

THE DIVERSITY OF LEARNERS' VOICES AS A DRIVER FOR DESIGNING A LEARNING SYSTEM 4.0 THROUGH A TRIZ-BASED METHOD

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ABSTRACT

The rapid evolution of Industry 4.0 has increased the gap between academic programmes and labour-market expectations. Although Education 4.0 promotes learner-centred and digitally supported learning, many existing systems still lack personalisation, accessibility, pedagogical support, and connection with real industrial contexts. Designing an effective Learning System 4.0 therefore requires combining technological advances with a clear understanding of learners' expectations. This study focuses on learners' voices as an initial step within the ConNect method, a TRIZ-based design method for developing a Learning System 4.0. A structured questionnaire was administered to engineering students at the beginning of their programme to collect data on their profiles, pedagogical preferences, expectations, and perceived learning difficulties. An open-ended question also explored what students expect from a learning system to support their transition into employment. The study adopts a mixed-method approach. Descriptive statistics are used to identify overall trends and differences across student profiles, while thematic coding of open responses highlights recurring themes. The expected outcomes aim to identify learners' priorities and define pedagogical requirements to support the future design of a Learning System 4.0.

Keywords: Industry 4.0, Education 4.0, Learning System 4.0, learners' voice, TRIZ-based design method, mixed-method approach

1 INTRODUCTION

The transition from school to higher education and then to industry has become increasingly complex, as students' learning pathways are not always aligned with their expectations, working methods, prior experiences, and skills [1]. This misalignment is reinforced by the rapid evolution of industrial skill requirements, driven by emerging technologies such as AI and new decision-making processes [2]. As global education systems evolve toward more digital, interconnected, and data-driven models often referred to as education and Learning System 4.0 there is a growing need to understand how these transformations are perceived and experienced by the students themselves [3]. Despite the rapid diffusion of advanced technologies such as learning analytics, immersive environments, and adaptive platforms, the voices of learners remain insufficiently integrated into the design of these systems [4]. This need is empirically supported by Strating, Vanlommel, and Vermeulen (2025), who show that students' perceived opportunities to express their voice in curricular decisions are positively associated with the satisfaction of their basic psychological needs and their autonomous learning motivation. Their findings indicate that when students' expectations and experiences are not adequately captured, a misalignment arises between educational design and learners' needs, thereby reducing the effectiveness of educational systems [5]. The literature on student voice indeed shows a strong concentration of research at the secondary education level, to the detriment of higher education. A systematic review published in 2024 highlights that the majority of empirical studies focus on high schools, while research dedicated to higher education remains limited and is often theoretical [6]. Current literature highlights that overlooking user needs in education design can reinforce existing inequities and create new forms of exclusion, especially for learners who lack social capital or cultural representation within higher education [4]. In this context, capturing, interpreting, and acting upon the voice of learners becomes

essential to ensure that Learning System 4.0 does not merely digitise existing practices but instead fosters inclusive, meaningful, and empowering learning experiences [7]. Understanding learners' motivations, expectations, challenges, and perceptions is therefore a foundational step toward the creation of systems that support diverse pathways and promote equitable progression from education to employment [8]. In this study, learners' voices are considered as the first data collection step in a broader design process based on the ConNect method, a TRIZ-based design approach. They are used not only as descriptive feedback, but also as design inputs to identify needs and parameters for developing a Learning System 4.0. This paper presents a structured survey on students' profiles, learning preferences, expectations, and difficulties, followed by the methodology, results, discussion, and future work.

2 METHODOLOGIES

This study adopts a mixed-methods approach based on an online survey conducted among bachelor's and master's engineering students. Administered via LimeSurvey, the survey explored students' profiles, learning difficulties, and expectations regarding the design of a Learning System 4.0 focused on skills development and employability. A total of 334 complete responses were retained. Participation was voluntary and anonymous, and the data were collected for scientific research purposes.

3 DESCRIPTIVE ANALYSIS OF THE RESULTS

This section presents the descriptive results based on the 334 complete responses. It first describes the student population, then analyses students' responses and expectations regarding the development of a new Learning System 4.0.

