ISBN: 978-628-96613-3-0. ISSN: 2414-6390. Digital Object Identifier: https://dx.doi.org/10.18687/LACCEI2026.1.1.1109

Listening to Engineering Students with Disabilities: Qualitative Insights Towards Academic Equity and Inclusivity in the Era of Digital Transformation

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***Abstract*– Ensuring equitable participation of students with disabilities in engineering education remains a persistent challenge despite extensive inclusion frameworks and expanding support services. This study provides qualitative insights into domain-specific barriers these students face during their studies and early employment, and examines their readiness to adopt artificial-intelligence–based tools within an academic accommodation process. Thirteen semi-structured interviews were conducted with current and recently graduated engineering students with disabilities, representing diverse mobility, sensory, cognitive, and communication profiles. Reflexive thematic analysis revealed dominant barriers in both study and work contexts. While students expressed a strong preference for human counselling, they also recognized the value of AI tools for selected tasks. Findings highlight the continuing implementation gap between formal inclusion policies and everyday practice, and suggest that combining human support with carefully targeted AI solutions offers a feasible pathway toward more equitable, efficient, and individualized accommodation processes in engineering education.**

***Keywords*-- Students with disabilities, equity and inclusivity, engineering education, artificial intelligence.**

I. Introduction

Equal access to education—including for students with disabilities—is formally guaranteed by global and local frameworks. Across society, numerous initiatives promote adapting educational processes to the individual needs of persons with disabilities—ranging from the UN Convention on the Rights of Persons with Disabilities [1] to the ambition, set out in the 2020 Rome Communiqué, to create an inclusive European Higher Education Area by 2030 [2], alongside national and organizational efforts. Collectively, these actions aim to expand and enhance access to quality higher education, particularly for students from underrepresented and socially vulnerable groups.

Many universities strive to devote special attention to students with disabilities so as to include them in the teaching process as equal participants, and to prepare them well for the labor market so that—despite their disabilities—they are ready to contribute to their work tasks. To create the conditions necessary to broaden the availability of high-quality education for young people with disabilities—and to ensure equally accessible education for all students—the University of Rijeka established a student support and counselling organizational unit in 2011. Since then, this unit supports teaching staff and students in designing teaching processes tailored to the individual needs of students with disabilities, enabling equal access to education. In this paper, all adjustments and adaptations of the teaching process will be referred to as "accommodations". The number of students using their services has grown from 15 in 2011 to 156 in 2025. The group includes students from various study programs, including engineering, who, due to illness, impairment, or disorder, experience permanent, occasional, or temporary difficulties in carrying out every day academic activities. This paper will refer to them as "students with disabilities".

Despite continuous efforts in higher education to provide equal education opportunities, a persistent implementation gap remains. Students with disabilities encounter barriers that their peers do not, and these often intensify or change at the transition to employment. Obstacles often include mobility and wayfinding, inaccessible learning materials and tools, sensory and cognitive load in crowded or noisy environments, and limited procedural accommodations [3],[4],[5]. In engineering, these barriers can be field-specific: reading complex diagrams and models, fine-motor tasks (e.g., soldering, micro-connectors), work in high-noise production settings with alarm-driven processes, or multitasking under tight deadlines without unambiguous specifications. Despite the growing literature on inclusive education, evidence tailored to engineering study programs and jobs remains limited.

Motivated by the persistent gap between formal inclusion frameworks and day-to-day practice, this study aims to define a feasible academic accommodation process tailored to engineering education and supported by AI methods. It examines how domain-specific barriers manifest during engineering study and early employment, and which accommodations are most effective in practice. It also assesses students' readiness to use artificial-intelligence methods within an academic accommodation process designed to support their needs. In doing so, it contributes to a sustainable process that strengthens equity and inclusivity while keeping the student at the center. The next chapter presents the research topic and offers an overview of relevant related work. It is followed by the Methodology chapter, which details the procedures used to conduct the study. The Results and Discussion chapter then reports the empirical findings and examines their potential application within the accommodation process. Finally, the Conclusion synthesizes the main insights, outlines the study's limitations, and suggests directions for future research.

