Student Agency in Flexible Learning: Mechanisms, Barriers, and Equity

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***Abstract*—Declining student engagement in higher education has heightened interest in curriculum design. Flexible learning is widely adopted to improve engagement and equity, yet evidence suggests flexibility alone does not close equity gaps. Using Self-Determination Theory, we frame student agency in terms of capacity (forming autonomous choices) and realization (sustaining action), offering a lens for studying inequities in student engagement.**

We surveyed 372 first-year students in computing and engineering programs to examine how structural barriers relate to engagement in a flexible learning environment. Perceived learning value was positively associated with engagement frequency, while no robust differences in capacity were observed across demographic groups. In contrast, students who commute, work substantial hours, or have caregiving responsibilities reported higher structural barriers and lower relatedness and vitality, key psychological supports for sustaining engagement. These findings highlight a distinction between students' capacity to form intentions about how to engage and the conditions required to realize those intentions over time.

We conclude that flexible learning designs may support intention formation, but equitable realization of agency depends on reducing contextual barriers and supporting relatedness and vitality. The study contributes a theoretically grounded framework for interpreting engagement in flexible engineering education and highlights the need to design not only for choice, but for the conditions that enable students to act on those choices.

***Keywords*—Equity in engineering education, flexible learning, human-centered curriculum design, student agency**

I. Introduction

Student engagement in higher education has declined in recent years, driven by rising living costs, mental health pressures, and shifting expectations around flexibility and support [1]. Recent studies have highlighted the limitations of conventional blended learning – combining online learning materials and interactions with traditional face-to-face classroom methods – in fostering sustained engagement and equitable participation, particularly in large cohorts [2], [3]. While blended formats offer flexibility, they often lack mechanisms to support intentional learning behaviors and accommodate diverse student needs. Furthermore, autonomy-supportive environments have been shown to enhance engagement and achievement in STEM (Science, Technology, Engineering, and Mathematics) disciplines [4].

This paper examines the agency and equity dimensions of flexible learning environments, drawing on survey data from 372 first-year Computer Science and Electronic Engineering students at a university in England. Our goal is to move toward a student-centered approach that supports purposeful engagement across diverse student profiles.

We define *student agency* as the ability to make purposeful decisions about when, where, and how to engage with learning. Using Self-Determination Theory (SDT) as a framework, we examine how the three basic psychological needs – autonomy, competence, and relatedness – influence student motivation and academic achievement [5], [6]. In that context, agency encompasses not only the freedom to choose (autonomy), but also the understanding of what facilitates learning (competence), as well as the psychological resilience and social support needed to sustain those choices over time (vitality and relatedness).

We distinguish between *agentic capacity* – the ability to form intentional, autonomous learning choices – and *agentic realization* – the sustained enactment of those choices in practice. This distinction builds on prior work showing that: (1) agentic capacity may or may not be enacted in observable behavior; (2) perceived agency, in the presence of contextual and structural constraints, does not consistently translate into sustained engagement [7], [8]. Within this framework, we propose the following research questions:

- (**RQ1**) How is student agency associated with engagement and perceived learning value?
- (**RQ2**) What barriers and supports shape students' agency in flexible learning environments, and how do these differ across commuters, student workers, and caregivers?

We explore how structured flexibility and perceived barriers influence students' ability to act in blended learning environments. While most students report strong intentions to engage, our findings show that agency depends not on choice alone, but on the presence of social and emotional supports – suggesting that, even in flexible environments, equitable

engagement requires scaffolding for autonomy, vitality, and belonging.

Our findings show that flexible design effectively supports agentic capacity across student groups, enabling intention formation. However, structural barriers disproportionately affect certain populations, with commuters and caregivers reporting barriers 1.3 and 1.35 times higher, respectively

Critically, prior theory suggests that such barriers may leave agentic capacity intact while selectively eroding psychological vitality and sense of belonging, potentially constraining students' ability to translate intention into sustained engagement. This distinction highlights why flexibility alone is insufficient for equity: design must pair autonomy support with scaffolds for relatedness and well-being to enable full realization of agency.

II. Related Work

A. Student Agency in Engineering Education

A systematic review of student agency in higher education identifies agency as a multidimensional construct that involves both students' intentional capacity and the behavioral realization of that capacity in specific learning contexts [8]. Agency is conceptualized across several schools of thought, including social-cognitive, motivational, and assessment-oriented perspectives, being consistently viewed as individuals' capacities to take actions to improve their lives [9].

Student agency has been increasingly recognized as a critical component of effective engineering education, and a critical learning skill for students [9], [10]. Challenge-based and project-based learning environments show that when students are able to define problems, explore solutions, and reflect on their learning processes, they tend to develop a stronger sense of ownership, engagement, and responsibility for their learning. Recent studies in engineering education highlight how these approaches encourage students to take greater initiative, especially when supported by opportunities for choice and guidance throughout the project cycle [11], [12]. Flexible engineering programs that combine modular curricula, inclusive pedagogies, and student-centered cultures have the potential to support more diverse and engaged cohorts, particularly when design structures intentionally address access and inclusion [13].

