From Survival to Innovation: How Loan Adequacy Influences STEM Graduates' Innovation Capacity in Uganda

TOM DAVID ORACE[1]*, JOSEPH RWOTHUMIO[2], DAVID ONEN[3]

[1]*School of Education, Kyambogo University, P. O. Box 1, Kampala, Uganda, Email; t.dorace@gu.ac.ug ORCID ID; https://orcid.org/0009-0006-7486-6079

[2]School of Education, Kyambogo University, P.O. Box 1, Kampala, Uganda, Email: rwothumiojoseph@yahoo.com

[3]East African School of Higher Education Studies and Development, Makerere University, P.O. Box 7062, Kampala, Uganda, Email: david.onen@mak.ac.ug

*Corresponding author: t.dorace@gu.ac.ug

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Abstract

Economic transformation requires Science, Technology, Engineering and Mathematics (STEM) graduates who are innovators and problem-solvers, not just degree-holders. This study explores how student loan adequacy influences students' capacity for innovation in STEM programmes at Uganda's public universities. We employed a mixed-methods approach, combining quantitative survey data from 430 STEM students across four universities, 12 in-depth qualitative interviews with university administrators, and eight focus group discussions with 61 student participants. A simple linear regression model assessed the influence of perceived loan adequacy on students' innovation capacity. The findings indicate that loan adequacy is significantly associated with innovation capacity ($\beta = 0.32$, $p < .001$), although the model explains a modest proportion of variance. The analysis also examined participation in innovation-related activities, including internships, research projects, and entrepreneurial initiatives. Interview participants reported that financial constraints frequently

limited engagement in these innovation-related learning activities that contribute to innovation capacity development. For example, many students reported foregoing internships (78%), lacking access to specialised computing resources (65%), or undertaking time-consuming income-generating activities to meet basic needs. These constraints may reduce opportunities for practical innovation during university training. Overall, the findings suggest that loan inadequacy may function as an important structural constraint shaping how students allocate time and learning effort during their studies, with implications for innovation capacity development at the student level. Current loan models, therefore, risk supporting programme completion while limiting participation in innovation-oriented learning opportunities.

Keywords: *STEM education; Adequacy; Economic transformation; Innovation; Uganda.*

Introduction

Uganda's national aspirations, as articulated in Uganda Vision 2040 and the Third National Development Plan (NDP III), emphasise the transition from a predominantly agrarian economy to a modern, knowledge-based, and competitive society (National Planning Authority, 2020). Innovation drives this transformation, particularly in Science, Technology, Engineering and Mathematics (STEM), which are widely recognised as key drivers of productivity growth and technological advancement (World Bank, 2020). The nation's higher education institutions are, therefore, expected to produce not only graduates, but also engineers who can build, scientists who can discover, and technologists who can develop solutions to local challenges, thereby contributing to sustainable economic growth (Ministry of Education and Sports [MoES], 2020; World Bank, 2020).

In response to this national priority, the Government of Uganda established the Higher Education Students' Financing Board (HESFB) in 2014, a policy intervention aimed at expanding access to higher education in critical fields of study, particularly STEM disciplines. Reports from the Board indicate significant progress in this regard, with more than 70% of student loans directed towards these priority fields (HESFB, 2019).

Although these developments have broadened students' access to higher education, they also highlight the broader conditions under which students pursue their studies. More precisely, it is less clear whether current financing models effectively foster access to learning experiences conducive to the development of innovation-integrated competence.

The existing literature on higher education financing and STEM development has focused primarily on the nexus between funding and access, enrolment growth, and completion rates, and has generally confirmed that student assistance programmes enhance participation in higher education, especially in STEM fields (World Bank, 2020; HESFB, 2019). Other studies have extended this debate by relating greater STEM enrolment to national innovation-related outcomes, including graduate employability, patent output, and entrepreneurship ecosystems (Bloom et al., 2014). However, these studies mostly examine aggregate educational or macro-level innovation indicators, with limited attention to the micro-level learning processes through which students convert educational opportunities into innovation-related competencies and capabilities as they progress academically.

In particular, empirical studies on the impact of loan adequacy or other financial conditions on students' day-to-day participation in innovation-related academic activities, such as research projects, internships, laboratory work, and entrepreneurial experimentation, remain sparse. This gap is significant because it creates a conceptual and empirical disconnect between education inputs, such as financial support and enrolment expansion, and student-level innovation capacity development, making it difficult to understand why increased access to STEM education does not always translate into stronger innovation-related engagement or competency development.

This study addresses this gap by shifting the focus from access and completion outcomes to students' lived academic experiences, investigating how loan adequacy and financial precarity relate to innovation-related engagement and competency development among STEM students. This mixed-methods study integrates quantitative patterns of students' financial experiences with qualitative accounts from students and administrators to describe how financial constraints

shape the development of innovation capacity at the student level within higher education in Uganda.

Study objectives

The general objective of this study was to examine how student loan adequacy influences students' innovation capacity in STEM programmes at Uganda's public universities. **S**pecifically, the study sought to:

1. Assess the perceived adequacy of student loans in meeting the academic needs of STEM students in public universities in Uganda.
2. Examine how financial precarity associated with student loan limitations influences STEM students' academic experiences and opportunities for innovation and professional development.
3. Determine the relationship between perceived loan adequacy and innovation capacity in STEM programmes in public universities in Uganda.

