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Breaking Barriers: A Systematic Review of Inclusive Practices in Higher Education for Engineering Students with Disabilities

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Abstract. This systematic review paper focuses on inclusive practices in higher education for engineering students with disabilities. It addresses systemic barriers and highlights the role of faculty in creating inclusive environments. The article presents a qualitative synthesis that combines qualitative and quantitative research findings. Using a systematic review approach guided by PRISMA guidelines, we meticulously selected and scrutinised 34 relevant articles. The systematic literature review consolidates information from various sources to comprehend global inclusive practices in engineering education. Challenges identified include staff perceptions and inadequate infrastructure. Inclusive education theories, such as the Social Learning Theory and the Theory of Planned Behavior, provide frameworks for understanding and addressing these challenges. Attitudinal factors of parents, teachers, and students, along with accommodations like universal design, play crucial roles. The study underscores the benefits of inclusive practices, such as improved retention, employment rates, and the incorporation of diverse perspectives in STEM fields. It emphasises the imperative for public institutions to champion inclusive policies, considering social norms, perceived control, and skills enhancement. In conclusion, the paper advocates for inclusive practices in higher education for engineering students with disabilities. It offers insights, recommendations, and a call for further research to enhance sustainability and accessibility in engineering education.

Keywords: disability; engineering; higher education; inclusivity; skills; systematic review

1. Introduction

Experiencing a disability can greatly marginalise a child's life. Addressing the learning needs of students with disabilities in education, particularly in resource-constrained settings such as schools, districts, regions, or countries, poses

significant challenges (Cech, 2023). Inclusive education, which involves fully engaging all students, including those with disabilities, in high-quality education, has proven effective in promoting learning for everyone, despite ongoing implementation challenges (Starks & Reich, 2023). The importance of inclusive higher education for individuals with disabilities cannot be overstated, as it greatly contributes to breaking down barriers and fostering a more equitable and inclusive society (Emmers et al., 2020). Higher Education Institutions (HEIs) have a shared responsibility to collaborate with government agencies and special education specialists to implement inclusive and equitable educational practices (McCall et al., 2020). By working together with these stakeholders, HEIs can ensure that students with disabilities receive the necessary support for academic excellence and active participation in campus life. The United Nations Educational, Scientific, and Cultural Organization emphasises the critical importance of removing barriers to education for disabled individuals and ensuring their full and equal participation in society (McCall et al., 2020). While these declarations and legislations represent significant progress toward inclusive education, more is still required to guarantee the right to non-discriminatory quality education.

Inclusive higher education actively promotes the participation and integration of students with disabilities, cultivating a supportive and inclusive learning environment (Molina et al., 2016). Inclusive practices in higher education for engineering students with disabilities are essential for ensuring equal opportunities and access to STEM education and careers. However, there are systemic barriers that hinder the successful recruitment and retention of these students in STEM programs and careers, including lack of awareness, inadequate physical infrastructure, and limited accessible literature (Hawley et al., 2013). Students with disabilities face challenges in accessing higher education due to various barriers, including the physical environment, entrance requirements, and levels of awareness (Jeannis et al., 2019).

Lecturers play a crucial role in inclusive education and require support and understanding to create an inclusive environment for students with disabilities (Moriña et al., 2014; Molina et al., 2016). Faculty staff readiness to work with students with disabilities is vital for the success of inclusive education (Soloviova et al., 2022). Addressing attitudinal factors and perceptions of parents and teachers regarding career entry into science and engineering for students with disabilities is also essential (Alston et al., 2002). Accommodations, including universal design for learning, significantly mitigate barriers for students with disabilities in higher education (Black et al., 2015; Lang et al., 2008).

Inclusive education is a global concern, with studies from various countries emphasising the need for facilitation and support for students with disabilities in general education schools (Long et al., 2022). Researchers have examined the impact of the education system on the social development of people with disabilities and emphasised the need to evaluate inclusive learning conditions and their influence on the formation of social competence for students with disabilities (Babić & Dowling, 2015).

This study specifically addresses the need for inclusive practices in higher education, focusing on engineering students with disabilities. Despite the United Nations' emphasis on the right to a non-discriminatory, quality education for disabled individuals, systemic barriers persist. These barriers hinder the recruitment and retention of students with disabilities in STEM education. The study identifies challenges such as staff perceptions, inadequate infrastructure, and attitudinal factors, emphasising the vital role of faculty in creating inclusive environments. Additionally, the lack of awareness, physical barriers, and limited accessible resources pose significant obstacles to the successful integration of students with disabilities in higher education.

This systematic literature review (SRL) aims to provide comprehensive information on inclusive practices in higher education for engineering students with disabilities. It consolidates a significant volume of information from various articles, contributing to understanding the global context and encouraging further research and applications in the area. The goal of this review is to increase interest in research and applications, providing insights into sustainable education with technological and economic benefits. The paper systematically examines and assesses the current landscape of inclusive practices in higher education for engineering students with disabilities. The aim is to identify effective strategies, challenges, and opportunities. The study seeks to offer a comprehensive understanding of existing inclusive initiatives for students with disabilities in engineering programs and recommendations for advancing inclusive practices to promote equal opportunities and accessibility within engineering education.

1.1 Research Questions

To address the above problem, the following research question guided the systematic review process:

- What are the predominant challenges faced in implementing inclusive practices for engineering students with disabilities in higher education?
- How do existing theories and frameworks contribute to understanding and addressing the challenges of inclusive practices in higher education for engineering students with disabilities?
- What is the impact of attitudes and self-efficacy of faculty members in creating inclusive environments for engineering students with disabilities in higher education?
- What specific benefits can be attributed to implementing inclusive practices in higher education for engineering students with disabilities?

