Access to Computer Science for Blind and Visually Impaired Students

Barriers, Support and Inclusive Practices in Austria, Ireland and Slovenia

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1. Introduction

The Access2CS project aims to promote inclusive and accessible Computer Science (CS) education in Higher Education. Students with visual impairments encounter specific barriers in Computer Science education, a field that often relies heavily on visual content, complex interfaces, and rapidly evolving technologies. These challenges affect access to learning materials, participation in practical activities, and assessment processes. As a result, there is a need for clearer institutional guidance and more inclusive practices to support their academic success.

This document has been developed to support Higher Education institutions, educators, and support services in understanding how to create more accessible and inclusive learning environments for blind and visually impaired students in Computer Science and related disciplines. It brings together insights from institutional practices, research, and stakeholder experiences to inform more effective support strategies.

The document is structured in three main parts.

The first part presents findings from institutional analysis, including legal frameworks, service structures, and support systems across Austria, Ireland, and Slovenia. This section highlights how different higher education systems address accessibility and inclusion.

The second part explores insights from qualitative interviews with university staff and support services, focusing on practical challenges, existing support mechanisms, and areas for improvement in the inclusion of students with disabilities.

The third part provides a synthesis of existing research on barriers, assistive technologies, pedagogical approaches, and institutional practices, offering evidence-based guidance for improving accessibility in Computer Science education.

By combining institutional perspectives, practical experiences, and research evidence, this document aims to support the development of more inclusive policies, teaching practices, and learning environments that promote equal access and participation for blind and visually impaired students in Higher Education.

2. Desk Research

The desk research section offers a comparative overview of the legal frameworks, institutional structures, and support services that shape the study conditions of blind and visually impaired students in higher education in Austria, Ireland, and Slovenia. It synthesises national laws, policy documents, and publicly available information on university service centres, admission procedures, and accessibility measures, with a specific focus on computer science and related technical disciplines.

2.1. Laws and regulations supporting students with disabilities

2.1.1. Austria

Students with disabilities in higher education in Austria are supported and protected by several laws and regulations. One of the most important of these is the Federal Disability Equality Act (BGStG). This law ensures that people with disabilities are not discriminated against. It also ensures that public facilities, including universities, are accessible. Accessibility means that buildings, services and information must be usable by everyone, including people with disabilities (§ 6 BGStG; RIS, 2023). Another important law is the Universities Act 2002 (UG, 2002), which specifically addresses the rights of disabled students. The Act requires universities to make 'reasonable adjustments' to ensure that disabled students are not disadvantaged. This can include extra time for exams, accessible learning materials or other support to facilitate study (RIS, 2023).

Austria has also signed the United Nations Convention on the Rights of Persons with Disabilities (UN CRPD). This international treaty guarantees the right to education for persons with disabilities. It requires universities to be inclusive and accessible, giving all students equal opportunities to succeed (UN, 2023). In addition, the Disability Employment Act (BEinstG) protects people with disabilities in the workplace. This legislation is particularly relevant to students who want to undertake an internship or start their careers after graduation (RIS, 2023).

2.1.2. Ireland

The legal framework for disabilities in Ireland includes both international and national legislation. The main components aim to promote equality, prohibit discrimination and ensure access to services and supports available for people with disabilities.

The key elements of the Irish legal framework are:

- Disability Act 2005 (2005). The Irish Disability Act places a statutory obligation on public bodies to promote equality and social inclusion, including the provision of assessments of need and access (to buildings, services, or information), amongst others.
- United Nations Convention on the Rights of Persons with Disabilities (United Nations, 2006). Ireland ratified this convention in March 2018. The United Nations Convention on the Rights of Persons with Disabilities is an international treaty ratified by Ireland that establishes the rights of people with disabilities and sets out obligations for the state to promote, protect and ensure those rights. In Ireland, IHREC is the official Independent Monitoring Mechanism for the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD).
- European Union (Accessibility of Websites and Mobile Applications of Public Sector Bodies) Regulations 2020 (European Union, 2016) and European Union (Accessibility Requirements of Products and Services) Regulations 2023 (European Union, 2019) The EU Accessibility of Websites and Mobile Applications of Public Sector Bodies and the EU Accessibility Requirements of Products and Services propose standardised accessibility requirements for specific products including technological products and services where information is provided by a public body.
- Education of Persons with Special Education Needs Act 2004 (Government of Ireland, Oireachtas 2004). This legislation addresses schoolchildren but also describes the right to an inclusive educational model, which may be useful. It ensures that, wherever possible, the education of people with special educational needs takes place in an inclusive environment alongside those without such needs. It also ensures that people with special educational needs shall have the same right to avail of and benefit from appropriate education as do their peers who do not have such needs.
- Equal Status Acts 2000 to 2015 (Government of Ireland, Oireachtas 2000). This act establishes that discrimination includes a refusal or failure by the provider of a service to do all that is reasonable to accommodate the needs of a person with a disability by providing special treatment or facilities, if without such special treatment or facilities it would be impossible or unduly difficult for the person to avail himself or herself of the service. It also states that an educational establishment shall not discriminate in relation to the admission of a person as a student, the access of a student to any course, facility, or benefit, and any other term or condition of a student's participation in the educational establishment, amongst others.

2.1.3. Slovenia

Students with disabilities in higher education in Slovenia are supported and protected by several key laws and regulations. One of the most important is the Act on Equalisation of Opportunities for Persons with Disabilities (ZIMI) (2010), which prohibits discrimination based on disability and establishes obligations to ensure equal opportunities and

accessibility in public services and public facilities, including universities. Accessibility under ZIMI includes physical, informational, and communication accessibility, ensuring that university environments, materials, and services are usable by all students and adapted for students with disabilities. A second important act is the Protection Against Discrimination Act (ZVarD) (2016), which provides a general anti-discrimination framework applicable to education and establishes the Advocate of the Principle of Equality as an enforcement mechanism for addressing discrimination complaints. In addition, the Higher Education Act (ZViS) (n.d.) imposes obligations on higher-education institutions to provide appropriate conditions for students with disabilities, including adjustments that enable equal participation and completion of studies. National guidelines, such as the NAKVIS Accessibility Guidelines for Tertiary Education (2022), further clarify expectations for reasonable accommodations and accessible learning environments.