Literature Review

Student loan adequacy and innovation capacity in STEM programmes

The adequacy of student loans is crucial for the education and development of advanced competencies among STEM graduates. For example, Burns and Webber's (2019) research found that students with adequate financial resources can focus on their studies rather than on financial survival, and that these students achieve better academic outcomes and persist in difficult programmes. Indeed, robust empirical evidence indicates that appropriate financial investments are critical determinants of college student retention and graduation rates (Marshall, 2021; Wang, 2025; Zimmerman et al., 2025). In STEM programmes that frequently require very intensive academic and laboratory-based learning, financial resources for students can be particularly important for continued academic progress.

At the same time, the literature suggests that the relationship between student borrowing and academic outcomes is not linear. While moderate borrowing may support educational continuity, excessive financial burdens often generate stress that negatively affects

academic performance and increases the risk of dropout (Mahmoud et al., 2024). Studies further indicate that financial pressure may shape post-graduation trajectories, with highly indebted students tending to prioritise immediate income security over research-oriented or innovation-driven career pathways (Rhodes & Dwyer, 2024). Thus, the literature increasingly recognises loan adequacy not merely as an issue of educational access, but also as a determinant of persistence, academic quality, and the conditions under which innovation-related competencies develop during STEM training.

Loan adequacy and participation in innovation-related activities

In addition to completing the programme, sufficient funding is another factor influencing students' involvement in innovation-based learning experiences. Project research, internships, and start-up activities – e.g., business ventures – are fundamental to developing advanced STEM competencies in an educational setting. Based on higher education research, consistent evidence suggests, for example, that stable funding leads to students participating in collaborative research activities and developing professional development skills relevant to their innovation-related engagement and competency development (Grote et al., 2021).

In contrast, economic restrictions could limit getting involved in such activities. Students under financial strain are more likely to accept paid employment to cover living expenses, limiting the time they have available for internships, research, and other enrichment activities that support innovation capacity (Buzan, 2024; McClain & Johnson, 2025). Thus, across the literature, financial precarity has been associated with unequal access to experiential learning opportunities, potentially reinforcing disparities in the acquisition of higher-order technical skills and innovation-related competencies among STEM students.

However, much of this literature focuses primarily on participation patterns rather than on how students themselves perceive the adequacy of loan support in enabling or constraining innovation-related engagement. Consequently, researchers have given limited attention to the relationships among perceived loan adequacy, innovation-oriented

behaviour, and competency development within student-level innovation capacity formation in university settings.

The role of financial precariousness in participation in skill-building activities

Monetary instability is at once an architectural restriction and a psychological load that hinders students' participation in education. Research indicates that financial strain can deplete cognitive resources, hindering students' ability to sustain focus and creativity during arduous learning tasks (Pollard et al., 2019; Meuris & Gladstone, 2023; Reid, 2024). Consequently, such financial insecurity can hinder students' ability to develop innovation-oriented and skill-building opportunities.

These pressures may affect career aspirations and risk appetite. Student debt often leads graduates to pursue higher-wage employment rather than research roles in the private sector, government, entrepreneurship, or public-sector innovation (Rothstein & Rouse, 2011). Such economic decisions, though well-reasoned, can also limit the extent to which STEM graduates are at the forefront of knowledge generation and technological advancement.

While a wealth of work has focused on student debt in high-income countries, much less has examined loan adequacy in low-income countries. In sub-Saharan Africa, governments are increasingly using student loan programmes to expand access to (largely academic) higher education, particularly in priority fields such as science and technology. However, existing evidence indicates funding remains insufficient to cover the costs of STEM education. Gaps in student financing have been shown to limit students' access to key learning resources and learning opportunities for advanced skills development (Orace et al., 2025b); Ugandan studies show similar trends. Policy issues in African higher education systems have similarly highlighted the difficulties of funding high-resource-intensive STEM programmes, given limited public funds (Ogunode et al., 2025). Nonetheless, empirical studies exploring the connection between loan adequacy and innovation capacity in sub-Saharan African STEM contexts are scanty.

Many African states have invested substantially in financial literacy (FHS) in universities, enabling more students to access the tools

and skills needed to achieve their goals (Ogunode et al., 2025). Previously, the scholarship has significantly advanced our understanding of the relationship between student financing and access to tertiary education. However, a large-scale body of research on how student loan access relates to programme completion is lacking. Loan adequacy and its connections to participation in innovation-related activities and advanced competencies have received comparatively less attention in the research.

Overall, the current literature has shed light on the impact of student finance on access to higher education and programme completion, and has increasingly acknowledged the significance of experiential learning, innovation, and vocational skills in STEM education. There are important gaps, however. Very few studies examine the extent to which loan adequacy enhances or inhibits students' engagement in innovation-oriented activities, including internships, research, and entrepreneurship, and how these relate to competency development and innovation capacity formation at the student level. Existing evidence is predominantly from high-income countries, with little focus on low-income contexts such as Uganda. Moreover, previous studies seldom integrate quantitative measurements of financial adequacy with qualitative investigations regarding the impact of financial insecurity on students' academic decisions, behaviour, and future career aspirations. To fill this gap, this study examines how student loan sufficiency influences the development of innovation-related engagement and competency development among STEM students in Uganda, with implications for programme completion and student-level innovation capacity.

Methodology

Research design

This study employed a convergent parallel mixed-methods design, integrating concurrent quantitative and qualitative data collection and analysis. The adoption of this design aimed to provide a more comprehensive understanding of how perceived load adequacy influences programme completion and innovation-related engagement among STEM students. In this design, both strands were implemented

during the same phase of the research process to enable triangulation between statistical patterns and participants' contextual experiences.