B. Agency and Self-Determination Theory

Grounded in Self-Determination Theory, we conceptualize student agency as the intentional, volitionally endorsed pursuit of learning goals, grounded in the satisfaction of three basic psychological needs: autonomy, competence, and relatedness. SDT predicts that when these needs are satisfied, individuals engage in intrinsically motivated, self-determined behavior characterized by both the capacity to form intentions and the psychological resilience to enact them [14], [15].

Autonomy refers to the subjective experience of meaningful choice, an internal drive to organize one's actions and experiences in a way that aligns with personal values and sense of self – a prerequisite for motivation, but not a guarantee of engagement. Students' ability to engage meaningfully depends on contextual scaffolding, emotional well-being, and strategic capacity [16], [17].

Agency is enacted when learners are enabled to deliberate, plan, and act within supportive, flexible environments. Because agency is context-sensitive and co-constructed, the challenge is to foster an interactive learning environment that can recognize and respond to the diverse, dynamic, and agentic expressions of students' needs [18]. Hence, we distinguish between two dimensions of agency, both depending on autonomy, competence, relatedness and vitality:

- *Agentic Capacity* refers to students' perceived ability to form intentional, autonomous learning choices.
- *Agentic Realization* refers to the sustained enactment of those choices in practice.

We also consider two core SDT constructs: *vitality* is a key indicator of subjective well-being; *relatedness* refers to the sense of belonging and social connectedness. While our findings draw on shared psychological supports, they suggest an asymmetry in vulnerability: realization is particularly sensitive to structural barriers that erode vitality and relatedness, reducing the emotional energy and social infrastructure needed to sustain engagement even when choice remains available.

C. The Equity Gap

Equity in education requires rethinking what is taught, how it is taught, and who participates in shaping the learning experience. Equity-centered frameworks emphasize sociocultural relevance, inclusive pedagogy, and structural flexibility as core design principles for supporting diverse cohorts and addressing persistent inequities [10], [13]. Implicit norms, values, and expectations embedded in curricula help explain how formally open opportunities may still feel exclusionary for minoritized students [19]. While blended learning can broaden access and flexibility, it does not inherently reduce inequity. Key challenges include digital literacy disparities, unequal access to devices and connectivity, and uneven implementation of inclusive pedagogies [20]. Equity-oriented curriculum design must therefore consider not only students' access to courses, but also how design decisions about time, space, technology, and interaction patterns differentially support or constrain students from diverse backgrounds.

D. Participatory Curriculum Design

Co-creation in higher education, defined as collaborative processes where staff and students work together to design curricula, pedagogical practices, or learning environments, has been linked to improved inclusion, motivation, confidence, and self-regulation among students, as well as enhanced learning outcomes and relationships [21]–[23].

Typologies of co-creation distinguish between partnership classrooms, pedagogical consultation, curriculum co-design, and knowledge co-creation, each offering different levels and forms of student involvement. Across these modes, students are positioned as responsible actors and intentional partners rather than passive recipients. Peer educator and co-designer

roles further illustrate how interpersonal connection and shared responsibility can support students' confidence and participation in engineering programs [24]–[26].

The Beyond Blended framework developed by Jisc [27], [28] promotes co-design towards structured flexibility across time, space, materials, and group roles. It aligns with principles from Universal Design for Learning [29], advocating for inclusive curriculum design that supports varied learner pathways.

III. Context

Royal Holloway participated in a Beyond Blended pilot program during the 2024/25 academic year, involving nearly 500 first-year students from Computer Science and Electronic Engineering [30]. First-year students were selected because they have not yet been shaped by established university routines and are more receptive to novel pedagogical approaches. Additionally, their grades do not contribute to degree classification, reducing anxiety about academic risk.

Structured flexibility was enhanced by hybrid lecture delivery, scaffolded formative activities, and proactive communication strategies. Furthermore, autonomy support was operationalized as a foundational design principle, by requiring students to select their participation modality: in-person or online (students who did not actively choose a mode would be assigned to in-person attendance by default).

An initial analysis of the pilot focused on delivery mechanics and engagement patterns, using attendance data, formative task completion, and summative performance to evaluate the impact of structured flexibility. It demonstrated that:

- Engagement was selective but strategic, peaking around assessments.
- Formative tasks served as revision tools, even when not consistently completed.
- Students who proactively selected their attendance mode demonstrated significantly higher exam performance compared to those who accepted the default mode.

While these findings validated the viability of flexible delivery, they also raised questions about the underlying mechanisms driving engagement and equity: specifically, the role of autonomy, well-being, and social connection in shaping learning behaviors – the motivation for our research questions.

IV. Methodology

A. Survey Design and Administration

The module ran for 11 weeks, from January to April 2025. Assessment employed a strategic combination of formative and summative components designed to support ongoing learning while maintaining robust academic integrity. Summative assessment consisted of two invigilated quizzes delivered in weeks 6 (Quiz 1) and 10 (Quiz 2), each comprising 10 questions completed within 30 minutes (with 5 extra minutes for students requiring specific accommodations). Two practice attempts were provided one week prior to each assessment to familiarize students with the format and content coverage. This hybrid assessment approach balanced the low-stakes formative character and flexibility of online coursework with the high academic integrity safeguards of supervised examination conditions, yielding a final grade distribution combining 30% from the two summative in-course quizzes (15% each) with 70% from an end-of-year exam occurring in June.