2. Theoretical Framework

The Social Model of Disability underpins this study. The Social Model of Disability, as elucidated by Bampi et al. (2010), Lang (2007), and Goering (2015), challenges the traditional medical model by highlighting the crucial role of social structures in creating barriers for individuals with disabilities. Unlike the medical model that centres on individual impairments, the Social Model focuses on social policy, cultural norms, and institutional practices, emphasising the need for societal change (Marks, 1997). This theory has far-reaching implications for research and practice, providing a lens through which to address systemic issues.

While the model has faced critique, particularly concerning its practical implications for designing assistive technologies (Dewsbury et al., 2004), it has achieved widespread acceptance and is recognised as a valuable framework for comprehending and addressing the complexities of disability (Bickenbach et al., 1999). The Social Model's influence in our argument also extends beyond academic discourse, contributing significantly to societal awareness and policy discussions surrounding disability.

The Social Model of Disability holds profound relevance to this study on inclusive practices in higher education for engineering students with disabilities. The model's emphasis on social structures and institutional practices aligns seamlessly with the study's focus on identifying and addressing barriers within the educational system. Therefore, by adopting this theoretical framework, the study aims to explore how societal attitudes, cultural norms, and institutional structures contribute to the challenges faced by engineering students with disabilities. The Social Model provides a conceptual lens through which the study can analyse and understand these challenges within the broader context of higher education using existing literature exploration. Furthermore, the model's call for a shift in focus towards social policy and cultural factors resonates with the study's goal of advocating for inclusive policies and practices within academic institutions. Hence, it serves as an insightful and applicable theoretical framework, enriching the study's capacity to unravel the complexities surrounding inclusive education for engineering students with disabilities.

3. Methodology

The following section provides an overview of the methodology employed to conduct a systematic review on inclusive practices in higher education for engineering students with disabilities. The aim of the systematic review was to identify patterns across engineering and education in higher institutions by integrating various studies. The research approach was qualitative and aligned with the systematic review method, adhering to the guidelines of PRISMA. The objectives were to identify, classify, and summarise research on inclusive practices in higher education for engineering students with disabilities.

The search strategies yielded 34 peer-reviewed papers for analysis. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines checklist by Page et al. (2020), an extensive search was conducted on Scopus, Google Scholar, and Elsevier (ScienceDirect) to extract articles. These databases were chosen for their perceived quality outputs. The search terms included "higher education," "engineering," "inclusivity," "disability," "policies," "access," "engineering," and "students." The initial search yielded 112 articles, with 20 duplicates removed. A subsequent screening of 92 abstracts excluded 57 papers that did not specifically address the study's objective. A total of 34 articles were retrieved, analysed, and included in the study. The details of these articles are presented in Table 1. Article details, authors' affiliations, journal names, and publication years were recorded in an Excel spreadsheet for data collection. The eligibility of the 34 retrieved articles was assessed by two reviewers, with disagreements resolved through consensus or consultation with a third reviewer.

The study evaluated literature related to inclusive practices in higher education for engineering students with disabilities using predefined keywords and a checklist refined based on a preliminary trial. To align with the engineering and built environment domain, the checklist was streamlined to 18 key points. One author led the data extraction, which was cross-validated by another author, and any discrepancies were resolved through dialogue.

Inclusion and exclusion criteria were established based on PRISMA recommendations, excluding non-research articles, works in progress, and those that did not meet the inclusion criteria. The search was limited to peer-reviewed journal articles published in English, and Google Scholar and Scopus were the primary databases used to retrieve information. Specific inclusion and exclusion criteria are outlined in Figure 1.