ZIMI (2010) bans discrimination, mandates accessibility, and requires the removal of physical and informational barriers, forming the core legal basis for ensuring accessibility in universities. ZVarD strengthens this protection by introducing a unified anti-discrimination regime covering both direct and indirect discrimination and by providing students with access to an official complaints' procedure through the Advocate (2016). ZViS (2021) and accompanying sectoral guidelines specify the practical responsibilities of universities, including extended exam time, adapted course requirements, alternative formats for learning materials, and support services, all recognised as "reasonable adjustments" aimed at preventing disadvantage. Together, these laws and regulations create a coherent framework that obliges Slovenian higher-education institutions to actively support students with disabilities and ensure conditions for their full academic participation.

2.1.4. Conclusion

All three countries prohibit discrimination against students with disabilities and oblige universities to provide reasonable adjustments such as extended examination time and accessible learning materials. They are based on the UN Convention on the Rights of Persons with Disabilities and understand accessibility in multidimensional terms (physical, informational and communicative). Austria uniquely integrates labour market aspects through the Disability Employment Act, Ireland has a differentiated system with formal enforcement mechanisms (IHREC), and Slovenia is characterised by detailed national guidelines (NAKVIS Guidelines) and a coherent overall framework. The three countries follow a common duty of care for students with disabilities but differ in their implementation structures: Austria focuses on labour market integration, Ireland on differentiated regulations with clear monitoring, and Slovenia on precise sectoral guidelines.

2.2. Service Centres and Contact Points: Roles and Responsibilities

2.2.1. Austria

Most universities in Austria have special service centres or contact points for students with disabilities. These centres are often referred to as "Barrier-Free Studying" or "Integrated Studying Centres/Institutes." They play an important role in helping students with disabilities organise their studies and get the support they need. For example, the Barrier-Free Studying Team at the University of Vienna provides support for students with disabilities and chronic illnesses (University of Vienna, 2023). At the Vienna University of Technology (TU Wien), a Disability Officer helps students create accessible study conditions and ensures that their needs are met (TU Wien, 2023). Similarly, the Integrated Studying Centre at the University of Graz or the Institute for Integrated Studies at Johannes Kepler University in Linz offers individual consultations and technical support for students with disabilities.

These service centres have several responsibilities. They advise students on how to make their studies accessible and help them apply for exam accommodations, such as extra time or alternative formats. They also provide technical aids, such as screen readers, Braille displays, or tactile maps, to make learning materials more accessible. Additionally, they work to raise awareness among university staff and faculty about the needs of students with disabilities. These centres act as a bridge between students and the university administration, ensuring that students with disabilities receive the help they need to succeed in their studies.

2.2.2. Ireland

The disability and access services in Ireland are governed by a diverse set of organisations, each with specialised competencies essential for driving inclusion across policy, education, and social services.

National Policy, Universal Design, and Strategy

At the highest level, the National Disability Authority (NDA, 2026) holds the core competency of national policy and strategy development, advising the government on resources and best practices for the disability sector as a whole. Closely supporting this is the Centre for Excellence in Universal Design (2026), whose expertise lies in setting and promoting Universal Design (UD) standards. This competence is vital for ensuring that the physical environment, digital interfaces, and services are inherently accessible to everyone. The principles of UD are formally applied to third-level education through the ALTITUDE National Charter for Universal Design in Tertiary Education (Atlantic Technology University 2024), which is in charge of establishing a unified, national framework for implementing Universal Design for Learning (UDL) across the third-level (university) sector.

Higher Education and Cross-Sectoral Support

In the area of academia, AHEAD (2026a) maintains the critical competency of higher education access policy and research. They advocate for effective measures to improve access, retention, and outcomes for students with disabilities at the university level. The practitioners who implement this policy are supported by the DAWN Network (Network of Disability Officers in Ireland 2026), which focuses on professional networking and coordination among Disability Officers in Irish Higher Education Institutions. Complementing this is the Disability Federation Ireland (DFI) (2026), which exercises its competency in federation and UN CRPD implementation by representing a broad coalition of disability organizations and leading the application of the UN Convention on the Rights of Persons with Disabilities. Separately, the Freedomtech project (2026) holds the competency of Assistive Technology (AT) community networking, facilitating the Community Hub for Assistive Technology (CHAT) to share knowledge among stakeholders. Additionally, Enable Ireland (2026) provides AT training across the country.

Blind and Low Vision (BLV) Services - Specialist Sensory Service

Services are driven by Vision Ireland (2026), whose primary competency is comprehensive national service delivery and information provision for the BLV community. Child Vision Ireland (2026) adds the competency of specialist BLV education for younger people. Research and patient advocacy are the domain of Fighting Blindness (2026), while Feach (2026) focuses on family support and representation. Finally, the Irish National Braille and Alternative Formats Authority (INBAF) (2026) is the sole national authority on Braille and alternative format production.

Deaf and Hard of Hearing Services - Specialist Sensory Service

This community is represented by the Irish Deaf Society (IDS) (2026), whose core competency is Deaf-led representation, advocacy, and social service provision. The National Charity for Deaf and Hard of Hearing People (CHIME) (2026) offers an important competency in community networking and social services for both Deaf and Hard of Hearing individuals. Academically, the Trinity College Centre for Deaf Studies (2026a) is the national expert in academic ISL/Deaf Studies and research, with the Irish Deaf Research Network (2026) supporting this by specialising in research coordination.

2.2.3. Slovenia

Students with disabilities in Slovenia can turn to dedicated university contact points and a national student association that provides practical, case-by-case support. At the University of Ljubljana (UL) (2026c), there is an institutional pathway for applying for "students with special needs and special status," managed through faculty student offices and a central equality and inclusion unit. The status allows students with disabilities to require adjustments depending on the nature of the obstacles they face in their studies. The university (2026b) also operates a Mobile Support team that offers tailored counselling, coordination, and training for staff to enable reasonable accommodations (e.g., exam adjustments, accessible materials, tutors). Other Slovenian higher-education institutions operate equivalent structures. The University of Maribor (2026a; 2026b) offers a Student Hub and faculty student-office procedures for granting special-needs status and coordinating adjustments, and individual faculties (and their career or student offices) act as first-line contact points for arranging adaptations and support services.