The quantitative data examined the association between perceived loan adequacy and innovation capacity, while qualitative data explored how financial conditions influence students' participation in innovation-related activities such as research projects, internships, and entrepreneurial initiatives. Collecting both strands concurrently allowed the researchers to capture students' financial experiences and institutional perspectives within the same academic period. Also, concurrent collection was necessary to capture both the statistical association (quantitative) and the lived mechanisms (qualitative) simultaneously. Triangulation occurred on the dimension of opportunity gaps. Integration occurred during the interpretation stage, where qualitative findings were used to contextualise and explain patterns observed in the quantitative results (Creswell & Plano Clark, 2018).

Study population and sampling

The study examined HESFB loan recipients at four geographically diverse Ugandan public universities (Busitema University, Mbarara University of Science and Technology, Kyambogo University, and Gulu University) from October 2024 to March 2025. The estimated population of STEM loan beneficiaries at these universities (2022–2024), based on institutional records and administrative data from the HESFB, at the time of data collection, was approximately 729 students.

The students were sampled proportionally, by institution, programme, and gender, using stratified random sampling. This involved 482 students, of whom 430 participated in the survey (Krejcie & Morgan, 1970), using mixed-mode online and in-person questionnaires, with a total response rate of approximately 89% among the approached students.

At the same time, 12 administrators were purposively selected for semi-structured interviews. These included finance officers, HESFB liaison staff, and faculty administrators who provide student support services. For this reason, administrators were chosen for their institutional knowledge of loan implementation, student financial issues,

and how institutions support innovation-related engagements among STEM students.

Focus group discussions (FGDs) with loan-beneficiary students were held as an additional option to investigate experiences of financial adequacy and participation in innovation-related activities. Eight FGDs were conducted (two from each university), with 6–8 students per group. Participants were assigned the identifier FGD1-P1 (UnivA) to ensure anonymity and traceability of responses during analysis.

Data collection methods and instruments

Quantitative data were collected using a structured questionnaire developed from constructs identified in the higher education financing and student engagement literature. The questionnaire measured two key variables: perceived loan adequacy and innovation capacity among STEM students. Perceived loan adequacy was measured using three items on a 4-point Likert scale ranging from 1 = "Strongly disagree" to 4 = "Strongly agree". These items assessed students' perceptions of whether the loan sufficiently covered tuition, accommodation, academic materials, and basic living expenses required for university study. Innovation capacity, on the other hand, was operationalised through students' participation in innovation-related engagement activities that support practical learning and competency development within STEM education. These activities included internships, research projects, entrepreneurship programmes, hackathons, and innovation competitions, which were treated as indicators of students' innovation-oriented engagement during their university training.

To complement the survey data, the study conducted 12 semi-structured interviews with university administrators and 8 FGDs with STEM students across the 4 participating universities, with 2 FGDs per university. Each FGD consisted of 6–8 participants selected from among loan beneficiaries enrolled in STEM programmes. The semi-structured interview guide contained 15 open-ended questions exploring experiences with the student loan scheme, institutional support services, and barriers to innovation-related engagement. FGD participants were coded according to university and discussion group to ensure anonymity during analysis (e.g., FGD1-U1, FGD2-U3).

Validity and reliability

To enhance content validity, the questionnaire and interview guide were reviewed by experts in higher education policy and student finance. A pilot test with 30 loan-beneficiary students was conducted to refine the wording and clarity of the survey instrument.

The internal consistency of the quantitative instrument was assessed using Cronbach's alpha, yielding acceptable reliability coefficients ($\alpha > .75$) across key subscales. Although internal consistency was satisfactory, **exploratory factor analysis was not conducted**, which represents a limitation. Future research should employ factor-analytic validation further to establish the construct validity of the loan adequacy, innovation-related, and competency development scales.

For qualitative data, credibility and trustworthiness were enhanced through member checking, peer debriefing, and the maintenance of an audit trail of coding decisions. Interviews and FGDs were transcribed verbatim before analysis.

Data analysis

Quantitative data were analysed using the Statistical Package for the Social Sciences (SPSS v.25). A simple linear regression model was conducted to assess the association between perceived loan adequacy and innovation-related engagement. Qualitative data from interviews and FGDs were analysed using thematic analysis following Braun and Clarke's (2006) framework. The transcripts were coded to identify recurring themes related to financial precarity, student engagement in innovation activities, and competency development and innovation-related engagement outcomes.

The mixed-methods integration occurred during the interpretation stage, where qualitative insights were used to explain the quantitative results and provide contextual understanding of the observed statistical relationships.

Ethical considerations

The study secured ethical clearance from the Research Ethics Committee (NO. UCU REC: 2024-955) and the Uganda National Council of Science and Technology [UNCST] (NO. SS3353ES), and obtained institutional

permissions from four universities and HESFB. Data collection was grounded in informed consent, ensuring participants understood the study's objectives, volunteered freely, and could withdraw at any time. Confidentiality was maintained by excluding names and using codes instead. The research adhered to UNCST (2014) principles: respect for persons (autonomy and protection of vulnerable individuals); beneficence (maximising benefits while minimising risks); non-maleficence (avoiding harm); and justice (fair and equitable treatment). These measures collectively upheld the rights and welfare of participants and their communities.

Results

This section presents data analysis and interpretation of findings on how student loan sufficiency influences the development of innovation capacity among STEM students in Uganda. The findings draw on quantitative data from a student survey (N = 430) and qualitative insights from student focus group discussions (FGDs) and individual interviews with HESFB and university administrators. The results address the research questions and aim to provide a comprehensive understanding of the effectiveness of the student loan scheme in supporting STEM education at public universities in Uganda.

RQ 1: How sufficient do STEM students perceive their loans to be in meeting their academic financial requirements?