II. Related Work

Prior research documents the barriers faced by students with disabilities compared to their nondisabled peers. These issues are especially pronounced in STEM fields (science, technology, engineering, mathematics), with engineering frequently singled out as a particular area of concern. Contemporary efforts in STEM place growing emphasis on engineering education that develops the competencies required in today's century [6], thereby promoting engineering education and Engineering education 5.0 [7] that actively builds so-called "21st-century skills", such as problem-solving, computational and data literacy, design thinking, teamwork and communication, ethical and societal awareness, and adaptability to fast-changing technologies. At the same time, engineering programs draw on a long tradition of rigor, established standards, and precision, grounded in principles of learning-by-doing and hands-on practice to prepare highly trained technologists capable of delivering practical, workable systems and technical machines [8]. Because conventional classrooms are structured around the needs of the majority without disabilities, students with disabilities are frequently limited in their ability to engage fully [9].

Previous studies point to numerous barriers faced by students with disabilities. This body of work generally examines particular groups of students (e.g., students with mobility or other physical disabilities, or students with visual impairments) and focuses on specific contexts (e.g., barriers that students with disabilities encounter in laboratories). This underscores the need for an individualized approach to each student who has specific difficulties in a specific environment. Today, a personalized approach is facilitated and accelerated by tools based on artificial intelligence (AI). Given the growing number of students seeking support and the insufficient number of experts able to provide timely assistance, there is an opportunity to apply artificial intelligence and other tools to automate certain academic accommodation processes [10]. Notably, although such tools are available, the question remains whether students with disabilities are willing to use them, and for which specific activities, which, among other things, is an issue examined in this study.

The barriers identified in the cited studies are numerous; this discussion focuses only on those encountered in engineering education settings. Students with physical disabilities often experience difficulties grasping and manipulating equipment and machinery. Additionally, students with disabilities frequently require more time to complete tasks. As a consequence, they are often relegated to the role of observers while others conduct, for example, experiments in science and engineering laboratories. This also indicates that instructors are not always prepared to work with students with physical disabilities and may at times provide insufficient accommodations, overaccommodate, or even hold low expectations of these students [11].

In their study [12], Rule and Stefanich identify problems such as inaccessible lab equipment, lack of assistive technologies, prejudice, assistants who do too much for the student and thereby prevent authentic experience and learning, poor self-esteem, and others. As helpful factors affecting the success of students with disabilities in STEM, they recognize many that relate to instructors—for example, teachers who hold high expectations and understand a case-by-case approach to reasonable accommodations, use universal instructional design strategies, and receive intensive training to meet specific student needs. They also identify factors linked to counselling and accommodation activities, such as tutoring services, academic support, exam accommodations, assistive technologies, lab assistants, and similar supports.

According to Pfeifer [13], factors that contribute to the attrition of students with disabilities from STEM include inadequate support during the transition to higher education, difficulties obtaining effective accommodations in STEM courses, issues with the physical and digital accessibility of STEM courses and labs, limited instructor knowledge about disability and accommodation practices, and student perceptions of STEM as an unwelcoming environment for students with disabilities

So, beyond physical barriers, attention must also be directed to personal ones. Research indicates that inaccurate perceptions of academic competence are a personal barrier that can affect student success. Some students with disabilities may hold a pessimistic view of their academic capability, underestimating it—perhaps because they are more acutely aware of their weaknesses. Conversely, some students with disabilities may hold overly optimistic views of their capabilities. Both cases can lead to inadequate actions – for example, not requesting needed accommodations – which may also be influenced by concerns about disability-related stigma [14].

In addition to physical and personal barriers, barriers related to the social environment should also be noted.

In recent years, it has been recognized that students require interventions to successfully complete their studies [15]. In line with this, Dekker et al. [16] report that roughly 1 in 3 students leaves higher education without completing the degree they enrolled in, with many struggling to adapt to the tertiary context—manifested in social integration difficulties and challenges in managing their learning processes, including goal setting, planning, monitoring, and time management. For some students with disabilities, barriers to completion include too few STEM role models, inadequate encouragement to pursue STEM, and insufficient instructor understanding of disability [17].

Engineering students and professionals with disabilities often experience less social inclusion among classmates and coworkers and less respect for their professional capabilities. Consequently, students with disabilities are less likely to persist and more likely to leave engineering study programs, and engineering professionals with disabilities are more likely to consider leaving their jobs, compared to their peers. These outcomes can be explained, in part, by greater exposure to interpersonal prejudice and bias – issues that require sustained attention throughout education – alongside reforms that ensure the availability, quality, and relevance of higher education while equalizing opportunities for all students [18]. In addition to academic difficulties and an inability to clarify or pursue their educational and career goals, students often leave higher education due to a failure to integrate into the institution's intellectual and social life [19].