Beyond campus services, the Slovenian Association of Disabled Students (Društvo študentov invalidov Slovenije, DŠIS (2026a) serves as a national contact point and service provider. The Association has offices in Ljubljana and Maribor, offers counselling and practical help (information on accessibility, assistive devices, transport, and digitisation of materials), runs workshops and peer support, and helps students navigate institutional procedures and entitlements. (DŠIS 2026b) Together, these university offices and DŠIS form the practical support network for students with disabilities in Slovenia.

2.2.4. Conclusion

All three countries have established dedicated service structures to support students with disabilities, providing advice on exam accommodations, accessible learning materials, and coordination between students and university administration. Austria operates university-based service centres (for example, "Barrier-Free Studying", "Integrated Studying" teams or Disability Officers) focusing on individual consultations, technical aids and staff awareness. Ireland has a specialised, multi-layered ecosystem with national organisations such as the National Disability Authority, AHEAD, the DAWN Network and specialist sensory services. Slovenia combines institutional contact points at universities (faculty student offices, Mobile Support teams) with a national student association (DŠIS) that offers counselling, peer support and practical help in navigating procedures and assistive technologies.

2.3. University Support Services

2.3.1. Austria

General support services for students with disabilities

Austrian universities offer a range of support services for disabled students. These services are designed to remove barriers and make studying easier for everyone. Many universities, for example, have made their buildings more accessible by adding lifts, ramps and accessible toilets. However, some older buildings still pose challenges and are not fully accessible (University of Vienna, 2023). Students with disabilities can also request exam accommodations, such as extra time, alternative formats (e.g., oral exams instead of written ones) or the use of assistive devices (TU Wien, 2023). Some universities also provide personal or study assistants to help students with their daily academic tasks.

Specific support services for blind and visually impaired students in computer science

Blind and visually impaired students in computer science face unique challenges, and universities offer specialised support to address their needs. For example, some universities provide programming tools and integrated development environments (IDEs) compatible with screen readers such as JAWS or NVDA (University of Graz, 2023). Tactile learning materials, such as tactile graphics and 3D models, are also used to make visual content, such as algorithms or data structures, more accessible. Furthermore, lecture notes and course materials are often provided in accessible formats, such as Braille, audio, or digital formats (University of Vienna, 2023).

2.3.2. Ireland

The university support services can be categorised into two groups: general support for students and specific support for students with disabilities.

General Support Services

General support services include academic support units, financial support, medical and counselling services, facilities such as creche and student accommodation (TU Dublin (2026a), University of Galway (2026b), University of Limerick (2026a), University College Dublin (2026), Trinity College Dublin (2026b).

Academic support units usually include an Academic Writing Centre, a Mathematics Support Centre, and a Computing Support Centre.

Financial support is offered by the Government of Ireland (Student Universal Support Ireland SUSI grant to cover fees and maintenance) and university-specific schemes, such

as compulsory travel schemes and student assistance fund for students experiencing short- or long-term financial difficulties while in third-level education.

Medical and counselling services are offered free of charge to registered students at Irish universities.

Student accommodation support or university-owned accommodation, as well as other facilities such as a creche for students who are parents and require such service, are provided in a number of universities.

Specific supports for students with disabilities

Additionally, Irish universities are required by law to provide support for students with disabilities. This is usually reflected in the form of disability support services (TU Dublin (2026b), Trinity College Dublin (2026c), University of Galway (2026b), University of Limerick (2026b). These services provide a wide range of services and fulfil a number of important functions such as:

- Management and coordination of support services and personnel
- Delivery of support services and provision of accommodations to students, including assistive technology, readers/scribes, time extensions for examinations/assessments and separate rooms for examinations, amongst others.
- Management of assistive technology and learning support services
- Supporting the college in the development of policies and guidelines in relation to students with disabilities
- Organisation and implementation of needs assessments
- Addressing staff training and development needs in relation to disability awareness
- Staff training and development
- Development of partnerships with specialist agencies, employers, schools, Colleges of Further Education and other institutions
- Production of promotional materials and guidelines for staff

Financial support for students with disabilities is provided by the Higher Education Authority (HEA) (2026). They provide a specific funding scheme called the Fund for Students with Disabilities (FSD). The purpose of the Fund is to assist higher education institutions in ensuring students with disabilities have the necessary assistance and equipment to enable them access, fully participate in and successfully complete their chosen course of study (AHEAD 2026b).

2.3.3. Slovenia

General support services for students with disabilities

Students with disabilities in Slovenia have access to a structured system of support services designed to promote equal participation in higher education. Universities typically

provide “special needs and special status” procedures through which students can request adaptations such as extended exam time, adjusted deadlines, alternative assessment formats, accessible learning materials, or personal assistance. These services are coordinated through faculty student offices and contact persons for students with special needs, as well as university inclusion coordinators. UL also offers psychological counselling, tutoring support, assistive technology resources, and help with navigating administrative procedures. Students receive accommodations tailored to their individual needs, which allows them to participate fully in academic activities.

Every year, UL dedicates funds for spatial and technical adjustments necessary for an accessible, inclusive, and equal environment for members of the academic community with special needs. The university cofinances adaptations for special needs students. The members acquired various adaptations, such as floor tactile signs for the blind and visually impaired, an optical microscope with screen, additional equipment for the microscope and a computer with desktop and wall monitor for work with the visually impaired, upgrading university member lifts with audio information for persons with various forms of disability, a laptop computer, anti-slip contrast strips for stairs, affixing contrast strips to glass surfaces, an evacuation chair, audio induction loop and adaptation of website.

Additional support was planned through the strategic goals for 2025. The University of Ljubljana (2025) will establish professional coordination for promotion and education in the field of an inclusive and equal academic environment at the University of Ljubljana. Based on the analysis of support systems of university members for students with special status, UL will prepare recommendations and guidelines that will support, encourage, and facilitate the process of integrating different groups of students. Furthermore, funds for co-financing adjustments for students with special needs will be increased and distributed through a call for proposals for UL members. Moreover, UL members will use various tools to better understand the career aspirations of their students and pay even greater attention to strengthening cooperation with career centres to ensure active and diverse guidance and counselling, including for students with special needs and special statuses.