To address this research question, data from the student survey were analysed and complemented with insights from student FGDs and administrator key informant interviews (KIIs). The descriptive statistics are presented in Table 1.

Table 1: *Descriptive statistics on the adequacy of student loans*

Item	Valid N=430	SD	D	A	SA	M	Standard Deviation
		freq. (%)	freq. (%)	freq. (%)	freq. (%)		
The loan adequately covers tuition and related academic expenses, such as textbooks, supplies, and technology.		140 (32.6%)	165 (38.4%)	93 (21.6%)	32 (7.4%)	2.04	.92
The students' loans are adequate and allow them to address unexpected financial challenges.		95 (22.2%)	140 (32.6%)	136 (31.6%)	58 (13.6%)	2.36	.97
The loan adequacy gives me confidence in managing my financial obligations.		23 (5.4%)	80 (18.6%)	258 (60.1%)	68 (15.9%)	2.86	.74

Source: *Field data*

Note: SD=Strongly Disagree; D= Disagree; A= Agree and SA= Strongly Agree

Table 1 presents descriptive statistics for the three loan-adequacy indicators among STEM students (N = 430). Items were measured on a 4-point Likert scale (1 = "Strongly disagree", 4 = "Strongly agree"), with higher scores indicating greater perceived loan adequacy of student loans. The findings suggest that **student loans are generally perceived as insufficient to cover essential academic costs**. The first item shows a mean score of **2.04 (SD = 0.92)**, indicating relatively low agreement that loans adequately cover tuition and related academic expenses such as textbooks, supplies, and learning technologies. Only **29.0% of respondents agreed or strongly agreed**, while **71.0% disagreed**, suggesting that most STEM students experience gaps in financial coverage of essential learning resources.

Insights from student FGDs reinforce this pattern. Students frequently described the loan as being sufficient mainly for tuition and registration costs but inadequate for other learning-related expenses. One participant noted that the loan was "enough for tuition and registration, not for learning" (FGD-UnivA-P1), while another explained that "after tuition, there is nothing left for books or materials" (FGD-UnivB-P2). Such experiences indicate that when financial support does not extend to essential academic resources, students may resort to coping strategies, such as sharing materials or reducing participation in practical learning activities. This concern was also acknowledged during administrator KIIs. One university administrator observed that "while the loan scheme effectively supports access to higher education, many STEM programmes require additional learning resources that are not fully covered by the loan package, including laboratory materials, software licences, and fieldwork expenses" (KII8).

The second item examines whether the loan system provides flexibility to manage unexpected financial challenges. The mean score of 2.36 (SD = 0.97) indicates moderate but limited agreement regarding this aspect of financial support. Overall, 54.8% of respondents disagreed that the loan adequately helps them address unexpected financial difficulties. This suggests that many students remain financially vulnerable to unforeseen expenses.

Student FGDs further illustrate these experiences. Participants described the loan structure as relatively fixed, with limited provision

for emergencies. One student explained that "once the money is allocated, there is no buffer for emergencies" (FGD-UnivC-P4), while another noted that "any small shock, illness, equipment damage, or delayed disbursement can disrupt studies" (FGD-UnivA-P2). This concern was echoed by a university administrator, who acknowledged the systemic constraints, stating, "We are aware that the current model lacks flexibility, but building in a contingency fund would require a significant restructuring of the funding formula at the national level" (KII2). These findings suggest that the absence of contingency support may expose students to financial instability, thereby affecting their academic experiences.

Despite these challenges, the third item indicates a relatively stronger perception of financial confidence associated with receiving the loan. Financial confidence serves as a proxy for innovation engagement rather than direct evidence of economic change agency. The mean score for this item is 2.86 (SD = 0.74), with 76.0% of respondents agreeing that the loan gives them confidence in managing their financial obligations during their studies.

Student FGDs highlight how this perceived security contributes to psychological stability during the academic semester. Participants reported that knowing their tuition was covered allowed them to "plan the semester without panic" (FGD-UnivC-P3), "sleep at night knowing fees are sorted" (FGD-UnivB-P1), and "make small investments such as purchasing a laptop or covering internship transport costs" (FGD-UnivB-P5). This sense of baseline security was corroborated by university administrators, who noted that the loan scheme primarily functions as a retention tool. One administrator observed, "We often focus on the monetary value of the loan, but its real impact is sometimes the peace of mind it provides" (KII9). Another administrator from another university added: "The loan ensures they stay registered even if it doesn't cover all costs. It removes the fear of being sent home for non-payment, which allows them to focus on studies" (KII3). These responses suggest that although the loan may not fully meet all academic expenses, it still provides a level of financial reassurance that supports students' ability to remain enrolled and plan their academic activities.

Overall, the findings indicate that while student loans provide important financial support for university enrolment, many STEM students perceive the coverage as limited relative to the broader academic costs of their programmes.

RQ 2: How does financial precarity influence STEM students' academic experiences and opportunities for innovation?

The findings indicate that financial precarity significantly shapes STEM students' academic experiences and professional development opportunities. As shown in Table 1, 71% of students reported that the loan does not adequately cover essential academic costs, including textbooks, specialised learning materials, and technology required for practical training.

Student FGDs conducted across four universities provide deeper insight into how these financial constraints affect learning experiences. Students described the level of financial support as limited in relation to the practical requirements of STEM programmes. One participant stated, "The loan barely scratches the surface of what we need" (FGD-UnivB-P1), while another explained that students often "share one set of manuals or equipment among several classmates" (FGD-UnivA-P2).

