximately the age of 21 to 23 and beyond (Citizens Information, 2024). The experiences of these students – both life and academic – are often different from those of students who begin their studies directly after high school. There can be personal, professional, or financial issues that cause them to start studies later than usual. Students over the age of 30 participated in this study.

Mature-aged students' decisions to pursue higher education are often influenced by personal and family circumstances (Chapin et al., 2024). One of the reasons can be future or existing career opportunities (Wong & Hoskins, 2022).

In regards to the barriers, mature-aged students face a variety of challenges that can impact their academic performance and well-being. Mature-aged students in the most cases work while studying, which creates challenges for them to balance work, family, and study duties (Baglow & Gair, 2019; Dervis et al., 2022; Crawford & McKenzie, 2023). Also, low socioeconomic status can influence dropout of mature-aged students (Padilla-Carmona et al., 2020).

Despite these challenges, mature-aged students often exhibit remarkable resilience and determination (Steel et al., 2024). Their life and work experiences enrich discussions during the study process, and they better understand the material (Brunner & Ehlers, 2022). Many mature-aged students have good study skills (Crank & Spence, 2024) and they are goal-oriented, which contributes to their academic success (Tilley, 2024).

Studies show that mature-aged students need tailored support that meets their unique needs. This can include financial assistance, flexible learning, childcare support,

and individualised counseling (Fischer & Kilpatrick, 2023; Macqueen et al., 2023). Some universities use mentoring programmes and peer networks that help students feel a sense of belonging to the student community (Nabi et al., 2024). For mature-aged students, an inclusive learning environment and academic support system are important to help them to complete their studies (Brunner & Ehlers, 2022).

In addition, mature-aged students often struggle to balance their academic responsibilities with family and work commitments. Time balancing often determines students' academic success, so that an individualised approach would be very supportive (Bick et al., 2024). Academic resilience is characterised by a student's ability to improve their academic performance after adverse events (Steel et al., 2024).

Next, the institutional support mechanisms are reviewed in the context of addressing the challenges and needs of mature-aged students.

Institutional Support Mechanisms

Institutional support is a crucial element in ensuring well-being and successful engagement in studies, especially for students who need to overcome knowledge gaps. These mechanisms often include programmes that aim to provide students with basic academic skills, fill knowledge gaps, improve stress management skills and prepare them for undergraduate studies. Universities may also offer preparatory programmes, which are open-access preparatory courses. These programmes are designed to respond to the diversity of students, taking into account different ages, cultural backgrounds and previous educational experiences, helping to develop academic literacy, numeracy and critical thinking, as well as building students' confidence (Crawford, 2014; Lisciandro & Gibbs, 2016). Some universities have also introduced specialised support classes to create a supportive learning environment and community that is proactive and responsive to students' needs (Crawford et al., 2016). The structure of these programmes is considered to be well-organised and helps to overcome knowledge gaps.

One aspect of a student support system is offering flexibility in study programme/course structures and making faculty available to students both in and out of class. A one-size-fits-all approach may not be appropriate, especially for those facing financial or psychological challenges (Douwes et al., 2023b). Lecturers play a crucial role in providing support and flexibility to students (Douwes et al., 2023b). The accessibility of the lecturer is also important, allowing the student to feel supported and to encourage engagement (Holles, 2021). This includes the availability, responsiveness and support of lecturers both in and out of class (Eloff et al., 2021; Baik et al., 2019). Lecturers can provide additional academic support by re-explaining content and being available for consultations outside of class time.

The relationship between academic staff and students is also important in the context of student well-being. Several research papers indicate that positive faculty-student relationship has an impact on student study motivation and engagement (Stroet et al., 2013, as cited in Douwes et al., 2023a), as well as on reducing stress factors in the learning environment (Baik et al., 2019; Eloff et al., 2021; Ryan et al., 2021, as cited in Douwes et al., 2023a). Research claims that faculty can provide academic and emotional support to students through encouragement, showing concern and being available (Eloff et al., 2021; Holles, 2021). Faculty from students' point of view often is perceived as confidants, monitors of student progress, and "connectors" who help students receive other support services (Douwes et al., 2023a). Rynke Douwes et al. (2023a) in his research says that faculty should play a "signaling" role, noticing and helping to address students' well-being issues (Douwes et al., 2023a). Essential qualities of these educators include an empathetic attitude, accessibility, and a demonstrated commitment to accessibility (Douwes et al., 2023b).