Accordingly, it is easy to understand the findings of research on the employment rate of people with disabilities, which is often half (i.e., up to twice as low as) the employment rate of people without disabilities [20]. Even after overcoming the barriers to earning a degree, students still confront obstacles to accessing opportunities in the STEM labor market [14]. Students and professionals with disabilities remain underrepresented across STEM-related career paths [21].

Barrier removal should be viewed as a goal not only for students with disabilities and their families. The benefits that neurodiverse students – and later, employees – can bring to engineering disciplines and the STEM field are increasingly recognized. For example, students with autism or dyslexia may possess assets that are highly desirable in engineering and have the potential to contribute to innovation in science and engineering [22].

Failure to acknowledge the diverse abilities and contributions of disabled individuals in engineering education both restricts their presence in the profession and deprives the field of valuable innovation. A reframing is therefore needed—one that recognizes, affirms, and elevates the expertise and potential of students and engineers with disabilities [23].

Research identifies various ways to remove barriers, some of which depend on the type of difficulties. Findings from a study [24] that conducted semi-structured interviews with six students, specifically students with non-apparent disabilities – showed that understanding and accommodations from engineering professors contribute to mental health. In removing barriers, the following can also help [11]: internships; mentoring; instructors who help students learn about available campus support; and access to personal support personnel. Academic counselling has been identified as being critical to student success, particularly for those from disadvantaged backgrounds. It has also been linked to student satisfaction and loyalty to the university, which should enhance student retention [25].

The study presented in this paper examined the specific barriers faced by students with disabilities, the barriers experienced by recent graduates, and the possibilities for overcoming these barriers through digital technologies and AI, as well as students' readiness to adopt such tools. AI can be defined as any software and hardware method that mimics human behavior and thinking [26], and, as such, can be integrated into selected steps of the process for supporting students' academic accommodations. The implementation of AI in the process of supporting students with difficulties would help to efficiently collect, process, analyze, and interpret data, and to make decisions or provide recommendations. The goal of such an intelligent system is to enable smarter and more efficient data processing and to automate processes [27].

III. Methodology

Given our research aim to define a feasible academic accommodation process tailored to engineering education and supported by AI methods and examine domain-specific barriers during engineering study and early employment, we conducted 13 semi-structured interviews with 7 current and 6 recently graduated engineering students with disabilities from 7 faculties offering engineering education. Our small sample reflects the small number of STEM students with disabilities at the University of Rijeka.

Interviews followed a protocol covering study and work-related barriers, current or previous accommodations, and desired support. The questions asked of the participants were grouped into four categories: (1) demographics; (2) barriers encountered during study/employment; (3) accommodations needed; and (4) AI tools. Each interview lasted approximately 55 minutes. Sessions were audio-recorded, transcribed, and anonymized. All participants provided informed consent to take part in the study.

Among the interviewees, there were 9 male and 4 female participants, aged between 21 and 31 with the average age of 25. Among the recently graduated, 3 were employed and 3 unemployed. The sampling of participants aimed to cover different disabilities, across mobility, sensory, and fine-motor/cognitive profiles. The participants reported to have the following disabilities: 5 motor impairment, 1 hearing impairment, 2 specific learning difficulties (dyslexia, dysgraphia, dyscalculia), 2 autism spectrum disorder (ASD), 1 speech-language-voice communication disorders, 1 chronic illness and 1 with multiple disabilities. All 13 participants used academic support and accommodations during their studies.

In the Results and Discussion section, quantitative data are summarized, while qualitative data were analyzed with reflexive thematic analysis (Braun & Clarke; [28]). Two researchers coded independently and reconciled any discrepancies. Priority setting used the MoSCoW method (must/should/could/won't).

IV. Results and Discussion

A. *Barriers During Engineering Study*

Qualitative data on domain-specific barriers that manifest during engineering study identifies three dominant themes: communication issues and lack of understanding from professors, inaccessible facilities and lack of necessary study accommodations as the most dominant barriers experienced during engineering study. These barriers were mentioned by the majority of the participants (13, 7 and 6 times, respectively), which confirmed findings from the related work analysis and authors' experience in working with students with disabilities.