After Quiz 2, during the same scheduled class time (one hour), students were invited to complete an anonymous survey, estimated to take around 2-3 minutes. Participation was incentivized with a small grade bonus worth 10% of the quiz grade, which was automatically received upon completion. The survey included three-point Likert scales and binary questions covering engagement modalities, perceived learning value, barriers to attendance and participation, and self-assessed indicators of student agentic capacity, social relatedness, and vitality. A qualitative optional open-text response captured students' reflections on their learning choices and experiences with flexible formats. The full survey text can be found in the Appendix.

This analysis of secondary data received ethical approval from the Research Ethics Committee of Royal Holloway, University of London (Reference: 886, 12 December 2025). Furthermore, the survey was conducted in accordance with institutional ethical guidelines: neutral wording was used to avoid leading responses; students were informed of the survey's purpose; time of completion was around 3 minutes; all responses were anonymized.

B. Data Processing and Analysis

The module ran with 490 enrolled students: 453 from Computer Science (including Software Engineering) and 37 from Electronic Engineering. All participants were first-year students, except for 8 second-year Computer Science students pursuing a joint degree with Media Arts.

A total of 26 students (5.3% of the cohort) never engaged with the module during the academic year and have no data points: 7 students disengaged from all modules; 18 students were repeating the module from a prior year; 1 student had documented extenuating circumstances. These students were excluded from the analysis.

This leaves a cohort of 464 active students for the study, from which 372 completed the survey, corresponding to an overall participation rate of approximately 80%. Some students were absent during Quiz 2, and could not participate in the survey, some others opted out. We address non-response bias through comparative analysis of respondents versus non-respondents. Self-reporting bias is inherent to survey methodology and is acknowledged as a limitation.

For comparison purposes, quantitative responses were linearly scaled to the interval [0,1] with higher scores consistently reflecting more of the corresponding construct (see Table I). Composite scales for each question were formed by averaging the scaled values over the corresponding items, following standard practice for psychometric scale construction [31]. Descriptive statistics and Spearman Correlations were used to explore relationships among variables. Demographic variations

were explored with Kruskal-Wallis tests for items and composites, and independent t-tests for continuous variables (grades, quiz completion times) using Cohen's d to measure effect sizes. Chi-square tests of independence examined categorical associations (e.g., commuting status vs. employment status).

TABLE I
SURVEY OVERVIEW

Items		Input	Construct	Completion
Q1	5	Likert	Engagement frequency	100%
Q2	8	Likert	Learning value	100%
Q3	6	Likert	In-person benefits	100%
Q4	7	Likert	Barriers	100%
Q5	5	Binary	Agentic capacity	100%
Q6	4	Binary	Relatedness	100%
Q7	5	Binary	Vitality	100%
Q8	1	Text	Student journey	8.9%
Q9	1	Binary	Commuting status	95.7%
Q10	1	Likert	Working status	87.9%
Q11	1	Binary	Caring status	86.8%

Q6.5 was excluded because it conflates relatedness and barriers.
Q7.1 and Q7.5 were reverse-coded for within-construct consistency.

The composite scales Q6 (relatedness) and Q7 (vitality) reflect the corresponding SDT-informed supports. Q5 provides an index of agentic capacity by capturing students' perceived autonomy (freedom to choose) and perceived competence (confidence in making effective learning decisions) – key elements that support intentional, self-directed learning. Q2 and Q3 relate to contextual perceptions of competence – students' beliefs about the effectiveness and value of different learning formats, which may shape their motivation, but do not directly reflect volitional intent or action.

As the survey data was collected anonymously, we could not directly measure agentic realization in terms of academic engagement or outcomes – objective lab attendance, quiz grades, etc.

C. Non-Response Bias Assessment

While individual survey responses cannot be linked to specific academic outcomes due to anonymity, aggregate comparisons between survey respondents and non-respondents remain valid for examining the relationship between reflective engagement (operationalized as survey completion) and academic outcomes. To assess whether survey respondents differed systematically from non-respondents, we compared grades across groups for the 464 active students – all grades are out of 100, and the survey bonus from Quiz 2 was removed. The outcome of the two-sample t-tests is presented in Table II.

TABLE II
ASSESSMENT GRADES VS. SURVEY COMPLETION (T-TESTS)

Assessment	Resp	Non-Resp	p	Cohen's d
Quiz 1	78.7	64.1	$< .001$	0.624
Quiz 2	74.7	44.9	$< .001$	1.356
Exam	52.6	43.6	$< .001$	0.570

Significant performance gaps favored respondents (Cohen's $d = 0.57 - 1.36$), suggesting they represent a more engaged subsample. This reflects a limitation, which will be addressed in Section VI: our findings describe engaged students' experiences within the flexible environment, not the full cohort (including those who never attended). While Quiz 2 participation was a condition to access the survey, the grade differential is persistent across all summative tasks (Quiz 1, Quiz 2, Exam), suggesting this pattern is robust and unlikely driven solely by attendance on Quiz 2. The gradient is particularly visible on the Exam, a higher-order assessment requiring synthesis and deep understanding, reinforcing that engagement – whether measured by survey completion, attendance, or performance – is associated with sustained learning.