3.1 Description of student population

The sample mainly consists of students beginning a new higher education programme, mostly first-year bachelor's students (70.3%) and first-year master's students (24.8%). The represented fields include Electrical Engineering and Industrial Computing, Multimedia and Internet Professions, Quality, Industrial Logistics and Organisation, Industrial Engineering and Maintenance, QHSE, and Industrial Engineering. These fields were selected due to our direct involvement, which limits the generalisability of the findings. Respondents had diverse academic backgrounds, mainly general (51.2%) and technological (37.1%) high school diplomas. Most students reported some professional experience (87.7%), ranging from short internships to apprenticeships. Their programme choice was mainly driven by personal interest (62.2%), followed by Parcoursup¹ (29.6%) and social influences such as family or peers (24.25%).

3.2 Learner's Expectations: Format

This section examines students' expectations regarding learning formats and their preferences across different pedagogical aspects.

- **Preferred learning format:**

Survey question: "What learning format do you prefer?"

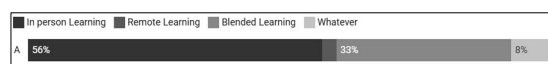


Figure 1. Students' preferences for learning

Figure 1 shows a strong preference for in person learning (56 %), while one third of students favour a blended learning (33 %). Fully remote learning is rarely preferred (3 %).

- **Preferred learning balance: Company vs University and Practice vs Theory**

Survey question 1: "What distribution between time spent in the company and time spent in university would best suit your way of learning?"

Survey question 2: "During the university programme, what balance between practical activities and theoretical courses would best suit your way of learning?"

¹ Parcoursup is a national admissions platform restricted to French nationals.

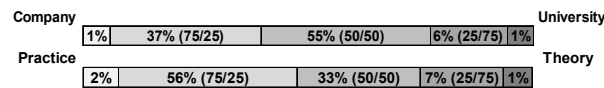


Figure 2. Preferred learning balance: Company vs University and Practice vs Theory

Figure 2 presents students' preferences along the company vs university and practice vs theory axes, analysed by study level and field. For company vs university, master's students mainly prefer 75 % company / 25 % university (48.1 %), while bachelor's students favour 50 % company / 50 % university (57.6 %). By field, QHSE students mostly prefer 75 % company / 25 % university (54.4 %), whereas QLIO students favour 50 % company / 50 % university (62.9 %). For practice vs theory, bachelor's students prefer 75 % practice / 25 % theory (61.1 %), while master's students favour 50 % practice / 50 % theory (44.6 %). By field, GEII students strongly prefer 75 % practice / 25 % theory (79.2 %), whereas GIM students mostly prefer 50 % practice / 50 % theory (77.5 %).

- **Learning conditions**

Survey question: "When learning something new, how important are the following conditions for you?"

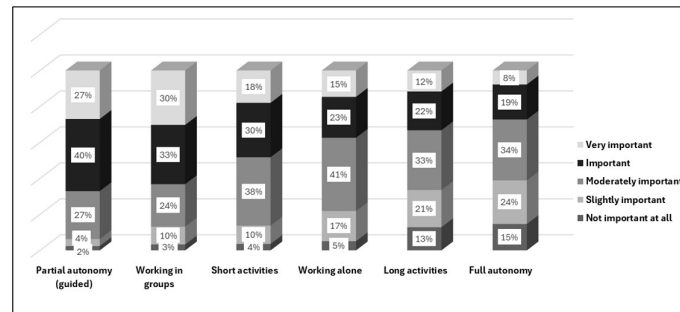


Figure 3. Importance of learning conditions

Figure 3 presents students' preferences regarding learning conditions according to their level of study. The results show a clear preference for partial autonomy among both bachelor's students (66.8%) and master's students (66.6%), while total autonomy is less frequently chosen. Similarly, students tend to prefer group work over individual work, with 66.4% of bachelor's students and 55.9% of master's students selecting this option. Regarding activity duration, most students do not express a clear preference between short and long-term activities, although short activities are slightly more favoured.

- **Importance of different learning elements**

Survey question: "If you could adapt your university programme, which elements would you consider important to modify?"

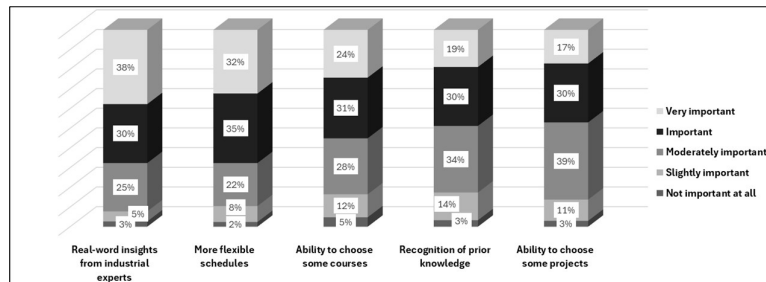


Figure 4. Importance of different learning elements

Figure 4 shows that students value learning elements linked to professional realities, especially industrial expert insights, flexible schedules, and course choice. Master's students show stronger preferences for autonomy and project selection, while bachelor's students appear to need more structure and guidance. Overall, engineering students seek more flexible, personalised, and professionally oriented learning experiences.