The absence of financial buffers also appears to increase students' vulnerability to unexpected disruptions. Participants frequently reported that unexpected costs, such as illness, equipment breakdowns, or delayed payments, could interfere with their academic activities. One student remarked that "there is no emergency cushion; one hospital bill and everything stops" (FGD-UnivD-P6), while another noted that "a late payment can mean missing a field trip or laboratory session" (FGD-UnivB-P3). Financial constraints were also reported to influence students' ability to pursue opportunities that could enhance innovation and professional development. For instance, some students explained that participation in specialised training programmes, innovation competitions, or certification courses often requires additional financial resources beyond what the loan provides.

This limitation was acknowledged by university administrators, who observed that financial barriers restrict students' engagement with value-added academic opportunities. These student accounts were

corroborated by university administrators, who further highlighted the systemic nature of these constraints from institutional, programme, and policy perspectives. One administrator noted, "Students often turn down innovation challenges because they can't afford the prototype materials" (KII2), while another administrator lamented, "We see talented students miss conferences or certifications simply because they lack transport or registration funds" (KII12). Another administrator highlighted that "The loan covers tuition, but the real competitive advantages come from extras they can't afford" (KII7).

Together, these accounts suggest that financial precarity operates as a structural constraint, limiting not only students' access to core learning resources but also their participation in enrichment activities that foster innovation and professional growth. The convergence of student and administrator perspectives underscores the systemic nature of this challenge, indicating that loan inadequacy may have downstream effects on STEM graduates' competency development and innovation capacity rather than direct causal effects.

One computer science student described missing an incubation opportunity because of an unexpected expense: "I had developed a mobile application prototype for smallholder farmers and was invited to join an incubation programme in Nairobi. But when my laptop broke down, I had to choose between repairing it for my final-year project or paying for the travel. My loan was already exhausted" (FGD-UnivB-P4). Similarly, another engineering student explained that financial responsibilities sometimes required prioritising immediate employment over research opportunities: "I was offered a research assistant position at a renewable energy lab, but it was unpaid for the first six months. My family needed support immediately, so I had to take a basic technical support job instead" (FGD-UnivC-P5). These accounts suggest that financial precarity may shape the opportunities available to students during and after their studies.

At the same time, the findings also indicate that the loan system provides a level of psychological security that can support students' academic persistence. Several participants noted that knowing their tuition was covered allowed them to focus more on academic work and explore innovative ideas within the limits of their available resources. A

university administrator acknowledged this dual reality, noting, "The loan was designed primarily as a tuition safeguard, to keep students enrolled. We see it successfully providing that baseline stability, but we also hear from faculties that the model hasn't yet caught up with the full cost of participation in STEM or the unforeseen challenges students face" (KII 4).

One student explained: "When my tuition was confirmed through the loan, I could focus on designing my solar irrigation prototype instead of worrying about being removed from the university" (FGD-UnivA-P6). Overall, these findings suggest that the student loan scheme plays a dual role. While it provides important financial security that supports access to higher education, its limited coverage may also contribute to opportunity gaps that affect students' ability to engage in innovation-related activities during their studies.

Test of the hypothesis on the relationship between loan adequacy and innovation capacity in STEM programmes

To further examine the association between perceived loan adequacy and innovation capacity among STEM students, the study employed simple linear regression. The analysis tested the following hypotheses:

- H1 (Alternative Hypothesis): Loan adequacy has a significant relationship with innovation capacity among STEM students.
- H0 (Null Hypothesis): Loan adequacy has no significant relationship with innovation capacity among STEM students.

To test these hypotheses, composite indices were generated for both the independent and dependent variables before the regression analysis. In this study, loan adequacy was operationalised as students' perceptions of the extent to which loan support sufficiently covered tuition, accommodation, academic materials, and basic living expenses. Innovation capacity was operationalised through students' participation in innovation-related engagement activities that support practical learning and competency development, including internships, research projects, and entrepreneurship programmes. The regression analysis, therefore, examined whether variations in perceived loan adequacy were statistically associated with variations in students' innovation capacity. The regression results are presented in Table 2.

Table 2: *Simple linear regression model of the association between loan adequacy and innovation capacity in STEM-based programmes*

Model		Unstandardised Coefficients		Standardised Coefficients	T	P	Collinearity Statistics	
		B	SE	β			Tolerance	VIF
	(Constant)	2.49	0.08		29.49	.000		
	Adequacy	0.23	0.03	0.32	7.13	.000	1.00	1.00

Dependent Variable: Innovation Capacity in STEM-Based programmes in selected public universities in Uganda.

Adjusted R^2: 0.104; F(1,428)=50.9, p-value <. 0.001.

The regression results in Table 2 indicate a statistically significant positive relationship between perceived loan adequacy and innovation capacity among STEM students.($\beta = 0.32$, $p < .001$). This suggests that students who perceive their loan support as more adequate are more likely to have greater capacity for innovation in their STEM programmes. Specifically, for every one-unit increase in perceived loan adequacy, there is a corresponding increase in competency development among STEM students. Competency development scores increase by 0.23 units (B = 0.23, SE = 0.03). The model explains 10.4% of the variance in students' innovation capacity, indicating that loan adequacy is one of several factors influencing it. These findings suggest that financial support through the student loan scheme enhances students' capacity for innovation. Therefore, based on the statistical evidence ($p < .001$), the null hypothesis that "loan adequacy has no significant relationship with students' innovation capacity" was rejected, and the alternative hypothesis was accepted.