D. Survey Participation vs. Attendance Selection

Among the 464 active students, 429 (92.5%) completed Quiz 2 and thus had the opportunity to complete the survey. Among those students, a chi-square test for independence examined the association between attendance mode selection and survey completion status (Table III). The test revealed no significant relationship ($\chi^2 = 0.037$, $p = .847$), which seems to indicate that proactive attendance mode selection and survey completion represent statistically independent dimensions of student engagement.

TABLE III
ATTENDANCE SELECTION VS. SURVEY COMPLETION CONTINGENCY TABLE FOR QUIZ 2 ATTENDEES

	Respondents	Non-Respondents	Total
Default mode	93	13	106
Proactive mode	279	44	323
Total	372	57	429

We have restricted this analysis to students who attended Quiz 2, as a full-sample analysis would conflate students who chose not to complete the survey with students who did not attend the assessment and thus had no opportunity to respond.

E. Survey Participation vs. Quiz Completion Time

One could argue that the non-responding students that have participated in the quiz may not have had enough time to complete the survey. However, completion time did not differ significantly between survey respondents and non-respondents. Students from both groups completed the assessment with nearly identical time distributions, as shown in Table IV. Furthermore, a two-sample t-test revealed no statistically significant difference: $t(427) = -0.464$, $p = .643$.

This finding suggests that non-respondents have made the conscious decision to not participate in the survey, regardless of the bonus (1.5 marks over 100 in the final module grade, which can make a difference in some limit cases).

V. RESULTS

A. Survey Respondent Characteristics

Of the 372 students who completed the survey, 187 (50.3%) lived locally and 169 (45.4%) were commuting students, with

TABLE IV
QUIZ 2 COMPLETION TIME BY SURVEY RESPONSE STATUS

Measure (minutes)	**Respondents** ($n = 372$)	**Non-Respondents** ($n = 57$)
Mean	23.4 ± 6.27	23.8 ± 6.55
Median	24.4	24.9
Range	$4.1 - 37.5$	$10.0 - 35.0$

16 missing responses. Work hours were distributed across three categories: 168 students (45.2%) worked no hours, 60 (16.1%) worked fewer than 10 hours per week, and 99 (26.6%) worked more than 10 hours per week, with 45 missing responses. 305 students reported having no caring responsibilities (82.0%), while 18 reported having caring responsibilities (4.8%), with 49 missing responses.

*B. **(RQ1)** How is Student Agency Associated with Engagement and Perceived Learning Value?*

1) Statistical Overview: Participants demonstrated moderate levels of agentic capacity in their learning choices ($M = 0.549$), reflecting intentional, strategic engagement. Engagement frequency across diverse learning formats was moderate-to-high ($M = 0.604$), and perceived learning effectiveness from available formats was consistently high ($M = 0.639$). Students also reported positive perceptions of in-person session benefits ($M = 0.630$). Composite scale descriptive statistics are presented in Table V.

TABLE V
COMPOSITE CONSTRUCTS

Question	**Composite**	**Mean**
Q1	Engagement frequency	0.604 ± 0.210
Q2	Learning value	0.639 ± 0.174
Q3	In-person benefits	0.630 ± 0.245
Q4	Barriers	0.425 ± 0.202
Q5	Agentic capacity	0.549 ± 0.270
Q6	Relatedness	0.486 ± 0.302
Q7	Vitality	0.512 ± 0.285

Agentic capacity, relatedness, and vitality were significantly intercorrelated ($r = 0.14 - 0.29$, all $p < .01$), supporting the coherence of these SDT-informed constructs (see Fig. 1). Students have reported the strongest correlations between engagement frequency, learning value and in-person benefits ($r = 0.30 - 0.60$, all $p < .001$).

2) Engagement and Perceived Learning Value: Contrary to what might be expected from SDT, agentic capacity showed no statistically significant correlation with reported engagement frequency ($r(370) = 0.025, p = .629$) nor with perceived learning value ($r(370) = 0.081, p = .119$). This unexpected finding is addressed as a limitation in Section VI-C.

The positive correlation between engagement frequency and perceived learning value ($r(370) = 0.596, p < .001$) is the strongest in our dataset (Fig. 1). This suggests that flexible design could promote a reciprocal relationship between learning value and engagement. By offering students

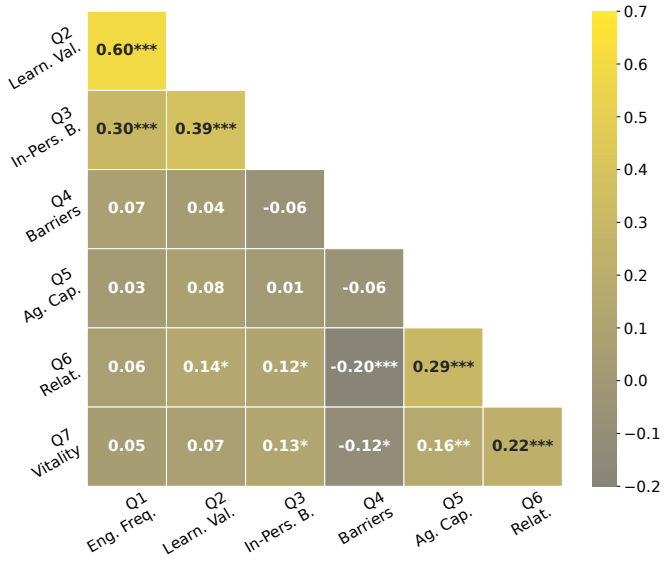

Fig. 1. Spearman correlation matrix among composite constructs (see Table V for full names). Significance: * $p < .05$, ** $p < .01$, *** $p < .001$.