- **Importance of learning resources**

Survey question: "When you start a new university programme, what would you like to have as a priority to learn effectively?"

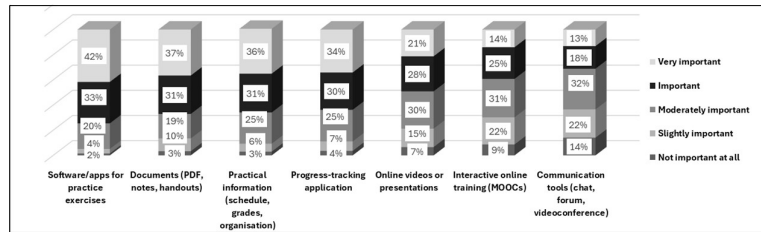


Figure 5. Importance of learning resources

Figure 5 shows that bachelor's and master's students mainly prioritise resources supporting active learning and task organisation, such as software, applications, notes, PDFs, and schedules. However, master's students value online videos and presentations more than bachelor's students. Interactive online learning and communication tools receive lower levels of importance in both groups.

3.3 Learner's Expectations: Content

This subsection focuses on students' expectations regarding university content to identify the elements they consider most important for their learning needs.

- **Difficulties encountered during learning**

Survey question: "What difficulties do you encounter during your learning process?"

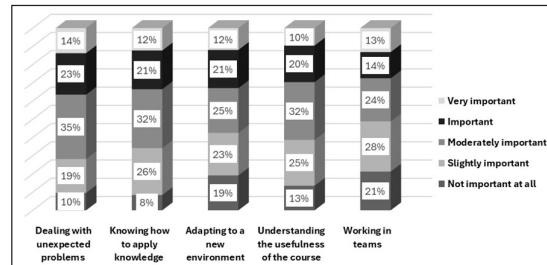


Figure 6. Difficulties during learning

Figure 6 shows that students mainly struggle with adapting to new situations and solving unexpected problems. These difficulties suggest that learning barriers are more related to applying knowledge in varied contexts than to understanding theory. They also indicate a need to better connect learning with professional realities and to develop initiative and adaptability.

- **Expectations about learning content**

Survey question: "How important are the following elements for your future employability?"

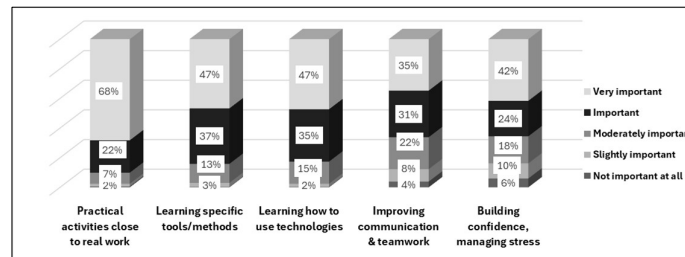


Figure 7. Expectations about learning content

Figure 7 shows that students mainly prioritise practice-based learning, especially practical activities connected to real work, followed by the acquisition of tools, methods, and technological skills. Although soft skills such as communication, creativity, and stress management are valued, they remain secondary. Overall, engineering students strongly associate learning and employability with technical and practical skills, which may reveal a gap with professional expectations where soft skills are increasingly important.

- **Expected roles of teachers**

Survey question: “In your opinion, what roles should teachers play to help you succeed in your learning at university, and how important is each of these roles to you?”

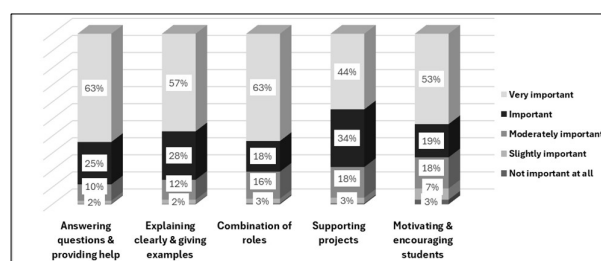


Figure 8. Expectations regarding teacher roles

Figure 8 shows that students mainly expect teachers to provide expertise, clear explanations, and concrete examples. This reflects a need for guidance and support, while revealing a gap with Education 4.0 principles that emphasise learner autonomy and the teacher’s role as facilitator.