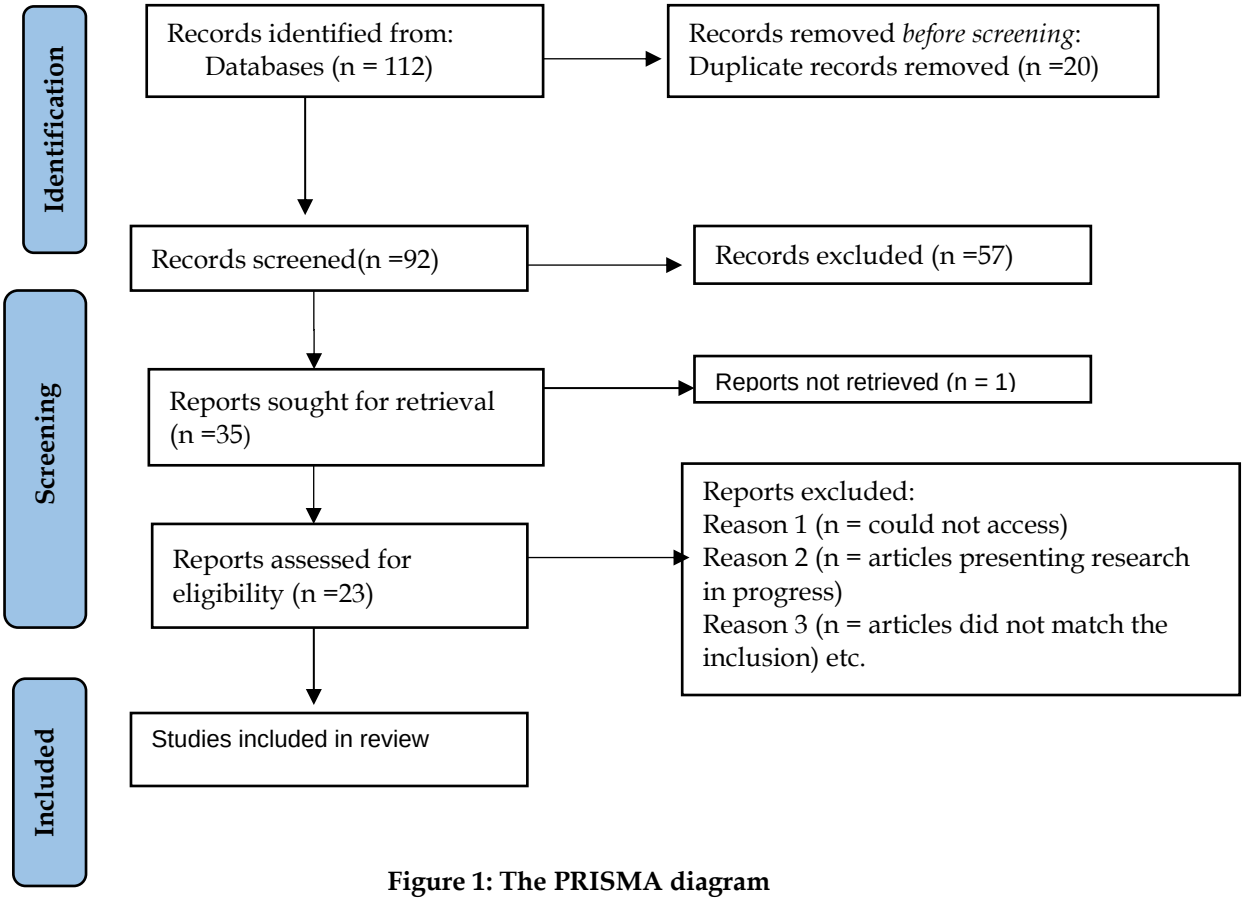

Figure 1: The PRISMA diagram

4. Findings

This section presents the findings derived from the comprehensive literature review. The subsequent discussion delves into Inclusive Practices in Higher Education for Engineering Students with Disabilities. The search encompassed various databases using the previously described keywords. Figure 1 illustrates the PRISMA diagram, visually representing the article selection process flowchart. The selected articles were scrutinised for their general characteristics, and data pertaining to inclusive practices in higher education for engineering students with disabilities were systematically extracted. Considering all the

criteria employed in the Systematic Review of Literature (SRL), the study identified the evolution of studies published in this area during the covered period. Figure 2 depicts the number of documents published per year from 1999 to 2023. Notably, there is a discernible upward trend in the quantity of published papers over time. A particularly noteworthy surge is observed between 2017 and 2023, underscoring a heightened and growing interest in the topic. This surge in publications suggests an increasing recognition of the importance of inclusive practices in higher education for engineering students with disabilities. Furthermore, the findings emphasise that fostering inclusivity in teaching and learning is beneficial to individual students and contributes to the creation of a more diverse and inclusive society as a whole. Institutions are increasingly urged to champion inclusivity, reflecting a broader societal shift toward recognising the value of diversity in educational settings.

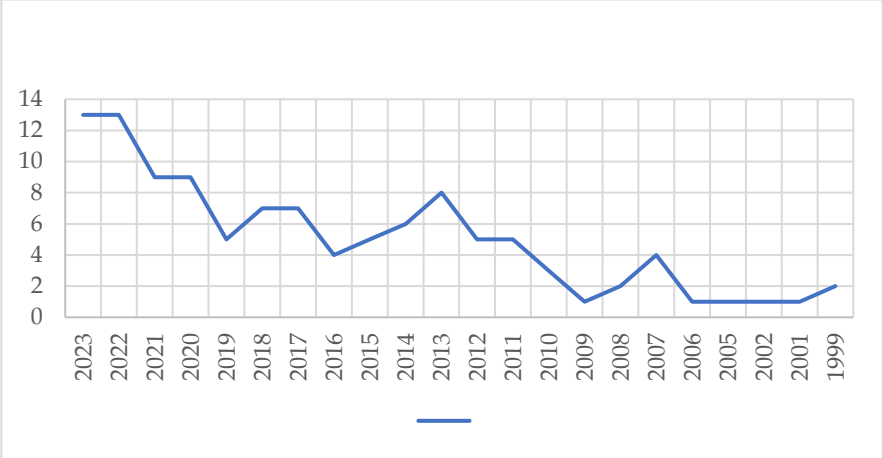

Figure 2: Documents per year

Figure 3 provides a breakdown of the countries from which the reviewed articles originated. The United States of America emerged as the predominant contributor with 60 articles showcasing substantial research output. Spain followed with 7 documents, while Canada and the United Kingdom both produced 6 articles each. Additionally, Italy and Russia contributed 3 articles each to the body of literature on inclusive practices in higher education for engineering students with disabilities. This distribution underscores the global nature of research on this subject, with the United States taking a prominent lead in the number of publications, followed by several other countries making notable contributions to the discourse.