the opportunity to engage with different modalities, they have the opportunity to learn about the unique value of each one (which works best, or for what purposes), in turn sustaining both engagement and perceived benefit. Nonetheless, even in a flexible environment with hybrid offer, students appreciate the benefits of in-person sessions, as attested by the strong correlation with both engagement and learning value.

Importantly, we could not detect significant differences in perceived engagement across demographics: commuters ($H = 2.247$, $p = .134$), workers ($H = 1.406$, $p = .495$), or caregivers ($H = 0.514$, $p = .474$).

*C. **(RQ2)** What Barriers and Supports Shape Students' Agency in Flexible Learning Environments?*

1) Barriers: Students reported a clear hierarchy of barriers to attendance (see Fig. 2). Logistical constraints dominated: 151 students (40.6%) reported transportation difficulties, and 124 students (33.3%) faced scheduling conflicts. Another high barrier was pedagogical: 145 students (39.0%) affirmed that course materials were sufficient without attendance. In contrast, motivational barriers were least common: 39 students (10.5%) found the module uninteresting, and 20 students (5.4%) thought material was too difficult.

This distribution reflects a design success: student choice in a flexible environment is linked to low motivational barriers. However, significant external logistical and personal barriers persist, significantly shaping students' learning experiences. These barriers may constrain agentic realization even when motivational readiness and intention (agentic capacity) are present, highlighting the importance of SDT-informed supports that address simultaneously autonomy and the structural conditions necessary for action.

2) Barriers and Supports for Commuters: Table VI displays critical equity differences ($H = 29.943$, $p < .001$), with

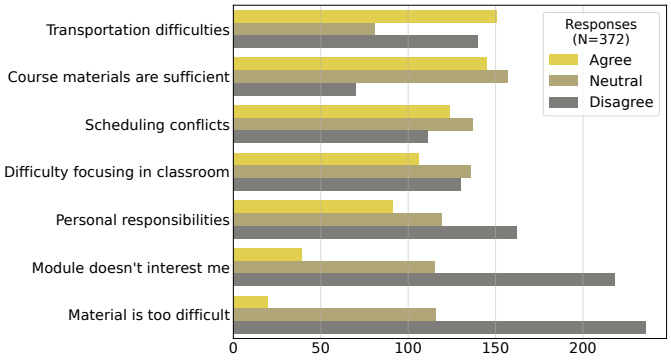

Fig. 2. Barriers response distribution (x-axis shows counts). Items are ranked by decreasing *Agree* count.

commuters reporting barriers 1.3 times higher than those of non-commuters ($M = 0.479$ vs $M = 0.369$), despite no significant differences reported in agentic capacity nor social connection. While there was a trend for higher vitality (commuters $M = 0.542$ vs. non-commuters $M = 0.484$), the difference was not significant ($H = 3.453$, $p = .063$). The overall pattern suggests constrained choice: commuters report similar agentic capacity but face logistical constraints, requiring a greater effort or compensatory strategies to maintain engagement (which is consistent across demographics).

TABLE VI
BARRIERS AND SUPPORTS BY COMMUTING STATUS

Scale	**Non-Commuters** ($n = 187$)	**Commuters** ($n = 169$)	p
Barriers	0.369 ± 0.190	0.479 ± 0.200	$< .001$
Agentic capacity	0.568 ± 0.267	0.546 ± 0.264	.423
Relatedness	0.512 ± 0.297	0.467 ± 0.302	.155
Vitality	0.484 ± 0.282	0.542 ± 0.293	.063

3) Barriers and Supports by Weekly Working Hours: As presented in Table VII, barriers increased systematically with work intensity: no work ($M = 0.381$), light work ($M = 0.427$, +12.1%), and heavy work ($M = 0.455$, +19.4% vs. no work). Kruskal-Wallis confirmed a significant effect across working categories ($H = 10.472$, $p = .005$). Pairwise comparisons revealed the strongest difference in barriers between no work and heavy work ($H = 9.952$, $p = .002$). Notably, similar engagement frequencies were reported across both demographics. This suggests that despite facing higher barriers, enough resilience factors (including similar social connectedness) may help working students to maintain agency and engagement.

4) Barriers and Supports by Caring Responsibilities: Students with caring responsibilities represent a low fraction of the overall cohort, with limited statistical significance. The 18 respondents in Table VIII reported barriers 1.35 times higher than those of students without caring responsibilities ($H = 9.397$, $p = .002$).