Specific support services for blind and visually impaired students in computer science

Regarding the inclusion and education of the blind and visually impaired students, Slovenia is classified in a group of countries with a well-developed system of special education for the blind and visually impaired (Smart Solutions for the Inclusion of Students with Disability in Higher Education 2022). Each faculty, including the Faculty of Computer and Information Science, has a contact person for special-needs students, who can help with how adjustments might work in that specific study programme. Specific support for blind and visually impaired students is thus personalized and course-dependent, due to the small number of such students enrolled in computer science higher education programmes.

Information and Communication assistive technologies for the blind and visually impaired include Online Notes (Center za jezikovne vire in tehnologije 2025), a system for automatic

speech-to-text conversion and translation. The system is implemented in several UL member institutions. The development of the tool was coordinated at the Faculty of Computer and Information Science at the University of Ljubljana, in close collaboration with the Centre for Language Resources and Technologies. Additionally, in the year 2025 University of Ljubljana, Faculty of Computer and Information Science acquired adaptations such as Braille signs for the blind and visually impaired, and anti-slip contrast strips for stairs.

Through UL's Self-advocacy for Students with Special Needs handbook ("Samozagovorništvo študentov s posebnimi potrebami") (University of Ljubljana, 2020) students are informed about their rights and how to request support and specific adjustments. Furthermore, the UL conducts interviews with students with disabilities at different member institutions to gather their feedback on the challenges and difficulties they face, as well as any additional needs they may have.

2.3.4. Conclusion

All three countries provide general support services for students with disabilities, including exam accommodations (extended time and alternative formats), accessible learning materials, assistive technology and personal assistance, coordinated through dedicated offices and contact persons. For blind and visually impaired students in computer science, all three offer screen reader-compatible tools, accessible course materials and tactile learning aids, while continuing to improve physical accessibility in sometimes challenging older buildings. Austria focuses on university-based services that provide technical aids, such as screen readers, Braille displays, and 3D models for algorithms, alongside exam accommodations. Ireland clearly distinguishes between general student supports (for example, writing centres, financial aid, counselling, and accommodation) and disability-specific services, which are supported by dedicated government funding and extensive staff training and needs assessment. Slovenia applies a structured "special needs and special status" procedure through faculty offices, provides annual funding for spatial and technical adjustments, and uses tools such as Online Notes and a Self-advocacy handbook, together with regular student interviews, to strengthen coordination and feedback. Overall, all three countries show a strong commitment to accessible education but differ in how they organise and resource support: Austria emphasises practical, direct services at the university level, Ireland operates a formalised, nationally funded infrastructure with clear institutional roles, and Slovenia combines individualised support with strategic planning, feedback mechanisms and regular investment in accessibility improvements.

2.4. Access and Admission

2.4.1. Austria

Special rules and support measures for students with disabilities during application and enrolment

Students with disabilities benefit from special rules and support measures during the application and enrolment process. For example, they can apply for compensatory measures, such as extra time for entrance exams or alternative exam formats. Some universities also offer personalised admission procedures and counselling to help students with disabilities navigate the application process (University of Vienna, 2023). Financial support is also available for students with disabilities. The Austrian Study Grant Authority provides additional funding, such as higher study grants or subsidies for assistive technologies, to help cover the costs of studying (Study Grant Authority, 2023).

2.4.2. Ireland

Special rules and support measures for students with disabilities during the application and enrolment processes at third-level institutions in Ireland are set out in the Disability Access Route to Education program.

The Disability Access Route to Education (DARE, 2026) is a program that offers an alternative route into third level for students whose disabilities have had a negative impact on their school experience. DARE offers college places on a reduced points basis. The scheme is available to school leavers under 23 years old with disabilities who have completed an Irish Leaving Certificate. This program has successfully increased the number of young people with disabilities entering tertiary education.

2.4.3. Slovenia

Special rules and support measures for students with disabilities during application and enrolment

Students with disabilities in Slovenia are supported during the application and enrolment process through specific procedures that recognise their special needs. Higher education institutions, such as the University of Ljubljana and the University of Maribor, allow candidates to apply for special needs candidate status at the time of their admission application. By submitting relevant medical documentation, candidates can request adapted procedures, receive support during admission, and, after enrolling, obtain the status of student with special needs. This status entitles them to specific adjustments such as adapted exams, extended deadlines, alternative assessment formats, or accessible learning materials. Universities also provide dedicated coordinators, student offices, and counselling services that guide students through the application and accommodation process.

In 2025, the Zakon o visokem šolstvu (ZViS) - Higher Education Act (2021) was amended, introducing an important change to the admission criteria for candidates with special status. In previous years, candidates with disabilities who narrowly missed the standard admission score could still enrol if they achieved at least 90% of the required points. Under the new rules adopted by the Ministry, this 90% rule has been removed. Instead, special-status candidates must now meet the lower threshold ("zmanjšani minimalni prag") determined for their study programme, rather than a fixed percentage of the regular score. This reform aims to standardise entry conditions among all students, including those with disabilities.

2.4.4. Conclusion

All three countries provide special support measures for students with disabilities during application and enrolment, including compensatory arrangements for entrance examinations (such as extra time and alternative formats), personalised admission procedures and counselling. Students can apply for a special status by submitting medical documentation, which entitles them to specific adjustments throughout their studies, and financial support is available to help cover study-related costs. Austria offers compensatory measures for entrance exams and personalised admission procedures, with financial support from the Austrian Study Grant Authority in the form of higher study grants and subsidies for assistive technologies. Ireland operates a comprehensive financial support structure through schemes such as the SUSI grant and the Higher Education Authority's Fund for Students with Disabilities, and universities are legally required to provide disability support services with functions including needs assessments, staff training and partnership work. Slovenia has recently reformed its admission criteria by replacing the previous 90% rule with a reduced minimum threshold ("zmanjšani minimalni prag") for special-status candidates, thereby standardising entry conditions while maintaining targeted support. Overall, Austria focuses on direct compensatory measures and grants, Ireland on a formalised, government-funded infrastructure, and Slovenia on modernised admission criteria that balance standardisation with continued support for students with special needs.