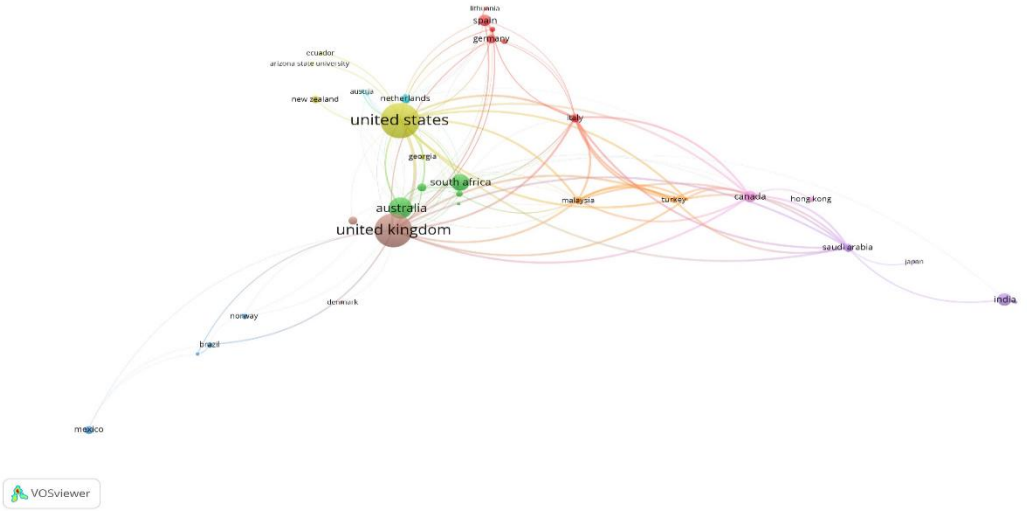

Figure 3: Bibliometric documents per country

Figure 4 elucidates the bibliometric connectivity of keywords within the articles, showcasing the interrelation of concepts across different sources and countries. This visualisation offers insights into the thematic coherence and collaborative trends in research on inclusive practices in higher education for engineering students with disabilities. The network of keywords demonstrates the interconnectedness of various research themes, reflecting the global collaborative efforts and shared focus among researchers. This bibliometric analysis provides a comprehensive overview of the key concepts and their relationships, contributing to a better understanding of the multidimensional aspects within the field.

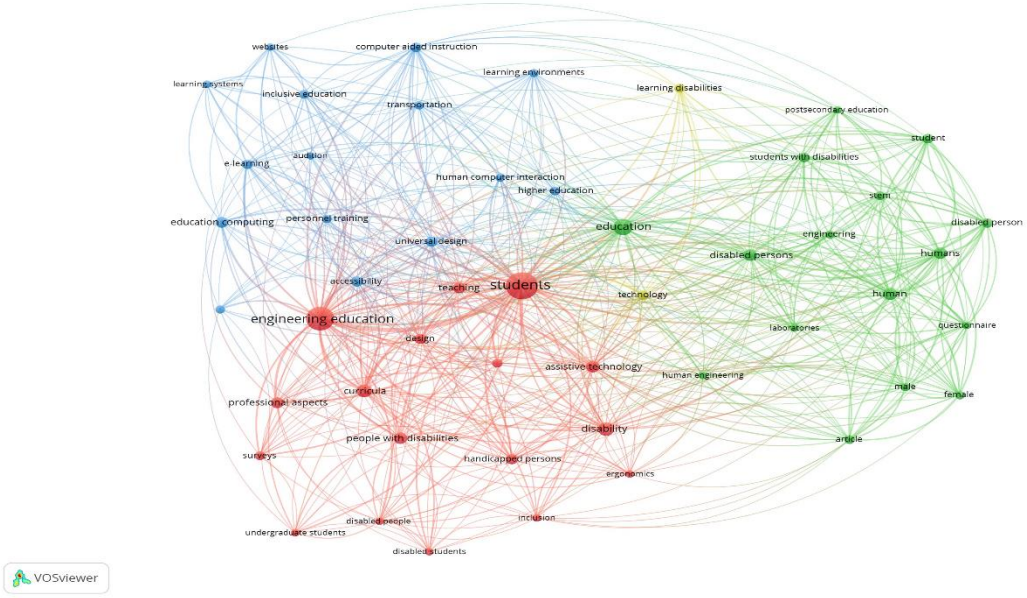

Figure 4: Bibliometric of keywords

Table 1 provides a comprehensive overview of the journals utilised in the Systematic Review of Literature (SRL) focused on inclusive practices in higher

education for engineering students with disabilities. The table includes key information such as the publication period, year of publication, and a specific code assigned to each journal article. This compilation sheds light on the evolution of interest in the topic over the years and underscores the breadth and depth of scholarly engagement. It's important to note that this meticulous selection process went beyond highlighting highly cited documents, ensuring a thorough exploration of inclusive practices in higher education for engineering students with disabilities.

Table 1: Journal coding

Item	*Title*	*Year*	*code*
1	*Journal of Engineering Education*	*2023*	*J1*
2	*Computers & Education*	*2023*	*J2*
3	*IEEE Access*	*2023*	*J3*
4	*Journal of Biological Education*	*2022*	*J4*
5	*The Journal of Special Education*	*2022*	*J5*
6	*Universal Access in the Information Society*	*2021*	*J6*
7	*IEEE Transactions on Education*	*2021*	*J7*
8	*Life Sciences Education*	*2023*	*J8*
9	*Australasian Journal of Engineering Education*	*2022, 2020*	*J9,J15*
10	*Peerj Computer Science*	*2022*	*J10*
11	*Life Sciences Education*	*2021*	*J12*
12	*European Journal of Special Needs Education*	*2020,2016*	*J13,J24*
13	*Journal of International Education in Business*	*2021*	*J16*
14	*International Electronic Journal of Elementary Education*	*2020*	*J17*
15	*Learning Disability Quarterly*	*2019*	*J18*
16	*Journal of Interactive Media in Education*	*2019*	*J19*
17	*Sustainable Cities and Society*	*2018*	*J21*
18	*Computers in Human Behavior*	*2018*	*J22*
19	*Canadian Psychology/psychologie canadienne*	*2017*	*J23*
20	*Journal of Research in Special Educational Needs*	*2016*	*J24*
21	*Higher Education Research & Development*	*2015*	*J25*
22	*International Journal of Web-Based Learning and Teaching Technologies*	*2014, 2014*	*J26, J29*
23	*Journal of Vocational Rehabilitation*	*2013*	*J27*
24	*Assistive Technology*	*2022,2019,2018,2013,1999*	*J11,J14 J20,J28,J34*
25	*Acm Inroads*	*2012*	*J30*
26	*Augmentative and Alternative Communication*	*2012*	*J31*
27	*International Journal of Rehabilitation Research*	*2007*	*J32*
28	*Equity & Excellence in Education*	*2007*	*J33*

5. Presentation of results

In this section, the results of thirty-four studies are systematically presented and categorised into various themes relevant to inclusive practices in higher education for engineering students with disabilities.