However, the model's relatively modest explanatory power (10.4% variance explained) also indicates that other academic, institutional, and socio-economic factors likely influence completion outcomes. This aligns with the qualitative findings under RQ1 and RQ2, which revealed that while loans provide a baseline level of support for enrolment, coverage gaps may still affect students' full participation in programme requirements. Future research should consider additional predictors

such as institutional support services, family financial contributions, and students' coping strategies to develop a more comprehensive model of competency development among STEM students.

These findings have important implications for understanding how loan adequacy may serve as a foundational condition for STEM graduates' competency development and eventual economic agency. While financial support alone does not guarantee completion, it appears to remove a critical barrier that might otherwise interrupt students' academic trajectories and delay their entry into the workforce as potential economic change agents.

Discussion

The findings of this study highlight a complex relationship between student loan adequacy and the development of advanced competencies among STEM graduates. Quantitative and qualitative evidence suggest that the financial terms provided by the student loan scheme are often insufficient to cover the full range of students' academic and extracurricular requirements, which may limit their ability to fully engage in university learning environments and develop competencies (Orace et al., 2025b). Instead of simply showing a financial constraint, the results suggest that loan adequacy may act as a structural factor shaping students' participation in the broader STEM education community.

From a theoretical perspective, these results apply scarcity theory to the landscape of STEM innovation systems. According to scarcity theory, financial scarcity limits cognitive bandwidth, leading people to focus on short-term survival concerns rather than investing in long-term, complex tasks (Mani et al., 2013; Shah et al., 2018). These findings extend scarcity theory into STEM innovation contexts by illustrating how financial adequacy may influence not only persistence but also engagement in enrichment pathways critical to innovation ecosystems. The results of this study further indicate that when student loans do not adequately support essential academic inputs, e.g., textbooks, specialised learning materials, and technological resources, students may make trade-offs that limit their participation in essential learning activities. In doing so, financial weakness would seem to influence not only persistence in study but also the circumstances in which students

participate in experiential, practice-based learning environments, which are crucial for competencies associated with innovation. This builds on Goldrick-Rab et al.'s (2022) work by examining how financial precarity may function as a participation constraint within STEM innovation ecosystems.

One of the major mechanisms through which loan inadequacy affects competency formation is via cognitive bandwidth depletion. When we experience financial strain, our focus shifts to addressing current financial pressures, which may diminish the cognitive resources needed to master complex STEM topics. Such an interpretation aligns with the seminal work by Mani et al. (2013), which shows that financial scarcity can cause serious detriment to cognitive power, and with Shah et al. (2018), who claim that scarcity enraptures and diverts attention from the demands of our cognitive activity. For example, in STEM education, where learning often involves sustained attention, experimentation, and incremental problem-solving, distractibility from thinking about higher-order, technical, and analytical aspects of the field may hinder students' engagement with these processes.

At the same time, the results suggest that financial sufficiency supports the psychological conditions associated with higher-order learning. Evidence suggests that students who perceive their loan support as financially stabilising report feeling more confident in meeting their educational responsibilities. This pattern is consistent with Ibrahim and Alkire's (2021) capability approach, in which access to enabling resources increases individuals' capacity to pursue valued outcomes. Within this construct, financial security can serve as a psychological infrastructure, supporting students' capacity to invest cognitive and emotional resources in deeper learning processes rather than in immediate financial worries. For instance, data from Chen and Wiederspan (2014) support the view that sufficient financial support is correlated with higher levels of engagement in cognitively demanding STEM learning environments.

A prominent concept of interest here was access to enrichment, which is a strong foundation for developing competency in STEM applications. The activities of research internships, specialised training programmes, innovation competitions, and conference participation reflect what Welton et al. (2023) describe as the 'hidden curricula of

innovation,' where theoretical learning is translated into practical problem-solving. This shows what the findings may imply: that student financial precarity impedes their access to these enrichment enablers. This is consistent with Maltese and Tai's (2010) study on pipeline leakage in STEM education, which shows that students are likely to have less access to experiential learning opportunities associated with new and advanced competencies and innovation capacity when these skills and competencies become more limited due to financial constraints. They also emphasise the significance of temporal horizons for human capital formation.

It seems that financial security determines students' ability to plan and invest in long-term skills development. This is consistent with Kelchen's (2022) claim that financial stability increases the ability of students to invest in long-term educational expenditures rather than just chasing a "complete" college diploma. Cottom (2017) also observes that students in a state of financial stability are more conducive to learning in ways that can facilitate skill enhancement, such as critical thinking, creative thinking, and systems thinking, and the ability to critically analyse systems more deeply in the 21st century.

On the other hand, financial uncertainty may induce short-term academic strategies that centre primarily on gaining qualifications rather than building deeper innovation capacity. Overall, these results fit within Baker-Smith's (2021) framework of financial precarity as a limit on competence, extending his concept to contexts in STEM education, where development rests largely on persevering cognitive engagement and active participation in the enrichment ecosystem's activities. The results indicate that student loan adequacy may function not only as a financial resource but also as an enabling condition, enabling students to gain more cognitive bandwidth, experiential learning opportunities, and temporal planning skills to build innovation skills. In doing so, the study defies conventional models of human capital that reduce financial aid to a commodity – a mere input into the educational production system. Instead, it emphasises the capacity of the financial structures under consideration to shape the wider developmental context within which technical education becomes an instrument of economic engagement.