2.5. Challenges and Barriers faced by students with disabilities and visual impairment

2.5.1. Austria

Despite the many support systems in place, students with disabilities in Austria still face significant challenges. One of the biggest problems is accessibility. While many university buildings and resources are accessible, older buildings and materials are often not fully barrier-free (University of Graz, 2023). For blind and visually impaired students in computer science, visual content is a major challenge. Diagrams, code editors, and other visual tools are often not designed to be accessible. Additionally, not all learning materials are available in accessible formats, which can make studying more difficult (TU Wien, 2023).

Another issue is the lack of awareness and training among university staff. Many lecturers and employees are not trained to understand the needs of students with disabilities. This can lead to unintentional barriers and make it harder for students to fully participate in their studies (University of Vienna, 2023).

2.5.2. Ireland

Access to learning is the cornerstone of success in education, and for children with disabilities such as vision impairment, low vision, deaf or hard of hearing, achieving true educational equity depends on overcoming a set of challenges and barriers.

In third-level education, these challenges are related to specific technological and systemic barriers that need to be addressed to foster inclusive learning environments:

Systemic Digital Inaccessibility

A major barrier is the presence of inaccessible learning management systems (LMS), online platforms, and institutional websites. Many platforms used for coursework submission, class announcements, and grade access are poorly coded or violate basic accessibility standards, rendering them unusable for screen readers. Furthermore, the availability of learning materials in advance remains a critical issue. Lecturers often upload readings, presentations, and handouts just before – or even during – a class. This lack of lead time is insufficient for Disability Support Services to produce the necessary specialized formats, such as tactile graphics or Braille versions, thus negating the student's access.

Assistive Technology (AT): Access and training

Timely access to relevant and required AT and the provision of training to achieve a proficient level of expertise is also necessary to ensure students with disabilities are able to engage with the course content and all educational activities on equal terms.

2.5.3. Slovenia

Despite the efforts, students with disabilities in Slovenia face insufficient institutional readiness at universities. A recent study found that many faculties are neither physically nor pedagogically adapted for students with special needs: architectural barriers remain, and many academic staff lack training in inclusive education, making the required adjustments difficult to implement. (Ravnikar/Krajnčan 2025) Higher education institutions also frequently lack a unified system for information and support, which means that students struggle to navigate accommodations, apply for support status, or know which offices to contact.

For blind and visually impaired students, the challenges are more specific and technical. According to a national report (SSSD-HE 2022), major barriers include limited access to assistive technologies, insufficient availability of accessible digital learning materials, and problems with information accessibility (for example, non-accessible web or Moodle environments). In 2025, UL is actively working to provide guidelines on how to make all the teaching materials accessible, including all of those that go onto the university's online teaching platform Moodle. Mobility is also a problem. Navigating campus, classrooms, and transport routes can be difficult, especially when buildings or paths lack adaptations such as tactile markings or contrasting signage. (SSSD-HE 2022) In 2025, the Faculty of Computer and Information Science introduced additional adaptations, such as Braille signs for the blind and visually impaired, and anti-slip contrast strips for stairs to improve the mobility of blind and visually impaired students.

2.5.4. Conclusion

All three countries face significant challenges in supporting students with disabilities despite existing support systems. Physical accessibility remains difficult, particularly in older university buildings, and limited awareness and training among academic staff are major barriers to inclusion. For blind and visually impaired students, access to assistive technologies and accessible digital learning materials is often insufficient; visual content in computer science, such as diagrams and code editors, remains largely inaccessible, and materials are frequently not available in advance in accessible formats. Austria identifies incomplete physical accessibility in older buildings and learning environments, as well as insufficient staff training on disability needs, with less emphasis on systemic digital barriers. Ireland identifies systemic digital inaccessibility as a central issue, including inaccessible learning management systems, online platforms and institutional websites, and underlines the lack of lead time for lecturers to provide materials so that Disability Support Services can prepare specialised formats; timely access to assistive technology

and adequate user training are also stressed. Slovenia reports broader institutional unreadiness, with many faculties not yet fully adapted physically or pedagogically, and a fragmented support landscape that requires students to navigate accommodations largely on their own; for blind and visually impaired students, additional challenges include mobility barriers on campus and limited campus adaptations, although the University of Ljubljana is implementing improvements such as Braille signage and contrast strips in 2025.

2.6. Implications for Practice

This section translates the findings from the desk research into practical implications for higher education institutions, educators, and support services. While Austria, Ireland, and Slovenia each operate within distinct legal and institutional contexts, common themes emerge in how accessibility is implemented in practice. The following country-level insights highlight key areas for improvement and provide targeted recommendations, followed by a synthesis of shared challenges and strategic priorities to guide more inclusive and accessible Computer Science education.

2.6.1. Austria

Austria has strong laws and systems to support students with disabilities, but there is still room for improvement. To make universities more inclusive, it is important to invest in making all university buildings and materials fully accessible. Universities should also develop more tools and resources for blind and visually impaired students, especially in fields like computer science. Regular training for university staff is also essential to help them better understand and support students with disabilities.

2.6.2. Ireland

Ireland has established a robust legislative framework and service providers to ensure that students with disabilities have a fair chance to succeed in third-level education. However, these strong legislative, policy, and support commitments are often not fully realised in practice. A core implementation challenge remaining is the wider adoption of Universal Design for Learning (UDL). To move beyond simply remediating inaccessible documents, the third-level sector must adopt a UDL approach. This means proactive design of instruction and materials, not reactive accommodation. It requires lecturers and course designers to have the competency to create “native” accessible content (e.g., using proper heading structures, image alt-text, and contrast) from the outset, embedding flexibility rather than treating accessibility as an afterthought.