5.1 Challenges of inclusive practices in higher education for engineering students with disabilities.

(J1 & J2) revealed that the challenges associated with inclusive practices in higher education for engineering students with disabilities encompass various aspects, including staff perceptions, training requirements, unadapted environments, teaching methods, and the under-representation of individuals with visible disabilities in academia and employment. (J3 & J4) state that in the context of higher education, inclusive practices encounter obstacles such as staff perceptions, training needs, and the limited representation of visible disabilities. This emphasises the imperative of fostering employability and skills development across all facets of teaching and learning. According to (J4 & J7), engineering students with disabilities encounter significant hurdles, and the adaptation of laboratories, equipment, programs, and support from tutors proves instrumental in overcoming these challenges, thereby facilitating inclusive education. Addressing the knowledge gap in effective inclusive education practices for students with disabilities, insights pertaining to policy, teacher preparation, and the active involvement of parents are very important (J1 & J14). The imperative of equality in engineering is highlighted through a workshop to educate and engage PhD students on equality issues. The goal is to cultivate an inclusive academic environment and provide guidance for future actions (J5 & J11).

In the realm of online and blended learning, inclusive practices play a crucial role in supporting disabled students and enhancing outcomes, especially in STEM disciplines (J4). Therefore, the key factors for inclusive education and accessibility in Higher Education encompass teacher education, proactive problematisation, research initiatives, and strategic actions. Specialised technical and organisational solutions are essential to overcome barriers for individuals with disabilities in higher education, involving students in the design process (J19). As engineering courses increasingly adopt project-based learning, particularly in design-based formats, ensuring accessibility for students with non-visible disabilities becomes paramount (J30 & J33). Lastly, while inclusive practices in computer science courses have the potential to enhance the experiences of disabled students, a methodological approach is essential to effectively address challenges in studying their experiences.

5.2 Inclusive Practices in Higher Education for Engineering Students with Disabilities

Inclusive education revolves around the integration of students with disabilities into regular classrooms alongside their non-disabled peers of the same age (J1). Although commonly associated with resource-rich developing countries, the pursuit of a more inclusive society doesn't always align with institutional activities (J5). Notably, true inclusion is not guaranteed by the availability of resources; paradoxically, collaborative societal involvement can yield valuable results even with limited resource allocation (J2). While (J20) states that distance learning is often promoted as an option for individuals with disabilities to attain higher education, it may not be considered the ideal model for inclusive education. Moreover, (J21) state that inclusive practices in computing education and the integration of technologies like podcasting can enhance the university experience for students with disabilities. In the realm of computer science courses,

inclusive practices can improve the experiences of disabled students, necessitating a methodological approach to address challenges in studying their experiences. Similarly, inclusive practices in online and blended learning environments can support disabled students and enhance outcomes in STEM disciplines, as suggested by (J26).

Higher education encounters challenges in implementing inclusive practices, including staff perceptions, training needs, and the low representation of visible disabilities. This underscores the importance of focusing on employability and skills development in all teaching and learning activities (J24). Diverse inclusive practices and cultures can maximise educational experiences for international and local students with disabilities in higher education (J26). However, Greek university students with disabilities face ongoing exclusion and learning barriers, emphasising the need for improved inclusive policies and practices in higher education (J24). Inclusive education in higher education involves a complex set of understandings and requires continuous reflection among practitioners to enhance the experiences of all stakeholders (J21). Integrating new technologies is a valuable tool to enhance inclusive teaching-learning processes and practices in universities for students with disabilities and Specific Learning Disorders (J22). Furthermore, inclusive curriculum design in higher education can minimise the need for reasonable adjustments, with staff training and awareness of disabilities being crucial for successful accommodations (J13).

5.3 Theories and Framework for Inclusive Practices in Higher Education for Engineering Students with Disabilities

This section presents the theories and framework for inclusive practices in higher education for engineering students with disabilities. The study encompasses key aspects of inclusive practices in higher education for engineering students with disabilities, including social learning theory and planned behaviour theory. It addresses challenges such as staff perception, training needs, and representation while promoting progressive accommodations and inclusive policies.

5.3.1 Social Learning Theory for Inclusive Practices in Higher Education

The concept of social learning theory, particularly in the context of inclusivity, underscores the varied perceptions of social exclusion, particularly concerning disabled individuals and other vulnerable groups across different societies (J8). Young people's attitudes toward inclusion are anticipated to be shaped by their social environments, with individual perceptions of external influences from third parties, specific groups, and institutions playing a pivotal role in their decision-making and subsequent actions. The substantial impact of friends, family, and educational institutions significantly moulds these attitudes (J10). However, there is a growing consensus that views social exclusion as a disruption of the social network. This perspective often ties back to the State's perceived failure, aligning with Francophone theses emphasising the involvement of all members of society in achieving social inclusion as a shared goal (J19 & J 28). Consequently, the prevailing social norm in the European context tends to favour inclusion. This commitment to inclusion is mirrored in the European Union's efforts to combat social exclusion, which is evident in treaties like Maastricht and Amsterdam and the active involvement of the European Social Funds in addressing social

exclusion issues (J8). The research presented here introduces a novel methodology for engineering education that seeks to foster the social inclusion of people with disabilities. This is achieved by creating learning experiences designed to develop disciplinary and personal competencies. Inclusive classrooms for students with learning disabilities can be challenging, leading to feelings of loneliness when bored or lonesome. Coping strategies observed include engaging in solitary activities and seeking companionship (J13).