Participants often reported „a lack of understanding from professors". For example, one participant reported „problems with professors who don't understand how to teach or who lack understanding. Professors are uneducated. Explaining what dyslexia is and that I'm not asking for special treatment. Some made things harder with their pseudo-accommodations or didn't recognize my accommodation at all."

Connected to the lack of understanding was also a lack of necessary study accommodations, as one participant explained: „Professors didn't understand my difficulty; some didn't initially accept my extended-time accommodation, or they would accept it but then make the oral exam unnecessarily difficult."

As for mobility issues, participants reported: "Most challenges I faced were due to physical barriers in the space, such as narrow classroom entrances, small rooms, and frequent elevator failures leading to my department, which made access to laboratory exercises especially difficult." Also, another participant stated; „The biggest challenge was the accessibility of the space. Some classrooms were, to put it best, poorly arranged (for example, too little space between desks or cramped entrances to the classroom). This made navigating with a wheelchair difficult. Another problem was elevator availability. It often happened that during a 15-minute break I had to stay on a certain floor because the elevator was overcrowded and constantly in use. Even if I decided to go downstairs for a break, there was a high chance I would be late for class."

Other barriers that were mentioned were: sensory load (noise, crowds, open-plan space) and multitasking (mentioned 4 times each); inaccessible/unsuitable tools (mentioned 3 times); fine motor skills and time management (mentioned 2 times each); induction difficulties, social difficulties, information and soft skills (mentioned once each).

The barriers our participants identified are in line with the results of other studies (e.g. [29],[30]) concluding that teaching staff do not have the necessary knowledge to promote student inclusion, nor are they aware of the needs of students with disabilities. The authors of this paper therefore see a possible solution to this issue by implementing teacher training on how to approach and support engineering students with disabilities. The training could include general diversity training, formal pedagogical training on implementing diversity principles into their teaching practice, but also meetings with peers and experts on particular topics. Furthermore, student support services are available for teachers as well, and can be a valuable asset in ensuring the quality of engineering education by meeting the needs of students with disabilities and integrating them in the study process.

B. Barriers During Engineering Employment

Following barriers during engineering study, participants were asked to focus on either current or desired employment barriers. They identified lack of accommodations, especially of working hours and working models as the most dominant barrier (mentioned 14 times), followed by inaccessible space and facilities (mentioned 10 times), and communication issues and lack of understanding from team leads, team members and clients (mentioned 10 times as well). These results show a similarity with the results from the previous section on barriers identified during engineering study. However, in this section they focused more on the accommodations of working hours and working models (e.g. remote work), not only on the physical accessibility. One participant emphasizes: "I would need to work part-time, not eight hours – the workday is too long." Another one said: "An additional challenge could be an inadequately adapted workspace and the possibility that it will be harder for me to find employment due to being limited to working exclusively remotely." As far as physical accessibility is concerned, another opinion stated: "When I think about it, I'm most afraid of having to depend on someone else regarding accessibility of the space. What matters most to me is being able to enter and navigate the workspace independently, without needing someone's help".

Communication issues and lack of understanding at work was rated high on the list of barriers with comments such as: "The biggest challenge for me could be communication and teamwork." or „My concentration is poor when I do several things at once if it involves other people. I would prefer to work alone".

Other barriers that were mentioned were: inaccessible/unsuitable tools (mentioned 5 times); multitasking (mentioned 3 times); fine motor skills, sensory load, time management, specialized transportation and personal assistance (mentioned 2 times each); and complex data and diagrams (mentioned once).

The difference between engineering education and employment is reflected in the participants' shift in focus: from teachers' awareness and disability-related expertise in education to the workplace environment in employment. By following established guidelines issued by the relevant state disability services, accommodating the workplace may be easier—particularly because it may require additional time and effort only at the beginning of employment. This initial investment can provide the support needed for the employee's success and, subsequently, for the company's success as well.

C. Effective Accommodations

When asked about which accommodations are most effective in practice, using the MoSCoW method, the participants offered dispersed answers. The "must have" and "should have" accommodations relate to accommodations of space, communication, deadlines, materials, tools and schedules, as well as availability of personal assistance, clear and binding instructions, induction and mentor support. There were no identified "could have" and "not at this time" (won't) answers.