2.6.3. Slovenia

Desk research findings demonstrate that Slovenia has established a solid legal and institutional framework to support students with disabilities, strengthened by recent amendments to the Higher Education Act (ZViS) (2021) and by comprehensive

anti-discrimination protections under ZIMI (2010) and ZVarD (2016). Universities, particularly the University of Ljubljana and the University of Maribor, have developed structured procedures for obtaining special-needs status, dedicated contact points, and a growing range of support services, including assistive technologies, adapted learning materials, counselling, and faculty-level adjustments. National organisations such as DŠIS (2026a) further enhance the support by providing practical help, advocacy, and guidance. Specialised resources for blind and visually impaired students, such as Information and Communication Technologies (ICT) assistive tools, accessibility upgrades, and personalised course-level adjustments, demonstrate that institutions are actively working toward more inclusive study environments. Nonetheless, the data also show that these systems, while well-intentioned and expanding, remain uneven across faculties and require further coordination and standardisation.

To strengthen inclusion, universities should prioritise the consistent implementation of accessibility standards across all faculties, supported by systematic staff training in inclusive and disability-aware pedagogy. Additional investments in assistive technologies and the digital accessibility of learning platforms such as Moodle are essential, as these represent key barriers for blind and visually impaired students. (SSSD-HE 2022) Institutions should also follow through on UL's 2025 strategic commitments (University of Ljubljana 2025), including establishing a central coordination body for inclusion, issuing university-wide guidelines, and further increasing financial support for spatial and technical adaptations. Regular consultation with students, through feedback interviews, should guide future improvements. Training for teachers is also essential in helping them better understand and support students with disabilities. Universities should acquire and develop more tools and resources for blind and visually impaired students, especially in computer science, mathematics, and engineering, where the accessibility of study materials is particularly challenging.

2.6.4. Shared Challenges and Strategic Priorities

Across the three countries, strong legal frameworks and support systems are in place, but practical implementation remains uneven. Common challenges include limited physical and digital accessibility, insufficient staff training in disability awareness and inclusive pedagogy, and gaps in the availability of specialised tools and resources for blind and visually impaired students, particularly in technical disciplines such as computer science. A key priority is the development of fully accessible environments, including buildings, platforms, and teaching materials. Equally important is the systematic training of academic staff to support inclusive teaching practices and to better understand the needs of students with disabilities. Another central priority is the transition from reactive accommodations to proactive approaches based on UDL, ensuring that accessibility is embedded in the design of teaching materials. This includes creating accessible content with appropriate structures, alternative text, and inclusive visual design. Strengthening institutional coordination and ensuring the consistent implementation of accessibility standards across faculties also emerge as critical priorities. This includes the development of university-wide guidelines, the establishment of central coordination structures, and increased investment

in assistive technologies and the accessibility of digital learning environments, such as learning management systems.

Finally, continuous engagement with students through feedback and consultation is essential to inform improvements and ensure that support measures respond effectively to real needs. While Austria places particular emphasis on infrastructure and resource development, Ireland highlights the importance of UDL as a systemic approach, and Slovenia focuses on institutional coordination and standardisation, all three converge on the need for sustained investment and a more proactive, integrated approach to accessibility.

3. Interviews

The interview section summarises qualitative insights from staff in disability support services, teaching, and student support at universities in Austria, Ireland, and Slovenia. It explores how accessibility for blind and visually impaired students in computer science and related fields is implemented in practice, including available services, technical support, teaching and examination arrangements, and perceived challenges and future needs.

3.1. Methodology

This section outlines the qualitative interview methodology used in the three partner countries. Semi-structured interviews with staff from university service and support centres were conducted (see Appendix for the guiding questions) to gather insights into institutional practices and challenges in supporting blind and visually impaired students.

In Austria, interviews were conducted with staff from five service and support centres, including two at technological universities, one at a university of applied sciences, and two specialised centres for deaf students (GeStu – Gehörlos erfolgreich Studieren) across different federal states. Semi-structured qualitative interviews were conducted online via Zoom, lasting 30–60 minutes, and all responses were recorded and anonymised for analysis. The interviews highlighted that it is difficult to identify blind and visually impaired as well as deaf students studying computer science in Austria.

In Ireland, three staff members from Technological University Dublin (TU Dublin) participated in the interviews: a Disability Support Officer, a computer science lecturer and researcher in Irish Sign Language and accessibility, and a tutor at the Academic Writing and Learning Centre, representing academic, technical and support perspectives. Semi-structured qualitative interviews were conducted online via Microsoft Teams between June and August 2025, each lasting 35–60 minutes; all interviews were audio-recorded, transcribed, anonymised and thematically coded. The analysis focuses on accessibility support for deaf, hard-of-hearing, blind and other students with disabilities in Irish higher education, particularly in computer science and related technical fields.

In Slovenia, one interview was conducted with staff from a service and support centre at the University of Ljubljana. A semi-structured qualitative interview was conducted in person over 45 minutes, and responses were recorded and anonymised for analysis. Some contacted support centres did not respond, and the very low number of blind and visually impaired students in higher education institutions posed additional challenges for recruitment.

In total, nine semi-structured interviews with staff from university service and support centres were conducted in 2025 across Austria, Ireland and Slovenia. Interview duration ranged between 30 and 60 minutes, and all interviews were recorded, transcribed, and thematically coded for analysis. The participating centres represent different institutional types and roles, and across all three countries, the teams reported that identifying blind

and visually impaired students in computer science programmes was difficult, reflecting the small population of such students in technical higher education fields.

3.2. Overview of Student and Support Services

3.2.1. Support services for blind and deaf students

Austria

Support services for blind and deaf students

Universities in Austria offer various support services for blind and deaf students, although significant gaps remain, particularly in technical fields such as computer science. One university provides digital teaching materials and some technical aids but lacks comprehensive services specifically for blind and deaf students. This is particularly evident in technical subjects, where the absence of such students highlights the existing barriers. A technical university of applied sciences adopts a reactive approach, addressing barriers on an individual basis. For example, a "blackboard camera" was purchased to help visually impaired students follow lectures. However, specialised software solutions or technologies tailored to the needs of blind or deaf students in technical fields are lacking.

A technical university collaborates with a service centre based at another university to provide accessible materials such as scanned books and documents. For deaf students, interpreting and transcription services are offered. However, there is no internal contact point specifically for blind and deaf students. The GeStu initiative, on the other hand, offers more structured support, including sign language interpreters, transcription services, and technical aids for blind and deaf students. GeStu also organises peer mentoring programmes and networking events to foster a community among students with disabilities.