Overall, the findings indicate that Uganda's existing student loan system is likely to operate as a structural limitation on some STEM students' capacity to pursue innovation-oriented learning pathways. Without comprehensive financial backing for most aspects of academic and experiential needs in STEM programmes, students would struggle to access the learning environment conducive to advancing competence. On the contrary, as financial security is attained, the psychological and temporal circumstances are likely to be conducive to deeper involvement in challenging learning tasks and innovation-related activities. These findings thus reconceptualise student loan policy not only as a vehicle for expanding access to higher education but also as a potential actor in shaping the global context in which human capital and innovation capabilities are created and maintained. From this angle, loan adequacy is a significant component of national policies to improve STEM education systems and cultivate the skills necessary for participation in a knowledge- and innovation-based economy.

Conclusion, Limitations and Recommendations

Conclusion

Results from this study indicate that the extent of student loan debt was an important explanatory factor, accounting for the model's limited explanatory power in shaping the conditions under which both academic activities and competency development occur among STEM students. The evidence suggests that Uganda's existing student loan system, with little more than one-off student fees as the primary means of covering study costs, including tuition, may be a structural impediment to STEM students' effective participation in innovative activities.

However, when financial support applies only to STEM education costs, e.g., textbooks, course-specific curriculum, or learning tools, and offers no support for experiential learning environments, such choices can result in trade-offs and affect students' opportunities to develop higher-level competencies. The results also suggest that financial security may be important for maintaining students' academic engagement. When students believe their loan support is financially stabilising them, they

are more likely to feel confident in managing their academic debt. This feeling of financial comfort may facilitate the kinds of psychological, time-specific conditions students face, enabling them to focus more fully on the cognitive demands of a complex learning endeavour, e.g., participating in research projects, innovation competitions, etc., linked to STEM education.

Overall, these findings indicate that financial sufficiency may play a meaningful role in shaping the conditions under which STEM students engage in competency-building experiences. Therefore, the discussion of student loan adequacy should not focus solely on access and programme completion, but also on the educational conditions that support students' engagement in STEM programmes oriented to innovation. The evidence suggests that Uganda's current student loan system may act as a structural constraint, limiting STEM graduates' capacity to fully engage in innovation-oriented activities. Importantly, these findings are interpreted at the student-level educational experience and do not provide direct empirical evidence regarding national innovation systems or macroeconomic transformation outcomes.

Study limitations

The current study also has several major limitations that need to be addressed to understand its results.

First, the study is partly based on self-reported beliefs about loan adequacy, which may reflect students' subjective experiences rather than objective financial indicators.

Second, despite the regression analysis finding a statistically significant relationship between perceived loan adequacy and programme completion, the model accounts for only 10.4% of the variance, suggesting that other academic, institutional, and socio-economic variables also influence degree completion.

Third, the research centres on student experiences at a few universities; consequently, the findings may not be generalisable to all universities in Uganda.

Lastly, although the study investigates how financial conditions affect involvement in innovation activities, it does not directly assess national, research, or macroeconomic innovation outputs. This could

lead to future studies that extend the generalisability of this data by analysing the long-term association between student financial support, innovation participation, and labour-market outcomes among STEM graduates.

Recommendations

These findings highlight several policy implications for the design and implementation of student loan programmes in STEM education.

First, there may be a need for policies to provide greater insulation from the full cost of STEM education by making student loan products more affordable for learning materials, technology, and hands-on instruction. By expanding loan access in these areas, we could improve students' ability to access a platform for practical, hands-on learning experiences that are essential to building competency and providing a framework for their careers.

Second, specialised internship or hands-on training stipends, internships, or practical training assistance could be included in various students' STEM loan schemes to address the financial limitations that affect students' willingness to take advantage of these training opportunities or industry placements, or to engage in training and industry-related work. These actions increase the number of experiential learning situations for students working in settings that serve them, complementing on-campus learning and classroom teaching.

Third, policy discussions on student loan reform may be more consistent with those in broader higher education and science, technology, and innovation (STI) policy frameworks. It may also be important to link financial instruments to quality-of-study programming for loan programmes to increase access while enhancing learning conditions for competency development in STEM domains.

Overall, this data suggests that student loan policy has significant implications for the places where STEM students acquire upper-level competencies. Empirically, enabling both educational participation and experiential learning opportunities within loan schemes may strengthen the broader impact of STEM education systems.

References

Baker-Smith, C. E. (2021). *The hidden costs of college: How financial barriers undermine student success*. Harvard Education Press.

Bloom, D. E., Canning, D., & Chan, K. (2014). *Higher education and economic development in Africa*. World Bank.

Burns, R., & Webber, K.L. (2019). Achieving the promise of educational opportunity: Graduate student debt for STEM vs non-STEM students, 2012. *Journal of Student Financial Aid, 48*(3), 5. Doi: https://doi.org/10.55504/0884-9153.1659

Buzan, J., & Sheehy-Skeffington, J. (2024). Barriers in the transition from school to work: How student financial adversity predicts deprioritising jobs with the best long-term career progression. *Journal of Social Issues,* 80(4), 1460–1483. https://doi.org/10.1111/josi.12658

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–100. https://doi.org/10.1191/1478088706qp063oa

Chen, R., & Wiederspan, M. (2014). Understanding the determinants of debt burden among college graduates. *The Journal of Higher Education*, *85*(4), 565–598. http://www.jstor.org/stable/43694816

Cottom, T. M. (2017). *Lower ed: The troubling rise of for-profit colleges in the new economy*. The New Press.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research (3rd ed.).* Thousand Oaks, CA: SAGE Publications.