This pattern indicates a vulnerable population facing structural constraints. However, it's worth mentioning that one of the barriers listed was specifically having caring responsibilities, which guaranteed a priori that this group would have more barriers than the others.

TABLE VII
BARRIERS AND SUPPORTS BY WORKING STATUS

Scale	**No Work** ($n = 168$)	**<10 h/week** ($n = 60$)	**>10 h/week** ($n = 99$)	p
Barriers	0.381 ± 0.201	0.427 ± 0.187	0.455 ± 0.196	.005
Ag. cap.	0.542 ± 0.278	0.577 ± 0.261	0.578 ± 0.259	.357
Relat.	0.504 ± 0.298	0.529 ± 0.323	0.477 ± 0.279	.473
Vitality	0.493 ± 0.282	0.567 ± 0.311	0.517 ± 0.290	.248

Although the scores might hint at lower agentic capacity, relatedness and vitality, consistent with what one might predict for the challenges posed by facing caring responsibilities, further research with more balanced samples would be needed to better clarify these relationships.

TABLE VIII
BARRIERS AND SUPPORTS BY CAREGIVING STATUS

Scale	**No Caring** ($n = 305$)	**With Caring** ($n = 18$)	p
Barriers	0.406 ± 0.199	0.548 ± 0.182	.002
Agentic capacity	0.565 ± 0.271	0.489 ± 0.230	.199
Relatedness	0.501 ± 0.301	0.472 ± 0.283	.680
Vitality	0.525 ± 0.287	0.478 ± 0.292	.537

5) Barriers as Selective Threats to Psychological Supports: Most critically, barriers did not uniformly constrain all learning supports. Barriers correlated negatively with relatedness ($r(370) = -0.197, p < .001$), indicating that higher logistical and personal constraints were linked to a significant erosion of students' sense of belonging and community. Barriers also correlated negatively with vitality ($r(370) = -0.122, p = .018$), showing that constraints depleted psychological energy and well-being. Contrarily, in-person benefits correlated positively with both relatedness ($r = 0.117$, $p = .023$) and vitality ($r = 0.126$, $p = .015$), showing that physical presence is an important ingredient in flexible learning environments, despite potential barrier counterparts.

Barriers showed no significant direct relationship with agentic capacity ($r(370) = -0.055, p = .287$). This could suggest that students facing high barriers (e.g., commuters, caregivers, workers) maintained similar agentic intentions but lacked the relational support and psychological energy to sustain engagement.

6) Commuters are Heavy Workers: A chi-square test revealed a highly significant association between employment status and commuting status ($\chi^2 = 26.99$, $p < .001$). As displayed in Table IX, commuters were much more likely than non-commuters to work more than 10 hours per week during term time (43% vs. 19%), and substantially less likely to not work (37% vs. 63%). These differences were not only statistically significant but also practically meaningful: the distribution of employment status within the commuter group was nearly inverted compared to non-commuters.

TABLE IX
COMMUTING VS WORKING CONTINGENCY TABLE

	No Work	<10 h/week	>10 h/week	Total
Non-Commuter	112	32	33	177
Commuter	54	28	63	145
Total	166	60	96	322

This finding highlights the structural disadvantages faced by commuting students, who must balance heavier work commitments with their studies. When evaluating equity in flexible learning, it is essential to account for this compounded challenge of commuting coupled with heavy employment. This pattern underscores the necessity for institutional support structures that are responsive to the lived realities of diverse student populations.

D. Qualitative Insights

Thirty-three students (8.9% of respondents) provided open-ended reflections, covering the themes displayed in Table X.

TABLE X
TOP THEMES IN OPEN-ENDED RESPONSES

Theme	**Responses**
Time and scheduling barriers	10
Material and content difficulty	8
Learning engagement and labs value	7
Vitality challenges	5
Social Connection and Isolation	2

Time and scheduling barriers dominated qualitative responses, with ten students highlighting commute times, module timetable conflicts, and competing assessment deadlines as impediments to consistent attendance: "the timetable of the module is very tough" and "when you're commuting for 2 hours for early lectures... we need sleep."

Material and content difficulty was the second most common theme. Eight students reported that challenging technical content required in-person explanations: "some areas in class were hard to understand, definitely needed the in-person support."

Learning engagement was mentioned by seven students, who provided appreciation for hands-on formats like labs and interactive problem-solving, with comments emphasizing that flexibility supported diverse learning preferences: "the labs made everything click."

Vitality challenges were referred by five students, who wrote about stress, sleep disruption from commuting, and mental health impacts: "my biggest struggle with attendance is due to a sleep disorder so I miss most 9AMs."

Social connection and isolation, notably, featured in only two responses, suggesting that most respondents did not experience social isolation as a primary concern – though this may reflect response bias toward engaged students.

The prominence of logistical and personal constraints in qualitative responses aligns with the quantitative hierarchy of barriers, reinforcing that constraints are primarily structural, not motivational.

VI. DISCUSSION

This study examined how student agency relates to engagement in flexible learning environments, and what barriers and supports shape students' capacity to exercise that agency across different groups. Findings reveal a nuanced picture: while our flexible learning environment is associated with agentic capacity and sustained engagement, structural barriers selectively undermine relational and emotional scaffolding.