The educational institution's climate and the perceptions of faculty themselves have a significant influence on the effectiveness of student support systems. The institutional environment, defined by its policies, structure, and culture, can both promote and constrain student and staff well-being (Eloff et al., 2021; Holles, 2021). Barriers such as limited access to support staff (mentors, tutors, psychologists, etc.), high faculty workloads, and large student groups can weaken faculty-student relationships and hinder the provision of support (Eloff et al., 2021). Faculty feel unsupported at the institutional level, while students report that inflexible policies and faculty unavailability negatively impact their well-being (Holles, 2021). Although positive teacher attitudes are crucial to the success of well-being interventions (Byrne et al., 2022), some teachers view well-being negatively because it creates additional workload and emotional burden for students, which they believe interferes with the delivery of the core curriculum (Byrne et al., 2022). Research suggests that creating a sense of belonging and an inclusive culture is critical to student success (Wilson Fadiji & Eloff, 2024).

In addition, faculty influence on student well-being extends beyond academic instruction, serving as a key source of social and emotional support that shapes students' motivation, psychological resilience, and sense of belonging. Essential qualities include pedagogical competence, clear communication, and responsive feedback adapted to students' academic and personal contexts (Douwes et al., 2023b). While existing literature identifies traits of supportive faculty, less focus is placed on how these are enacted in practice. Irma Eloff, Sumari O'Neil, and Herbert Kanengoni (2023) offer a taxonomy of six themes reflecting faculty roles in student well-being, which this study organises into two main dimensions: relational (direct contact) and professional (teaching style and approach). This framework informs the analysis of mature-aged students' experiences in STEM programmes.

Results

Thematic Analysis of Interviews

The thematic analysis of the interviews revealed five interrelated dimensions of well-being among mature-aged STEM students: academic, financial, physical, relational, and psychological resilience.

Academic Well-being

Academic well-being was shaped by students' ability to manage transitions, access resources, and receive faculty support. Some respondents described the difficulty of adapting to a new study field but acknowledged that well-structured programmes helped bridge knowledge gaps: "That transition from one field to another was challenging… but the programme was smoothly designed, so we could cover the gap." (Respondent No 6)

Others emphasised improvements in access to study materials and communication with teachers:"Everything is different now… materials are available online, and teachers are approachable, so it is possible to communicate with them." (Respondent No 4) (Here and below, quotes from respondents No 1, 2, 3, 4 and 5 are translated from Latvian.)

These insights underline that flexible programme structures and accessible faculty significantly enhance mature-aged students' academic engagement. At the same time, they reveal the importance of institutional policies that support re-entry and transition pathways, modular scheduling, and faculty development in inclusive pedagogy.

Financial Well-being

Financial well-being appeared as a decisive factor in shaping students' overall experience. For some, stable income or family resources eliminated financial concerns:"Our family has sufficient finances, so it does not affect my well-being." (Respondent No 4)"I am fully providing for myself and my family, so financial issues are not relevant for me." (Respondent No 5)

In contrast, others expressed concerns about meeting daily expenses while studying:"…it creates a bit of stress — whether I will manage to pay all the bills and if the money will be enough." (Respondent No 3)

These accounts demonstrate the uneven financial realities among mature-aged students. Those without stable support systems are at greater risk of stress and disengagement, indicating a strong need for institutional and policy measures such as targeted scholarships, tax relief, and employer co-financing schemes that can reduce financial pressure and enable sustained participation in STEM programmes.

Physical Well-being

Students also reflected on the ways in which their studies influenced their physical well-being. Remote learning, particularly during the COVID-19 period, was described as detrimental:"COVID times cut into my health — sitting far from the screen did not improve it at all." (Respondent No 2).