5.3.2 Framework for Inclusive Practices in Higher Education

The Design for ALL.L framework is introduced as a project-based learning initiative aimed at fostering social inclusion and empowerment for people with disabilities. This framework also provides innovative educational experiences for students without disabilities. Engineering students involved in Edumakers, a social service project, developed complex thinking and social intelligence skills, gaining empathy for visually impaired users and acquiring insights into educational inclusion (J15). The underrepresentation of persons with disabilities in STEM education theory, institutional planning, and critical social scientific studies is highlighted, emphasising the need for inclusive approaches. Integrated learning methods in engineering education, incorporating cognitive levels, social factors, teamwork, and behavioural elements, are identified as optimal for enhancing learning and teaching methods (J30). The challenges faced by disabled students at the University of Manitoba, including bodily-social challenges and low expectations for academic success, underscore the pressing need for greater advocacy for inclusive higher education (J27). Engineering education is encouraged to focus on skill development and adaptive expertise, drawing insights from neural, cognitive, and behavioural sciences results (J16).

5.3.3 Theory of Planned Behaviour Inclusive Practices in Higher Education

The studies indicate that the Theory of Planned Behavior (TPB) serves as a framework for understanding inclusive engineering education for disabled students. This theory is influenced by several factors, including attitudes toward inclusion, perceived behavioural control, subjective norms, role identity, and motivation to comply with policies (J30 & 28). Cypriot secondary school physical education teachers' inclinations to include students with physical disabilities in general PE classes are shaped by their perceived behavioural control and attitudes towards inclusion (J19). In the realm of gender dynamics, women students exhibit increased support for the inclusion of peers with disabilities in university settings, underscoring the role of gender in fostering disability inclusion in education (J31).

The interplay between attitude strength, role identity, subjective norms, and attitudes mediates the intentions of students to teach individuals with disabilities in the future (J27). According to (J8), pre-service teachers' willingness to engage in inclusive teaching is influenced by attitudes towards inclusion, perceptions of social norms, and their sense of competence in teaching inclusive classes. Furthermore, university students tend to empathise with disabled individuals, potentially facilitating their inclusion and integration into the university community (J8). The Theory of Planned Behavior posits that personal attitudes underlie individual actions, emphasising cognitive, affective, and behavioural inputs (J16). The study delves into various aspects of attitudes related to disability

and inclusion, particularly within the context of higher education. The hypothesis posits that youth, especially young Spanish university students, exhibit inclusive attitudes towards groups at risk of exclusion, particularly disabled individuals (J15). Examining the terminology of disability, the research adopts a social aspect-focused concept known as "functional diversity," emphasising difficulties individuals may face in various physical, sensory, or psychological areas. This perspective challenges traditional definitions and aligns with a broader understanding of disability as any special difficulty a person may encounter, fostering a more socially oriented approach to inclusivity (J28 & J31).

5.4 Attitudes and Self-efficacy for Inclusive Practices in Higher Education for Engineering Students with Disabilities

Attitudes and self-efficacy are pivotal in shaping the inclusion of individuals with disabilities within educational settings (J9 & J16). In the context of physical education (PE), teachers' attitudes and self-efficacy toward the inclusion of children with disabilities are influenced by personal attributes, school-related factors, and characteristics associated with the disabilities. These factors collectively mould teachers' behaviours and practices related to inclusion (J17). Within the domain of professional identity formation, undergraduate civil engineering students encounter challenges in navigating sociocultural expectations linked to disability. This underscores the need for heightened support and inclusive initiatives within the field, as highlighted by (J19). Additionally, integrating technology in inclusive science classrooms can positively impact academic achievement and attitudes for students with learning and other disabilities. However, further research is needed to comprehensively understand the effectiveness of technology in this context, as indicated by (J22).

A notable observation is the significant increase in the " Attitudes " factor after completing a physical education intervention program. Past research supports the idea that attitude change is a result of interactions with others and social factors. The study suggests that joint physical education programs contribute to behaviour changes in students without disabilities, fostering acceptance of pupils with moderate disabilities in mainstream physical education courses (J28). Moreover, there was a notable increase in indicators related to the "Intention" factor. Researchers speculate that non-disabled students' intention to accept the possible presence of disabled pupils in their PE class was shaped and changed through their participation in the intervention program. Another noteworthy aspect is the positive effect of "Information" after the implementation program, indicating that students gained valuable insights during the program (J31).

5.5 Benefit of Inclusive Practices in Higher Education for Engineering Students with Disabilities

J4, J7, J10, J11, J12, J16, J17, J18, J20, J22, J23, J24, J25, J27, J29, J30, J32, J34 are authors who emphasise the benefits of Inclusive Practices in Higher Education for Engineering Students with Disabilities. These studies suggest that inclusive practices in higher education for engineering students with disabilities can improve retention and employment rates, facilitate learning for all students by addressing diverse learning styles and abilities, and strengthen the nation's STEM

workforce. The inclusion of persons with disabilities in engineering education and careers is crucial for ensuring diverse perspectives and optimal service to society (J20). A teaching development program for engineering teaching assistants enhanced their awareness of diverse learning styles and abilities, promoting inclusive education and improved communication skills (J16-J18). Disabled engineering students face severe challenges, and adapted laboratories, equipment, programs, and tutors can help overcome these issues and promote inclusive education (J10-J12). Disabled and non-disabled students face similar challenges in learning and assessment experiences, highlighting the need for inclusive policies and practices (J4 & J7).

According to (J22-J25), a new stage in inclusive protocols for students with disabilities should focus on attention, including teacher training, inclusive curriculum, student service, and research, to achieve a more inclusive higher education system. Furthermore, (J10-J12) confirms that a narrative inquiry can enhance the understanding of student veterans and service members' experiences in engineering education, addressing challenges and enhancing the practical and theoretical impact of findings. Inclusive practices in computer science courses can improve the experiences of disabled students but require a methodological approach to address challenges in studying their experiences (J29-J30). Inclusive education benefits students with disabilities, but special educators may still prefer a segregated environment, and teachers with more experience need more support and professional development. A common platform for sharing best practices and maximising the global benefits of diversity and inclusion in engineering education can enhance learning opportunities and impact (J32-34). Design-based courses in engineering increasingly adopt project-based learning, and accessibility for students with non-visible disabilities becomes crucial.