Accessibility-focused study programs and initiatives

Most universities do not offer specific study programmes exclusively focused on accessibility. However, some initiatives integrate accessibility topics into existing programmes. For instance, a technical university offers courses on accessible construction, while a technical university of applied sciences provides a rehabilitation-oriented programme focusing on haptic solutions for assisted living. These programmes, however, are not specifically tailored to the needs of blind and deaf students, particularly in technical fields such as computer science.

Student enrolment numbers, particularly in computer science

The number of blind and deaf students in computer science is very low. Two universities report that no blind or deaf students are currently enrolled in their computer science programmes, highlighting the significant barriers these students face. A technical university of applied sciences lacks specific data on blind or deaf students in computer science, suggesting the university may not systematically track this group. In contrast, a

technical university supports three blind students and one deaf doctoral candidate in computer science, demonstrating that targeted support can promote participation and success.

Ireland

Support services for blind and deaf students

TU Dublin provides disability support through a dedicated Disability Support Service (DSS). In general, students registered in the DSS receive a range of support to ensure equitable access to learning. For deaf and hard-of-hearing students, services include ISL interpreters, note-taking or transcription assistance, and assistive technologies such as hearing loops, captioning, and speech-to-text tools. Blind and visually impaired students are supported through screen readers and magnification software. However, the system faces challenges such as shortages of qualified interpreters, inconsistent awareness of available technologies, and limited staff training on accessibility. Despite these gaps, the DSS provides vital, personalised assistance that enables deaf students to participate more fully in university life.

Accessibility-focused study programs and initiatives

Participants mentioned initiatives such as the Disability Advisory Working Network (DAWN), which connects disability officers across Irish universities. One interviewee mentioned that collaboration through DAWN allows universities to refer to one another for peer examples or resources that might not be available at TU Dublin, contacting, for example, the University of Limerick or Dublin City University for comparable cases. One of the interviewees also mentioned the Disability Access Route to Education (DARE), a national scheme in Ireland that offers reduced points entry and additional supports to students with disabilities who are applying to higher education through the Central Applications Office (CAO). The interviewee highlighted that students registered through the DARE (Disability Access Route to Education) scheme generally receive strong support, including interpreters or assistive technologies. Students outside DARE might struggle to obtain consistent access to interpreters or hearing technologies.

Student enrolment numbers, particularly in computer science

Specific numbers of deaf and blind students enrolled in computer science courses were not provided. However, a participant mentioned that TU Dublin has the highest number of deaf students nationally (approximately 9 sign-language users, and 50–60 hard-of-hearing students in 2024–25). Interpreting services are provided but constrained by shortages of qualified interpreters, inconsistent availability, and technical vocabulary gaps in ISL for computing and engineering. Blind or visually impaired students, however, are far fewer.

Slovenia

Support services for blind and deaf students

For both students with visual and hearing impairments (including blind and deaf students), UL provides different forms of support. The university provides tutors for students with special needs. Furthermore, there is a buddy system in which student tutors help students with disabilities with administrative issues and in finding the right accommodations. Furthermore, each faculty and academy within the university has a contact person who serves as the first point of contact for students with disabilities. This person ensures the student receives the required accommodation and communicates this information to professors. Additional support is usually provided at the course level, depending on the type of disability and based on the nature of the course.

Students obtain a special needs status once they apply and submit the required documentation. The student affairs commission at the faculty processes the application, reviews the documentation, and approves the special status. Apart from applying for a special status and filling out the accommodations sheet, these students are now also interviewed about their special needs when enrolling (by the Commission of Student Affairs), and their accommodations are revised yearly.

Accessibility-focused study programs and initiatives

UL provides training for all teachers and staff who want to work with students with special needs and disabilities. However, there are no specific activities and study programs focused on accessibility in computer science. The activities and programs for students with all forms of disabilities are organised at the university level.

Student enrolment numbers, particularly in computer science

In the school year of 2024/2025, the number of enrolled students in computer science programs is provided in the following table:

Table 1 Number of Enrolled Students in Computer Science at the University of Ljubljana, School Year 2024/25

	First year	Second year	Third year	Fourth year	Additional year	Total
Bachelor's degree	524	297	242		151	1214
Master's degree	158	118			77	353
Doctoral degree	16	10	5	15	4	50
Total	698	425	247	15	232	1617

In the year 2023/2024, the university had 20 deaf and hearing-impaired students and 36 blind, visually impaired students or students with visual function disorder. In the computer science programs for 2024/2025, we have 5 blind and 4 deaf students enrolled.

Conclusion

All three countries provide support services for blind and deaf students, including interpreting or transcription assistance, assistive technologies and individualised support via dedicated contact points, but all report very low numbers of such students in computer science and gaps in specialised support. Austria offers largely reactive and partly externalised support, with GeStu as a notable structured service for deaf students and currently only a few blind or deaf students in computer science. Ireland works with a centralised Disability Support Service at TU Dublin and national initiatives such as DAWN and DARE, providing a wide range of supports but facing interpreter shortages and uneven staff training, with comparatively many deaf and hard-of-hearing students and very few blind students. Slovenia supports students through faculty contact persons, a buddy system and a formalised special-needs status with annual review.

3.2.2. Technical Support

Austria

Social security measures for assistive technology

Social security measures play a crucial role in funding aids such as interpreters and technical assistance, ensuring that students with disabilities do not face additional financial burdens. For example, the GeStu initiative at a technical university is funded through such measures and provides services like interpreters and transcription free of charge. At a technical university of applied sciences, however, students are expected to bring their own resources or request individual adjustments, which can create additional challenges.

University-provided technical aids for blind and deaf students

Universities provide various technical aids, including screen readers, magnification tools, and transcription services. A technical university of applied sciences recently introduced a "blackboard camera" to help visually impaired students follow lectures more effectively. However, specialised software solutions for blind or deaf students in technical fields are lacking. A technical university offers tactile drawing tools, but these are rarely used due to their complexity. Students often prefer to use their own devices.

Availability and equipment of accessible computer workstations

Accessible computer workstations are limited at most universities. At a technical university of applied sciences, there is no specific information on the availability of such workstations, suggesting that they may not be adequately provided. A technical university and other universities have public computer workstations, but specially adapted workstations are

lacking due to high maintenance costs and low usage. Students, therefore, often rely on their own laptops with accessible software.