At the same time, others noted that logistical aspects of studying could encourage physical movement: "Lectures in different places — maybe it even made me move more." (Respondent No 4).

Such contrasting experiences suggest that while mature-aged students often deprioritise health under academic demands, institutional structures can play a role in promoting healthier lifestyles. Ensuring access to sports infrastructure, designing campuses that encourage physical activity, and supporting sustainable commuting options are important strategies to integrate physical well-being into higher education policy.

Relational Well-being

Relational well-being highlighted both challenges and resources derived from peer and faculty relationships. Some students described difficulties associated with generational differences: "I strongly feel the age difference… I was more like their parents' age." (Respondent No 4).

However, others experienced collegiality and mutual support: "We helped each other… I also felt useful and younger." (Respondent No 2).

Relational well-being was further strengthened when students felt a broader sense of belonging: "Now the situation is different — it's great to communicate with classmates not only about studies but also about other things." (Respondent No 3).

International students particularly emphasised the importance of supportive relationships: "We are far from our home. So, we feel that we have someone here." (Respondent No 6).

These narratives reveal that while age differences can create feelings of isolation, peer support and inclusive teaching practices are powerful enablers of belonging. Universities should therefore strengthen mentoring initiatives, intergenerational peer networks, and faculty training in inclusive pedagogies to sustain relational well-being.

Psychological Resilience

Psychological well-being and resilience were closely tied to stress and coping mechanisms. Some respondents reported difficulties in managing time and stress: "I do not manage stress very well, because I tend to postpone everything until the last minute." (Respondent No 4).

Others described how academic pressure made it difficult to disengage: "It is very difficult to disconnect, because the thoughts about studies are always in my head." (Respondent No 3).

These accounts show that while maturity provides a certain degree of resilience, structural barriers such as heavy workloads and limited counselling services undermine psychological well-being. Institutional responses need to include accessible psychological support, systematic awareness campaigns, and resilience-building initiatives embedded into STEM programmes.

Quantitative Analysis of Survey Questionnaires

The survey data were suitable for latent-structure analysis (Bartlett's $\chi^2 = 1545.98$, $p \approx 3.6 \times 10^{-124}$; KMO = .773). Using Horn's Parallel Analysis, we retained three factors and estimated an EFA with minimum residual (minres) extraction and oblimin rotation. The solution explained 39.37% of total variance (F1 = 16.40%, F2 = 11.69%, F3 = 11.28%), Internal consistency was $\alpha = .844$ (F1), $\alpha = .677$ (F2; after aligning item polarity within this factor), and $\alpha = .814$ (F3). The exploratory factor analysis yielded a three-factor structure that mirrors the lived realities reported by mature-aged STEM students (Table 1). Rather than isolating discrete checklists, the solution sketches an ecosystem in which academic quality is experienced through relationships, strain accrues across multiple life domains, and skills function as a scaffold for sustained participation.

Table 1

Top-loading Items per Factor

Factor	Question code	Question (Item)	λ
Factor 1	Q1	I am satisfied with the quality and availability of the teaching staff.	0.84
	Q30	I feel that I am generally listened to and respected at the University.	0.80
	Q5	I feel included and supported in my academic environment by the University	0.80
	Q3	The content of the courses is current and meets my needs.	0.73
Factor 2	Q20	I often experience physical fatigue or burnout related to my studies.	0.75
	Q19	The academic load negatively affects sleep quality and energy levels.	0.67
	Q21	I can effectively deal with the stresses of my studies.	0.66
	Q24	Academic requirements significantly affect my psychological well-being.	0.55
Factor 3	Q9	Digital/Technology Literacy	0.76
	Q10	Information Literacy	0.75
	Q7	Critical Thinking	0.69
	Q8	Ability to Learn	0.67

Source. Own research.