6. Discussion of Findings

It was found that the challenges associated with inclusive practices in higher education for engineering students with disabilities encompass diverse aspects, including staff perceptions, training needs, unadapted environments, and the under-representation of individuals with visible disabilities in academia and employment. Engineering students with disabilities face significant hurdles, with the adaptation of laboratories, equipment, programs, and support from tutors proving instrumental in overcoming these challenges. This justifies the presence of unadapted physical environments, staff perceptions, and the under-representation of individuals with visible disabilities in academia and employment (Gavrilova et al., 2021; Jaafar et al., 2020). In other words, the adaptation of laboratories, equipment, programs, and support from tutors is crucial in overcoming these challenges (Gavrilova 2021). However, the implementation of inclusive practices in higher education requires a comprehensive approach, including the design of policies, strategies, and actions (Moriña 2017). The use of technology can also play a significant role in addressing these challenges, but it requires further improvement and faculty training (Perera-Rodríguez & Moriña Díez, 2019). Despite these barriers, students with disabilities have demonstrated resilience and have identified strategies for dealing with these challenges (Strnadová et al., 2015).

Secondly, it was also found that while true inclusion may not solely rely on resource availability, collaborative societal involvement can yield valuable results even with limited resources. The pursuit of a genuinely inclusive society requires a nuanced approach that extends beyond resource-rich settings and acknowledges the importance of collaborative societal engagement. To support this, a range of studies underscore the importance of collaborative societal involvement in achieving true inclusion, particularly in resource-limited settings. Ansell et al. (2020) and AuCoin and Berger (2021) both emphasise the role of active inclusion management and effective collaboration in inclusive settings. AuCoin specifically highlights the need for shared planning, communication, vision, respect, and trust. This is further supported by Ahdiyana et al. (2021), who stress the importance of collaboration in realising an inclusive workforce for people with disabilities. These studies jointly reiterate the need for a nuanced approach to inclusion that prioritises collaborative societal engagement.

The study further confirmed that Social Learning Theory and the Theory of Planned Behaviours are key frameworks for understanding inclusive practices in higher education for engineering students with disabilities. Social Learning Theory and the Theory of Planned behaviour are crucial for understanding inclusive practices in higher education for engineering students with disabilities (Supple & Abgenyega, 2011; Mole, 2013). This is because these theories emphasise the role of social interactions and individual beliefs in shaping behaviour, which is particularly relevant in the context of inclusive education. However, there are still challenges in implementing inclusive practices, particularly in online and blended learning environments (Pearson et al., 2019). Despite these challenges, research has shown that students with disabilities can perform as well as their peers in higher education but may need additional support (Sachs & Schreuer, 2011). To address these issues, it is important to design policies and strategies that promote inclusive education (Moriña, 2017). This can be achieved by applying inclusive methodologies from a teaching perspective (Lorenzo-Lledó et al., 2020) and by creating a comprehensive environment for disabled students in higher education institutions (Jaafar et al., 2020).

The study also alluded to the fact that attitudes and self-efficacy play pivotal roles in shaping the inclusion of individuals with disabilities in higher education for engineering students. Teachers' attitudes and self-efficacy toward the inclusion of students with disabilities are influenced by personal attributes, school-related factors, and characteristics associated with the disabilities, ultimately impacting inclusive practices. To support this, a range of studies have highlighted the significant role of attitudes and self-efficacy in shaping the inclusion of individuals with disabilities in higher education for engineering students. Vaz et al. (2015) found that teacher attributes, beliefs, and efficacy are key factors in determining attitudes towards inclusion. Shaukat et al. (2013) further emphasised the influence of personal attributes, school-related factors, and characteristics associated with disabilities on teachers' attitudes and self-efficacy. Taylor and Ringlaben (2012) also discussed the importance of positive experiences and specific training in promoting inclusive practices. While Alghazo et al. (2003) highlighted the need for pre-service programs to enhance teachers' attitudes

towards inclusion. These findings all suggested the need for a comprehensive approach to promoting inclusive practices in higher education for engineering students.

The study also concluded that inclusive practices in higher education for engineering students with disabilities yield significant benefits, including improved retention and employment rates, enhanced learning experiences addressing diverse abilities, and contributing to a more robust STEM workforce. The inclusion of individuals with disabilities in engineering education is considered crucial for ensuring diverse perspectives and optimal service to society. The study emphasises the positive impact of inclusive practices, advocating for their widespread adoption to maximise the benefits of diversity and inclusion in engineering education. Research has shown that inclusive practices in higher education for engineering students with disabilities can lead to improved retention and employment rates, enhanced learning experiences, and a more robust STEM workforce (Sachs & Schreuer, 2011; Bellman et al., 2018). However, successful practices for increasing the inclusion of individuals with disabilities in STEM programs have been identified (Bellman et al., 2018), and the importance of student support services and faculty development in promoting retention and success has been emphasised (Getzel, 2008). The need for policies, strategies, and actions to ensure the success of all students has also been highlighted (Moriña, 2019).

7. Conclusion and Recommendations

In conclusion, this study delves into the multifaceted landscape of inclusive practices in higher education for engineering students with disabilities. The findings underscore the pervasive challenges, including staff perceptions, unadopted environments, and the under-representation of individuals with disabilities, emphasising the need for comprehensive strategies to foster inclusivity. Additionally, the study explores the theories and frameworks, particularly Social Learning Theory, the Theory of Planned Behaviours and the Design for ALL.L initiative, shedding light on the psychological and social aspects influencing attitudes and actions related to disability inclusion. Furthermore, the benefits of inclusive practices are evident in improved retention and employment rates, emphasising the positive impact of fostering diversity within engineering education.