Even though it is not an accommodation per se, the necessity for understanding, empathy, patience and readiness to listen were highlighted by most participants as important for overcoming previously identified barriers. Furthermore, several participants emphasized the need for further training of professors and mentors.

The following two comments soundly illustrate the previously mentioned accommodations:

"At university: more time, adapted font, oral questioning, more understanding from people, some mandatory training for professors. At work: a mentor at the beginning and understanding."

"It really comes down to organization and listening to others' needs, asking questions, and requesting clarification."

Additionally, several comments focused on "the possibility of working remotely", as well as "the continuous presence of an assistant while at the university or workplace", "less direct work with people", "better accessibility of the space—elevators, ramps, at least a handrail along the stairs".

The academic accommodations the interviewees had during their studies or internships include for example: extended time for exams; clearly defined schedule, deadlines and instructions; access to teaching materials in advance; using simple fonts in teaching and exam materials; support of an assistant when needed; enable individual and independent work even when assignments are planned for group work; organize student presentations in smaller groups or individually in front of the teacher/mentor; understanding difficulties related to communication and social interactions; accept wearing headphones to neutralize environmental noise and using anti-stress aids. To conclude, all of these accommodations are formulated so that they nourish personalized approach to the student, in accordance with student needs.

D. *Readiness to Use AI for Support*

To assess interviewee readiness to use AI methods within an academic accommodation process designed to support their needs, students were offered AI options selected on the basis of authors' previous research [10] and other studies [31], [32]. The AI options offered were the following:

- Automated scheduling of appointments with a student counsellor
- Chatbot / virtual assistant
- Automated selection of appropriate accommodations
- Customization of materials
- Assistive technology and accessibility tools (e.g., speech-to-text / text-to-speech, captions, etc.)
- Student monitoring/ supervision of progress using a specialized information system with machine-learning methods
- Automated referral based on needs (e.g., contact a counsellor, a doctor, student services, professor, etc.)

Participants could choose which of the AI options they considered helpful. They could choose multiple options. Results of their choices by frequency are presented in Fig. 1. The most popular option is the automated referral while the least popular option is automated scheduling. In addition to those, one participant, when asked to offer additional AI options, suggested an AI study guide.

Finally, interviewees were asked if they prefer to receive support from a counsellor or an AI agent. Only 1 participant preferred the AI agent, 3 the combination of both and the rest (9) preferred a real-life counsellor. The reasons for these choices were explained by the following answers:

"I think that human contact is better for receiving quality support, while AI is good for basic questions."

"For more general cases, an AI agent, because it saves time and the user gets an immediate answer. For more complex situations, I still think a human touch is needed."

"I don't know how much I can trust an AI option, nor how much it can replace a person. Human interaction is important — to be able to talk to someone and for them to understand the whole situation."

"AI is great for general information, but when it comes to very personal problems, it's better to talk to a person. A counselor would understand me more easily and could give me more practical advice."

V. CONCLUSION

The number of students seeking support has been increasing over the years, as has the complexity of their academic needs. As shown in this paper, students and alumni with disabilities encounter various barriers in engineering study and employment which can be addressed with appropriate accommodations and support. This should be reflected in government and institutional policies, recognizing the importance of accessibility of higher education for all groups of learners, providing equal opportunities, promoting diversity and support for the underrepresented and vulnerable

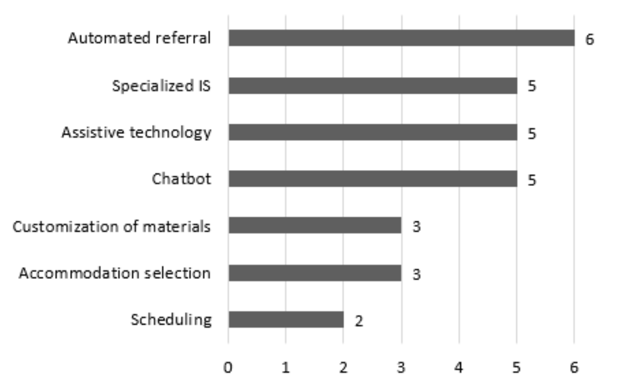

Fig. 1 Interviewee readiness to use AI within an academic accommodation process.

groups of students.