Factor 1 — Academic–Relational Support and Institutional Climate

Factor 1 gathers together what students encounter first and feel most strongly in their everyday study lives: approachable, competent staff and a respectful, inclusive climate. Items that load most heavily - satisfaction with teaching staff (Q1, $\lambda = .84$), feeling listened to and respected (Q30, $\lambda = .80$), and experiencing inclusion and support from university staff (Q5, $\lambda = .80$) - indicate that academic quality is read through a relational lens. Substantive loadings also appear on content relevance (Q3, $\lambda = .73$), suggesting that when course content aligns with needs and resources are genuinely usable, students perceive the environment as coherent and enabling.

Factor 2 — Resource Strain and Well-being Burden

Factor 2 traces a braided current of strain that runs through students' bodies, calendars, and budgets. The strongest signals come from physical fatigue and disrupted sleep (Q20, $\lambda = .75$; Q19, $\lambda = .67$) together with psychological demands and coping (Q21, $\lambda = .66$; Q24, $\lambda = .55$). Interlaced with these are financial capacity and stress. Statistically, these indicators travel together; interpretively, they describe a single lived situation in which paid work, family responsibilities, and study load pile up in the time.

Factor 3 — Academic Skills and Literacies

Factor 3 isolates the competence layer that allows students to stay afloat and move forward: digital and information literacy (Q9, $\lambda = .76$; Q10, $\lambda = .75$), critical thinking and the ability to learn (Q7, $\lambda = .69$; Q8, $\lambda = .67$), a sense of having the skills needed for study. Here the loadings form a clear profile: students' progress is buttressed by capacities that can be learned, refreshed, and recognised.

Discussion

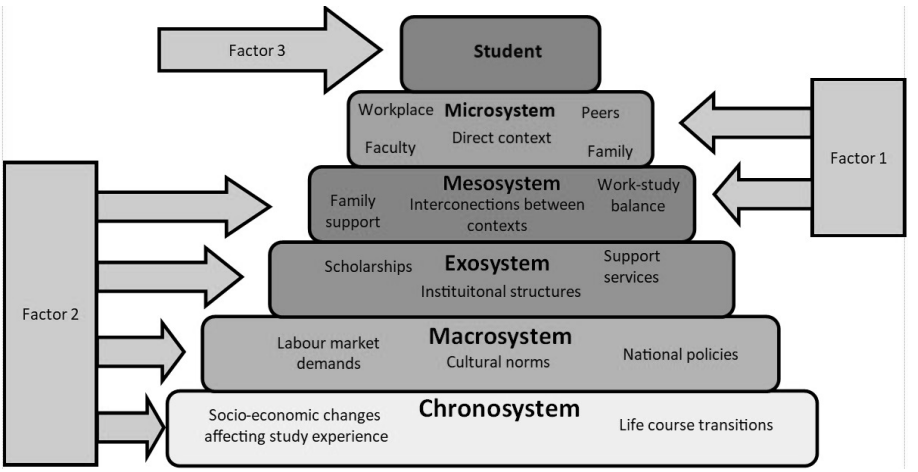
The present study's findings reveal a nuanced understanding of mature-aged STEM students' well-being, best elucidated through an adapted Bronfenbrenner's bioecological model (Bronfenbrenner, 1989; Bronfenbrenner & Morris, 2006) to conceptualise mature-aged STEM students as active agents embedded in and influenced by multiple interconnected systems. This integrated framework allows for a comprehensive analysis, illustrating how five core well-being dimensions – academic, financial, physical, relational, and psychological resilience – are not isolated but are dynamically shaped

by multiple, nested environmental systems. By applying this lens, we move beyond individual-centric explanations to appreciate the systemic factors influencing student success and persistence within higher education.

Our mixed-methods analysis further specifies three interrelated factors that critically impact mature-aged STEM students' well-being: (1) Academic–Relational Support & Institutional Climate [F1], (2) Resource Strain & Well-being Burden [F2], and (3) Academic Skills & Literacies [F3]. These factors, derived from our empirical data, are embedded within the layers of Bronfenbrenner's model, offering a robust conceptual framework for understanding well-being needs and guiding intervention design. This model is visually represented in Figure 1, illustrating the multi-level influences on these key factors.