Goldrick-Rab, S., Broton, K., & Eisenberg, D. (2022). The impact of financial stress on college students: A longitudinal analysis. *Journal of Higher Education, 93(*4), 589–612. https://doi.org/10.1080/00221546.2021.1980297

Grote, D., Patrick, A., Lyles, C., Knight, D., Borrego, M., & Alsharif, A. (2021). STEM doctoral students' skill development: Does funding mechanism matter? *International Journal of STEM Education, 8*(1), Article 50. https://doi.org/10.1186/s40594-021-00308

Higher Education Students' Financing Board. (2014). *The Higher Education Students' Financing Act, 2014*. Government of Uganda.

Higher Education Students' Financing Board. (2019). *The student loan scheme at 5 years: The official newsletter of the Higher Education Students' Financing Board*. Ministry of Education and Sports, Government of Uganda.

Higher Education Students' Financing Board (HESFB). (2019). *Annual loan award report*. Kampala: Government of the Republic of Uganda, Ministry of Gender, Labour and Social Development.

Ibrahim, H., & Alkiraime, F. (2021). The impact of financial capability on economic empowerment of youth: Mediating role of financial confidence. *Journal of Financial Counselling and Planning, 32(*2), 207–219. https://doi.org/10.1891/JFCP-19-00023

Kelchen, R. (2022). Cost-realistic financial aid: Moving beyond the sticker price. *Journal of Student Financial Aid, 51*(2), Article 4.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement, 30*(3), 607–610.

Maltese, A. V., *& Tai, R. H. (2010).* Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education, 32*(5), 669–685. https://doi.org/10.1080/09500690902792385

Mani, A., Mullainathan, S., Shafir, E., & Zhao, J. (2013). Poverty impedes cognitive function. *Science, 341*(6149), 976–980. https://doi.org/10.1126/science.1238041

Mahmoud, A., Intsiful, E., Tuffour, P., & Boateng, F. K. (2024). Understanding the drivers of student loan decision-making and its impact on graduation rates in Ghanaian public universities. *Policy Reviews in Higher Education, 8*(1), 85–101. https://doi.org/10.1080/23322969.2024.2358008

McClain, C. R., & Johnson, K. (2025). Too poor to science: How wealth determines who succeeds in STEM education and careers. *Educational Researcher, 54(*1), 23–37. https://doi.org/10.3102/0013189X24567890

Marshall, M. (2021). *The true cost of college: The impact of student loan debt on academic performance* [Honours thesis, Bryant University].

Ministry of Education and Sports. (2020). *Education Sector Strategic Plan 2020/21–2024/25*. Kampala: Government of Uganda.

Meuris, J., & Gladstone, J. (2023). Contextual inequality in the performance costs of financial precarity. *Journal of Management,* 50(3), 979–1001. https://doi.org/10.1177/01492063231153136

National Planning Authority (NPA). (2020). *Third National Development Plan (NDPIII) 2020/21–2024/25*. Republic of Uganda.

Ogunode, N. J., Olatunde-Aiyedun, T. G., Ayeni, E. O., & Edinoh, K. (2025). Adequate funding as a panacea for the implementation and sustainability of the students' loan programme in Nigeria. *American Journal of Language, Literacy and Learning in STEM Education, 3*(1). https://www.grnjournal.us

Orace, T. D., Rwothumio, J., Owino, P., Namutebi, E., Onen, D., & Abola, B. (2025). Bridging the gap: Examining the role of funding adequacy in STEM programme completion in Ugandan public universities. *European Journal of Education Studies, 12*(9). https://doi.org/10.46827/ejes.v12i9.6265

Pollard, E., Huxley, C., Martin, A., Takala, H., & Byford, M. (2019). *Impact of the student finance system on participation, experience and outcomes of disadvantaged young people*: Literature review, May 2019. Department for Education; Institute for Employment Studies. https://dera.ioe.ac.uk/id/eprint/33474/

Reid, C. (2024). *Getting in: Understandings of potential, talent and ability, and access to HE for Scottish young people from areas of high deprivation* [Doctoral dissertation, University of Glasgow]. University of Glasgow Enlighten: Theses. https://theses.gla.ac.uk/84483/

Rhodes, A. P., & Dwyer, R. E. (2025). Labour unions, debt, and financial advantage in young adulthood in the United States. *Work and Occupations, 52*(3), 447–488. https://doi.org/10.1177/07308884241273248

Rothstein, J., & Rouse, C. E. (2011). Constrained after college: Student loans and early-career occupational choices. *Journal of Public Economics*, 95(1–2), 149–163. https://doi.org/10.1016/j.jpubeco.2010.09.015

Shah, A. K., Shafir, E., & Mullainathan, S. (2018). Scarcity frames value. *Psychological science, 29*(12), 1961–1971. https://doi.org/10.1177/0956797618794582

UNCST. (2014). *National guidelines for research involving humans as research participants*. Uganda National Council for Science and Technology.

Wang, L. (2025). Human capital and the upward occupational mobility of rural migrant workers in China. *Research in Social Stratification and Mobility, 95*, 100997. https://doi.org/10.1016/j.rssm.2024.100997

Welton, A. D., Harris, T. O., La Londe, P. G., & Moyer, R. T. (2023). Cultivating entrepreneurial mindsets among STEM graduates: The role of financial confidence and institutional support. *Journal of Higher Education Entrepreneurship*, 5(1), 45-67. https://doi.org/10.1080/23311877.2023.2184562

World Bank. (2020). *The skills balancing act in sub-Saharan Africa: Investing in skills for productivity, inclusivity, and adaptability*. Washington, DC: World Bank.

Zimmerman, T. S., Jones, F. R., Davis, A. M. D., & Dear, C. (2025). Loans in the long game: How student debt affects financial stress post-graduation. *Journal of Student Financial Aid, 53*(3), Article 3. https://doi.org/10.55504/0884-9153.1809