A. Agency as Capacity vs. Agency as Realization

The intent–action gap we have identified between students' self-reported engagement/intention and their participation patterns [30] supports a distinction between agentic capacity and agentic realization. This distinction has important implications for how we theorize agency in higher education, as it provides an important conceptual foundation for distinguishing between the capacity to choose and the realization of those choices in practice.

Within SDT, favorable learning conditions that support autonomy, competence, and relatedness are associated with greater psychological vitality and a stronger sense of agentic capacity, supporting persistence and engagement over time [5], [6]. In our data, all three constructs (agentic capacity, relatedness and vitality) were positively correlated, as were the ones related to the learning environment (engagement frequency, learning value and in-person benefits).

Unexpectedly, we did not observe statistically significant differences in relatedness or vitality across commuter, caregiver or worker groups. This may reflect contextual factors, compensatory strategies, or limited sensitivity of self-report measures. However, prior research in flexible and blended learning contexts consistently identifies relatedness and vitality as particularly vulnerable under structural constraints [7], [15].

Barriers such as commuting, scheduling conflicts, or caregiving responsibilities selectively undermine relatedness and vitality: a student may retain the intention to engage (agentic capacity), but reduced peer interaction or depleted energy may prevent them from sustaining that engagement (agentic realization). This asymmetry underscores that while autonomy-supportive design is essential, it is not sufficient. A flexible learning model that provides choices without also investing in structures for relatedness and vitality may fall short in enabling agentic realization.

B. Designing Beyond Choice

1) Scaffold the Development of Agentic Capacity: SDT suggests that curriculum design should incorporate specific instruction and scaffolding to help students develop their agentic capacity. Opportunities for self-reflection and assessment (based on observed academic outcomes) would guide them on what types of learning modalities actually help their learning, or in which ways to better use the different resources.

2) Prioritize Barrier Reduction: Our barrier hierarchy is instructive for design. Logistical barriers (scheduling, transportation, material accessibility) dominate. These are not individual-level challenges; they are design and institutional challenges. 40.6% of students report transportation difficulties, with commuters proportionally more affected. 33.3% report scheduling conflicts, suggesting that even with flexibility, course timetables remain constraining.

3) Invest in Well-being: Within SDT, well-being is conceptualized as subjective vitality (energy for engagement) that emerges when basic psychological needs (including relatedness) are satisfied. Relatedness and vitality are linked to in-person learning, and reduced by barriers. Curriculum design should incorporate mechanisms to detect engagement barriers early and connect at-risk students with peer mentoring and institutional support [15], [17].

C. Limitations and Boundary Conditions

1) Single Cohort: Our sample comes from first-year Computer Science and Electronic Engineering at one university in England. Results may not generalize to other disciplines, student populations, or educational systems. The tuition-funded model of English higher education may produce different patterns than fee-free or fully-subsidized systems. Restricting the population to first-year students, whose agency may still be developing, limits generalizability to later-year students.

2) Statistics: Survey non-respondents showed lower academic performance (9-point deficit), suggesting potential response bias, as our respondents are more engaged than the full population. The caregiving sample is small ($n = 18$), limiting statistical power: results for caregivers should be interpreted cautiously. Survey measures reflect students' perceptions: barriers are self-reported; perceived learning value does not equal actual learning gains (future research could include academic performance outcomes).

3) Survey Design: The lack of statistical significance in the null correlations between agentic capacity and engagement, learning value or barriers prevents us from exploring those potentially interesting outcomes. In order to reduce the survey's completion time, some questions used binary items instead of Likert scales. The corresponding lower resolution may have blurred existing effects, which we could enhance in the future by reducing the survey length and using Likert scales for all items – possibly capturing subtle variations in fragile constructs, such as relatedness or vitality, and how they interact with demographic groups.

4) Equity: To preserve anonymity in a relatively homogeneous cohort, detailed demographic variables such as gender identity, ethnicity, disability status, or socioeconomic background were not collected. This limits the ability to examine how structural barriers and engagement patterns may intersect across multiple dimensions of disadvantage. Furthermore, given the predominantly male composition of this cohort, the reported barriers should be interpreted as such. For example, caregiving responsibilities were among the least frequently cited challenges, which may reflect broader gendered trends in higher education, where women more often balance study with caregiving and domestic responsibilities.

D. Recommendations

1) For Course Designers: Flexibility does not solve equity, and barriers specific to the student population should be actively audited: commuters could benefit from compressed timetabling and alternative high-quality asynchronous access for some activities; caregivers would favor flexibility around assessment deadlines. Preserving the distinctive affordances of in-person interaction while making effective use of online materials, all students should clearly understand that engagement is supported through multiple pathways, not just attendance.

2) For Institutional Leaders: Institutional policies should address underlying barriers, such as transportation, childcare and scheduling inflexibility. Well-being should be foundational, including built-in support for workshops (stress management, sleep hygiene), peer support, and other incentives (prizes, completion points, or achievement badges).

3) For the Engineering Education Community: This study challenges the narrative that more choice leads to better outcomes. The evidence suggests that choice is necessary but not sufficient. True educational equity requires both expanding autonomy and addressing structural constraints. Flexible design is thus an equity *opportunity*, not an equity *solution*.