Figure 1

Adapted Bronfenbrenner's Bioecological Model for Mature-Aged STEM Students' Well-being Needs



Source. Own research, adapted from Bronfenbrenner & Morris, 2006.

The model delineates how each factor is influenced by the interconnected systems. For instance, Academic–Relational Support & Institutional Climate (F1) largely operates within the microsystem (e.g., direct interactions with faculty and peers, classroom climate) and mesosystem (e.g., the cohesion between study groups and mentorships), yet is profoundly shaped by exosystemic (e.g., university policies on inclusive pedagogy, faculty training initiatives) and macrosystemic (e.g., broader societal values on higher education and STEM importance) factors. This multi-level influence underscores the necessity of a holistic approach to fostering a welcoming and academically stimulating environment, emphasising that interventions purely at the individual level are insufficient without systemic considerations.

Similarly, Resource Strain & Well-being Burden (F2), encompassing financial challenges, psychological stress, and physical health, emanates from a complex interplay across all ecological levels. While daily financial pressures and work-study-family tensions manifest within the microsystem, the mesosystem highlights the conflicts arising from balancing these multiple roles. Exosystemic factors such as institutional financial aid policies and mental health support services, alongside macrosystemic influences like national economic policies and cultural attitudes towards adult learners, significantly mitigate or exacerbate this strain. Finally, Academic Skills & Literacies (F3) are developed through individual efforts within the microsystem, reinforced by peer collaboration in the mesosystem, and scaffolded by exosystemic (e.g., university workshops, academic support centers) and macrosystemic (e.g., national curricula standards, evolving demands of the job market) structures. The chronosystem, encompassing life-course transitions and broader socio-economic changes (e.g., the diffusion of AI in higher education), acts as a continuous conditioner, impacting the exposure to strain and the effectiveness of support mechanisms over time, thereby necessitating adaptive and flexible interventions.

In short, relational climate welcomes, skills scaffold, and integrated supports buffer strain. Together - and across time - these mechanisms form an ecological pathway to inclusive and sustainable well-being for mature-aged STEM students.

Complementing the bioecological model, layered matrix of institutional and policy-level interventions (Table 2) aligns the five well-being dimensions with interventions grounded in the quantitative factors - [F1] Academic–Relational Climate, [F2] Resource Strain/Burden, [F3] Skills & Literacies - and qualitative insights.

Table 2

Layered Matrix of Institutional and Policy-level Interventions for Mature-aged STEM Students

Well-being Dimension	Institutional Interventions	Policy-Level Interventions
Academic	• Andragogy & inclusive pedagogy training; norms for approachability & respectful feedback [F1] • Work-integrated learning with flexible placements; evening/weekend labs; virtual labs [F1] • Recognition of Prior Learning (RPL) with transparent mapping to STEM curricula [F1] [F3] • Modular/block scheduling; hybrid delivery; extended library/It hours [F1] • Course relevance reviews with industry panels; OER adoption [F1]	• National RPL standards and micro-credential frameworks [F1] [F3] • Targeted funding for WIL/placements and lab modernisation (incl. virtual/remote kits) [F1] • Performance metrics tying institutional funding to mature-aged retention/engagement [F1] • National broadband/OER support to reduce access gaps [F1] [F3]