To enhance inclusive practices, it is, therefore, recommended that higher education institutions prioritise awareness and training programs addressing staff perceptions and attitudinal factors. Strategic adaptations of laboratories, equipment, and teaching methods should be implemented to create an environment conducive to the success of engineering students with disabilities. Additionally, the study calls for a concerted effort to bridge the knowledge gap through comprehensive policies, teacher preparation, and active involvement of parents. Furthermore, the integration of Social Learning Theory and the Theory of Planned Behavior into educational frameworks is advised to cultivate inclusive attitudes among students and faculty. In essence, the study advocates for a holistic approach that fosters an inclusive and accessible higher education landscape for

engineering students with disabilities, recognising the significance of diversity in shaping the future STEM workforce.

On the recommendation for further studies, key variables, such as gender, the presence of a close person with a disability, and household composition, among others, are worthy of further investigation for their potential influence on personal attitudes toward inclusion, perceived control, and the active support of inclusion. Moreover, examining the implications of experiences and familiarity with individuals with disabilities could provide valuable insights. Additionally, exploring the role of belonging to an organisation dedicated to social assistance, social networks, and related factors could deepen.

8. Contribution to Existing Knowledge on Inclusive Practices

This study significantly contributes to the current understanding of inclusive practices in higher education institutions, specifically for engineering students with disabilities. It sheds light on the various challenges these students encounter, such as unadapted environments, staff perceptions, and under-representation in academia and employment. By validating the essential role of adapted laboratories, equipment, and support from tutors, the study emphasises the need for comprehensive strategies and policies that cater to these students' specific requirements. The integration of Social Learning Theory and the Theory of Planned Behaviors establishes a strong theoretical framework, highlighting the significance of social interactions and individual beliefs in shaping inclusive practices.

9. Implication of Social Model of Disability

Incorporation the Social Model of Disability as the theoretical framework in this study has profound implications for the findings. The framework, championed by scholars such as Bampi, Lang, Marks, and Goering, redirects the focus from individual impairments to societal structures, shedding light on the systemic barriers faced by engineering students with disabilities in higher education. The study's identification of challenges, including staff perceptions, unadapted environments, and under-representation, aligns seamlessly with the social model's emphasis on dismantling societal barriers. Therefore, recognising disability as a product of social and environmental factors, the study indicates the imperative of societal change in fostering inclusivity. This theoretical lens not only enhances the understanding of challenges faced by students with disabilities but also shows the urgent need for comprehensive policies, teacher preparation, and active involvement of parents to create a truly inclusive educational environment. The "Social Model of Disability" thus serves as a guiding framework that not only shapes the study's findings but also advocates for transformative actions in higher education to remove structural obstacles and ensure equal opportunities for engineering students with disabilities.

10. Implications for Policy Development

Policy Formulation and Implementation: Comprehensive Inclusion Policies: Institutions need to develop and implement policies that address the full spectrum of challenges identified, including physical, attitudinal, and structural

barriers. Mandatory Training Programs: Policies should mandate regular training for faculty and staff to improve their understanding and attitudes towards students with disabilities. Incentives for Adaptation: Establish incentives for departments that successfully adapt their environments and practices to be more inclusive. **Funding and Resources:** Increased Funding: Allocate specific funds to adapt laboratories and purchase specialised equipment. Resource Allocation: Ensure equitable distribution of resources to support students with disabilities, including technological tools and support services. **Monitoring and Evaluation**: Regular Assessments: Implement monitoring and evaluation frameworks to assess the effectiveness of inclusive policies and practices regularly. Feedback Mechanisms: Establish robust feedback mechanisms to continuously gather input from students with disabilities on the effectiveness of policies and practices.

11. Implications for Educational Practice

Curriculum and Instructional Design: Inclusive Curriculum: Develop and integrate an inclusive curriculum that considers the diverse needs of students with disabilities. Flexible Teaching Methods: Promote the use of flexible teaching methods that can be adapted to accommodate different learning needs. **Faculty Development**: Continuous Professional Development: Provide ongoing professional development opportunities focused on inclusive teaching practices. Collaboration and Support: Encourage collaboration among faculty members to share best practices and support each other in implementing inclusive strategies. **Student Support Services:** Dedicated Support Services: Enhance support services such as tutoring, mentoring, and counselling specifically tailored for students with disabilities. Accessible Information: Ensure that all information and resources, including digital content, are accessible to students with disabilities.

12. Future Research Directions

Diverse Demographics:

- Gender and Inclusion: Investigate the influence of gender on attitudes towards inclusion and the experiences of engineering students with disabilities.
- Cultural Influences: Explore how cultural backgrounds impact perceptions and practices of inclusion.

Longitudinal Studies:

- Impact Over Time: Conduct longitudinal studies to assess the long-term impact of inclusive practices on the academic and career outcomes of students with disabilities.
- Policy Effectiveness: Evaluate the long-term effectiveness of policies and practices designed to enhance inclusion.

Technology and Innovation:

- Role of Technology: Examine the evolving role of technology in facilitating inclusive education and identify emerging tools and practices.
- Innovative Practices: Investigate innovative practices and strategies that can further enhance the inclusion of students with disabilities in STEM fields.

13. Limitation

This review might be considered limited as it only includes articles on education in engineering and built environments. The research search strategy might lead to some limitations as well. Although well considered, the authors included mostly papers found to be discipline-specific, and only English peer-reviewed articles were used for the systematic literature review.

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Appendix A- PRISMA REFERENCE

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