• Open-ended question

In the final survey question, students stated what a learning programme should provide to support their transition into employment. A thematic analysis of 274 responses identified six recurring themes, presented in Figure 9.

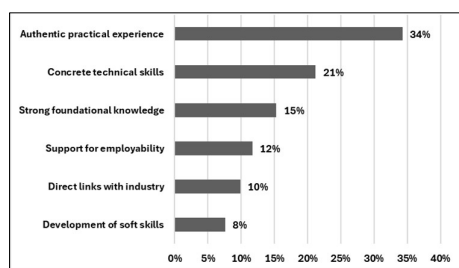


Figure 9. Distribution of students' expectations for employability

Figure 9 shows that students mainly associate employability with practical experience and technical skills, while foundational knowledge is seen as complementary. They also value stronger links with industry, whereas soft skills are less prioritised.

4 BEHAVIOURAL ANALYSES

The behavioural analysis highlights strong student expectations for practical, profession-oriented learning. Students prefer real-world situations, company exposure, and hands-on activities integrated into university programmes. They also expect greater adaptability, flexibility, and accessibility through flexible schedules, course organisation, project choice, digital tools, and clear learning information. These expectations reflect difficulties in applying knowledge, solving unexpected problems, teamwork, and adapting to new environments. Master’s students show stronger needs for autonomy, project choice, and flexible pathways, while bachelor’s students prefer more guidance, structure, and pedagogical support. Students strongly value employability, technical skills, professional tools, and real work practices, while soft skills receive less attention. They also expect teachers to provide clear explanations, continuous guidance, and direct support, which differs from the Education 4.0 vision of teachers as facilitators and coaches. Therefore, students need to be progressively supported toward autonomy through an expert-coach role combining expertise, guidance, and co-construction of knowledge. Overall, the results align with Education 4.0 by identifying conditions for its implementation. The proposed Learning System 4.0 should emphasise hands-on, project-based, and problem-solving activities linked to industry, while promoting collaborative learning, flexible modular pathways, adaptive digital tools, feedback, self-assessment, progress monitoring, confidence, and autonomy.

5 DISCUSSIONS

The results highlight five consistent expectations that shape students’ learning behaviours: flexibility, accessibility, adaptability, employability, motivation and engagement. Students prioritise practice learning, flexible and personalised learning paths, easy access to resources and information, and strong links with professional contexts. These expectations are closely aligned with the core principles of Education 4.0 as defined by Peter Fisk [3], which promote flexible learning across time and place,

personalised and adaptive pathways tailored to individual capabilities, freedom of learning methods and tools, project-based and experiential learning connected to real-world contexts, stronger emphasis on data interpretation and critical thinking, continuous competency-based assessment instead of traditional exams, greater student involvement in shaping curricula, and a shift in the teacher's role toward mentoring and guidance in increasingly autonomous learning environments. The first contribution of this study lies in its empirical grounding within higher education. Several recent studies confirm that higher education students favour active learning approaches based on the concrete application of knowledge and exposure to situations close to the professional world [9].

6 CONCLUSION AND PERSPECTIVES

To design a Learning System 4.0 aligned with students' expectations, this study uses a Voice of the Customer (VoC) approach, derived from Lean management and continuous improvement, to capture stakeholder needs through surveys. Engineering students are considered the primary customers, as they are the direct beneficiaries of the learning system. Students particularly value practice-based learning, flexible and personalised pathways, easy access to resources, and stronger links between academic learning and professional contexts. However, the study is limited to engineering education and cannot yet be generalised to other disciplines. Moreover, while the survey provides a broad quantitative overview, it does not explain the underlying reasons behind students' choices. Future research should therefore include qualitative methods, such as interviews or focus groups, and explore disciplinary differences within engineering education. This survey represents a sub-phase of the VoC process within ConNect, a TRIZ-based design method for Learning System 4.0. Future work will integrate the perspectives of teachers and companies and use these results to define action and evaluation parameters, analyse their relationships, identify contradictions, and generate innovative solution concepts.

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