VII. Conclusion

Flexible learning design successfully supports student agentic capacity and enables engagement to support learning. However, structural barriers can limit the realization of that agency for a significant portion of the student population. Commuters, caregivers, and workers maintain similar agentic capacity as their less-constrained peers, yet face substantially higher barriers. At the same time, reported engagement frequency remains remarkably stable across all groups, suggesting that barriers do not reduce perceived engagement *per se*, but are associated with reduced emotional support, operationalized here as relatedness and vitality.

We suggest that flexible design addresses the motivational dimension of engagement – *How do I want to learn?* – without fully addressing the structural dimension – *Can I engage despite my constraints?* Moving forward, institutions must pair flexibility, which expands autonomy, with targeted barrier reduction and well-being support, which sustains the relational and emotional resources needed to translate intention into sustained engagement. In addition, flexible designs should explicitly integrate support for the development of students' agentic capacity, including opportunities for reflection and calibration of engagement strategies.

Design recommendations include structured attendance flexibility, responsive formative feedback, targeted support for peer connection, and integrated well-being infrastructure. Together, these strategies advance student-centered engineering education by prioritizing learners' lived experiences and constraints.

For the engineering education community, the takeaway is to design for student agency, but not to assume agency alone suffices. The structural and psychological enablers of agentic capacity need to be scaffolded: equity in flexible learning is not simply a matter of offering more options, it is a matter of ensuring that those options are genuinely accessible to all students with diverse lived circumstances.

Future research combining validated psychological measures with behavioral and longitudinal data is needed to further examine how agentic capacity is realized in practice.

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APPENDIX: SURVEY INSTRUMENT

The following reproduces, verbatim, the student survey conducted on Moodle. While the wording of instructions, questions, and response options remains unchanged, the formatting has been condensed to save space. With the exception of Question 8 (an open-ended text field), all questions required a response – this was indicated by a red exclamation mark appended before each of those questions, which is a non-configurable characteristic of the Moodle template deployed at our institution.

Engagement survey

We would like to ask you to take 2-3 minutes to answer a few questions about how you have engaged with the teaching and learning materials in this module. This is part of the Jisc pilot program we have been running, which was described in the first lecture and also in an Announcement Forum post.

Your answers will help us decide how we should best update the delivery of teaching in the Department in future years.

Your answers will remain completely anonymous. 10% of your marks for the second Assessed Quiz will be awarded for submitting this survey. You can complete the survey after the 30 minute time limit for the assessed quiz; completion of the survey is not timed.

– Your engagement

1) During the term, how often do you engage with the following?(Never / Sometimes / Often)
(i) In-person lectures. (ii) Online lectures. (iii) Labs. (iv) Recorded lectures. (v) Pre-recorded videos.

2) How well do you learn from each format? (Not at all / Slightly / Very)
(i) In-person lectures. (ii) Online lectures. (iii) Recorded lectures. (iv) Reading course materials. (v) Self-sourced materials. (vi) Peer support. (vii) Pre-recorded material. (viii) Labs/practicals.

3) What specific benefits do you get from in-person sessions? (Not at all / Slightly / Very)
(i) Better understanding of complex topics. (ii) Direct interaction with instructor. (iii) Engagement with classmates. (iv) Fewer distractions. (v) Immediate answers to questions. (vi) Structure and routine.

4) Why would you not attend in-person lectures or labs? (Disagree / Neutral / Agree)
(i) Course materials are sufficient without attendance. (ii) Difficulty focusing in classroom environment. (iii) Personal responsibilities (childcare, family care). (iv) Scheduling conflicts. (v) The module doesn't interest me. (vi) The material is too difficult. (vii) Transportation difficulties.

– Your learning journey

5) Your learning choices (select all that apply)
(i) If I stop attending lectures or labs, it's easy for me to get back on track. (ii) I make conscious choices about which classes to attend. (iii) I view challenges in my learning as opportunities to develop my abilities. (iv) I connect what I'm learning to my future professional goals. (v) I feel confident in my ability to determine which module components are essential for my learning. (vi) None of the above.

6) Your social connection (select all that apply)
(i) I feel like I belong in the university community. (ii) I have friends I can study with or discuss course material with. (iii) I feel comfortable participating in class discussions. (iv) My friends' attendance patterns influence my own attendance decisions. (v) I prioritize social opportunities over class attendance when conflicts arise. (vi) None of the above.

7) Your energy (select all that apply)
(i) Anxiety or stress significantly impacts my ability to attend classes. (ii) I generally feel energetic enough to participate fully in my classes. (iii) I have effective strategies for managing academic stress. (iv) I maintain a sleep schedule that supports my academic commitments. (v) Physical discomfort affects my attendance. (vi) None of the above.

8) Would you like to add anything about your student journey?

– Tell us about you

9) Are you a commuting student? (Yes / No / Prefer not to say)

10) During term time, how many hours per week do you work on a job? (None / Less than 10 hours / More than 10 hours / Prefer not to say)

11) Do you have caring responsibilities? (Yes / No / Prefer not to say)