Well-being Dimension	Institutional Interventions	Policy-Level Interventions
Financial	• Targeted bursaries for mature-aged learners; 48-hour micro-grants for emergencies [F2] • Flexible fee payment plans; tuition caps for part-time progression [F2] • Employer co-financing MOUs; paid internships/apprenticeships [F2] • Embedded financial coaching/literacy within programmes [F2]	• Tax credits/deductions for adult study; income-contingent loans [F2] • Statutory study-leave entitlements/return-to-learn incentives for employers [F2] • National/sector scholarship funds for mature-aged STEM up/re-skilling [F2] • Childcare subsidies linked to enrolment; portable benefits for part-time workers [F2]
Physical	• Timetable protected well-being hour; predictable scheduling to support sleep [F2] • After-hours campus safety, lighting & shuttle; lockers/showers for active commuting [F2] • Telehealth/occupational health for lab-intensive programmes; ergonomic audits [F2]	• Subsidised public transport passes; cycling infrastructure grants [F2] • Health-promotion funding for HEIs (sleep, fatigue & injury prevention in STEM) [F2] • Minimum campus safety standards for evening/weekend provision [F2]
Relational	• Cohort-based timetabling & small-group seminars for belonging [F1] • Near-peer & intergenerational mentoring (incl. international student pairing) [F1] • Faculty availability standards (office hours; response-time SLAs) [F1] • Community-of-practice events & networking for working adults (after hours/online) [F1] • Anti-ageism & inclusion training for staff/students [F1]	• Inclusion benchmarks in accreditation; funding tied to belonging/persistence indicators [F1] • Visa/immigration facilitation for international mature-aged students [F1] • National incentives for intergenerational mentoring programmes [F1]
Psychological	• Stepped-care model: triage → groups/workshops → counselling; after-hours/tele-counselling [F2] • Curriculum-embedded mental-health literacy & stress-management in STEM [F2] • One "no-questions" flexible deadline per course; workload calibration & assessment spacing [F2] • Analytics-enabled proactive outreach with human case-management [F2][F1]	• Minimum counsellor-to-student ratios; sustained mental-health funding in HE [F2] • National crisis-line integration with universities; protected mental-health leave [F2] • Quality Assurance standards requiring stepped-care availability and after-hours provision [F2]

Source. Own research.

Conclusions

This study set out to explore two key questions: (a) What institutional support mechanisms do universities implement to promote the well-being of mature-aged STEM students? and (b) What institutional and policy-level interventions are necessary to promote inclusive and sustainable support systems for mature-aged students in STEM education? The findings demonstrate that while mature-aged students (aged 30 and above) bring valuable life experience, motivation, and resilience to higher education, they face unique challenges - particularly in balancing academic responsibilities with work and family obligations. These difficulties have at least two consequences. For existing students, they increase the risk of dropping out, especially if financial strain, psychological stress, and physical exhaustion are experienced in isolation. The second risk can be described as student attrition, in the sense that, considering all the potential difficulties, 30-plus people do not decide in favour of starting their studies.

A mixed-methods approach - drawing on literature review, student survey, and qualitative interviews - revealed three interlinked factors shaping student well-being: [F1] Academic - Relational Support & Institutional Climate, [F2] Resource Strain & Well-being Burden, and [F3] Academic Skills & Literacies. Faculty engagement emerged as central: students consistently highlighted the positive impact of accessible, empathetic, and responsive staff who foster inclusive academic environments. Relational support from both faculty and peers not only promotes academic success but also nurtures a sense of belonging and motivation. However, students reported that financial burdens, psychological strain, and neglect of physical well-being often remain insufficiently addressed - requiring coordinated institutional and policy-level interventions that go beyond classroom engagement.

Guided by Bronfenbrenner's bioecological model, the research mapped student experiences across microsystem to chronosystem levels, showing how well-being is shaped by interconnected personal, institutional, and structural factors. Faculty - student relationships, inclusive pedagogy, and targeted academic supports function most effectively when embedded within a broader framework of flexible learning structures, mental health resources, financial assistance, and national policies that recognise the needs of mature-age learners.

To address these multi-layered demands, the authors propose a layered matrix of interventions that aligns each well-being dimension - academic, financial, physical, relational, and psychological - with concrete institutional and policy actions. These include andragogical training for staff, Recognition of Prior Learning (RPL), hybrid course delivery, targeted bursaries, stepped-care mental health models, and performance-based funding tied to mature-aged engagement. Ultimately, fostering sustainable participation in STEM education requires not only recognising mature-aged students as a diverse and growing demographic but also redesigning higher education ecosystems to support their long-term well-being, retention, and contribution to inclusive societal progress.

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