When we look at the barriers students identify, we can conclude that if basic needs are not met, for example, mobility issues or teacher understanding, students rarely mention other barriers that would improve the quality of their studies. But, when basic needs are met, students tend to focus on specific accommodations tailored to their specific needs. This implies the necessity for an adequate system of informing all stakeholders about the rights and inclusion strategies for students with disabilities within the higher education system.

Even though our results show a preference for real-life counselling support, as there is a persistent shortage of resources and trained counsellors, students recognize some possibilities where AI can be of assistance, highlighting the need to leverage technology—especially AI—to help address certain barriers they encounter.

Participants' opinions are mostly in line with the fact that the support from a real person provides understanding, empathy and adaptation to specific circumstances that AI still cannot fully recognize. However, AI tools can be useful for fast communication, scheduling meetings, and technical support for both counsellors and students. AI is also useful for communication outside working hours so a combination of human and artificial intelligence would be the ideal solution.

It is essential to consider students' preferences and their readiness to integrate selected AI tools into already demanding studying routines. Ultimately, students are the primary actors in the learning process and must be provided with high-quality, individualized support, especially in preparation for the labor market of the future. Based on the authors' experience, the synergy between the faculty and student support services has proven successful in meeting the needs of students with disabilities and in integrating them, without compromising the quality of engineering education.

Unfortunately, there are usually no comparable individually tailored support services available in employment. Even where state-run support services exist, they often lack a tight connection with employers that university support services typically have with faculty. Therefore, employers' understanding is crucial, as is their awareness of the range of accommodations that may be necessary to enable employees with disabilities to manage and complete work tasks effectively and efficiently.

In conclusion, the findings highlight a persistent implementation gap between formal inclusion policies and everyday practice. They also suggest that combining human support with carefully targeted AI solutions offers a feasible pathway toward more equitable, efficient, and individualized accommodation processes in engineering education—particularly in employment contexts, where designated support services are often lacking. Various artificial intelligence approaches integrated into educational information systems could enable all students, including students with disabilities, to increase their motivation to study, benefit from a personalized approach aligned with the concept of Education 5.0, which emphasizes student-centeredness, equitable access, tailored learning and flexibility, support the early identification of problems with the aim of reducing student dropout rates, and improve student success and the acquisition of new knowledge.

A. Limitations and Implications

The principal limitation of this study is the small sample size and its focus on self-reported perceptions from engineering students with disabilities. Nevertheless, the authors consider the responses relevant and valuable. The research was conducted in a country with a small population which, compared with larger nations, has a relatively small student body (approximately 16000 students at the university the research was conducted). In the previous academic year, 156 students requested accommodation support, of whom 46 were from STEM fields, including engineering. First-year undergraduate students were excluded because, at the time of data collection, their time at the university was too short to yield responses that could be deemed sufficiently informative. Even so, following this preliminary investigation, it would be useful to survey the entire population of students with disabilities, as well as recent graduates from STEM-related fields. These groups could help identify additional accommodation practices in engineering and STEM that may improve students' outcomes on the labor market. This position aligns with [23]: "By prioritizing thorough data collection and analysis, higher education stakeholders can better understand the challenges faced by disabled students in engineering education and work towards creating more equitable and supportive learning environments. This will in turn benefit disabled students while concomitantly broadening diversity, equity, and inclusion initiatives within engineering education."

In addition to constraints of generalizability, the effectiveness of AI-supported accommodations was explored as a prospective component of accommodation processes rather than as an implemented intervention. Participants' views therefore reflect expectations shaped by prior experiences, accessibility concerns and limited exposure to specific tools. Despite these limitations, the findings offer important implications for both research and practice. Therefore, future studies will empirically evaluate concrete AI applications within accommodation workflows, examine differential impacts across disability profiles, and address ethical, accessibility, and trust-related considerations. Practically, the results support a hybrid model in which AI complements—rather than replaces—human counselling, informing the careful, context-sensitive integration of AI into inclusive support systems in engineering education.

Acknowledgment

This research was supported by the project Development of an Information System for Personalized Learning Based on Learning Analytics – ISLA-PL (uniri-iz-25-266), funded by the European Union – NextGenerationEU. The views and opinions expressed are solely those of the author and do not necessarily reflect the official stance of the European Union or the European Commission. Neither the European Union nor the European Commission can be held accountable for them.

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