Specialised software for blind students and its functionality

Specialised software for blind students includes tools such as screen readers and software that converts complex mathematical formulas into accessible formats. These tools are essential for understanding visually intensive content in technical fields such as computer science. At a technical university of applied sciences, however, there is no evidence of the development or implementation of such software, representing a significant gap in technical support.

Ireland

Social security measures for assistive technology

The DSS provides practical accommodations directly to students registered with it. These supports are typically implemented within the university rather than through external agencies. Although no interviewee detailed formal financial measures for technology, there was clear reference to academic adaptations, particularly exam supports such as the provision of interpreters for deaf students and tailored tutorials before assessments. One participant described arranging refresher sessions with interpreters before exams to help deaf students review content and prepare effectively. Overall, exam-related and academic accommodations are managed internally through the DSS rather than through external social security systems, reflecting a locally coordinated but resource-limited approach.

University-provided technical aids for blind and deaf students

Participants highlighted that access to assistive technology largely depends on university-level provision through the DSS. One participant mentioned the university currently has 2 (two) Assistive Technology Officers (ATOs), who can advise students on how to use the assistive technologies available; however, these professionals are in charge of a large group of students, struggling to provide personalised individual assistance. Another participant mentioned knowing the existence of ATOs, but highlighted that knowledge of this role among staff is low. At TU Dublin, deaf and hard-of-hearing students primarily benefit from interpreting services, hearing loops, and captioning or speech-to-text tools, although awareness of which lecture halls are equipped with these systems is limited. Interpreters are externally contracted. Their pay structure (half-day/full-day rates) and working conditions make education work unattractive compared to court or general practitioner interpreting. Interpreters often lack access to Wi-Fi, staff rooms, or parking, contributing to turnover and shortages. Blind or visually impaired students were rarely mentioned, suggesting that this group is small and that specialised aids for them may be limited or handled on a case-by-case basis. There is also a read and write interactive interface free for any student attending TU Dublin.

Availability and equipment of accessible computer workstations

There was no reference to dedicated accessible computer workstations on campus, and participants implied that students typically rely on their own devices. In the School of Computer Science, assistive technologies such as colour-contract keyboards, reading pens and braille keyboards were recently acquired through an internal project but are not yet being used by the students.

Specialised software for blind students and its functionality

There was no mention of specialised software for blind students, such as screen readers or tactile tools, indicating either that these tools are not widely implemented or that awareness of their use is minimal among the interviewees. One participant mentioned, though, that blind students could avail of a braille device through the National Council for the Blind of Ireland (NCBI), although a good number of younger people do not learn braille and might prefer screen readers. Overall, technological supports appear to exist but are fragmented, inconsistently publicised, and not part of a comprehensive or well-resourced system.

Slovenia

Social security measures for assistive technology

There are social-security measures in Slovenia that support persons (including students) with disabilities in obtaining assistive technology and other support. For example, people with sensory impairments (such as blindness or visual impairment) are eligible for co-financing of technical aids and assistive devices. The state typically co-finances the value of such aids. Access to assistive technology is provided through the national health insurance system: individuals covered by health insurance (everyone with permanent residence) become eligible for “technical devices” when an expert medical opinion confirms the need.

University-provided technical aids for blind and deaf students

Technical aids acquired through University-provided funding include: floor tactile signs for the blind and visually impaired, an optical microscope with screen, additional equipment for the microscope and a computer with desktop and wall monitor for work with the visually impaired, upgrading UL member lifts with audio information for persons with various forms of disability, a laptop computer, anti-slip contrast strips for stairs, affixing contrast strips to glass surfaces, audio induction loop and adaptation of website.

The university provides tutors for students with disabilities, including blind and deaf students. However, when it comes to technical aids, the system is not homogeneous, and tutors' roles differ depending on students' needs.

Availability and equipment of accessible computer workstations

There are no university-wide accessible computer workstations at the University of Ljubljana.

Specialised software for blind students and its functionality

Assistive software tools for the blind and visually impaired implemented on the university level include Online Notes, a system for automatic speech-to-text conversion and translation. The system is implemented in several UL member institutions. The development of the tool was coordinated at the Faculty of Computer and Information Science at the University of Ljubljana, in close collaboration with the Centre for Language Resources and Technologies.

Conclusion

All three countries acknowledge the importance of assistive technology and technical aids for blind and deaf students, and screen readers, magnification tools and interpreting services are available in all three contexts, while specialised software and systematically accessible computer workstations remain limited. Austria relies largely on social security funding and reactive, case-by-case provision, with initiatives such as GeStu and individual solutions like tactile tools or a “blackboard camera”, but with few specialised software solutions in technical fields. Ireland provides assistive technology through the Disability Support Service, including interpreting, hearing loops, captioning, speech-to-text tools and Read and Write for all students, yet faces constraints due to limited Assistive Technology staff and uneven staff awareness. Slovenia combines state co-financing of technical aids with university-level investments in tactile signs, adapted lifts, induction loops and other aids at the University of Ljubljana and has developed Online Notes, an automatic speech-to-text and translation system, although fully accessible computer workstations are not yet available across the university.

3.2.3. Teaching and Learning Support

Austria

Accessibility of teaching materials for blind and deaf computer science students

Teaching materials are often adapted to be accessible, for example, by converting documents into screen-reader-friendly formats or by providing interpreters for lectures. At a technical university of applied sciences, however, teaching materials are only adapted upon request, highlighting the reactive nature of the approach. A technical university, as mentioned earlier, collaborates with a support and service centre to provide accessible materials, but the complexity of technical subjects limits the effectiveness of these adaptations.

Tutorials and training sessions for using assistive technologies

There are no structured tutorials or training sessions specifically designed to teach blind and deaf students how to use assistive technologies. Universities, such as technical universities of applied sciences, rely on students' prior knowledge, which is not always sufficient.

Accessible examination formats for blind students

Examinations are adapted on a case-by-case basis to meet the needs of students with disabilities. At a technical university of applied sciences, there are no standardised accessible examination formats, creating uncertainties and additional stress for students.

Ireland

Accessibility of teaching materials for blind and deaf computer science students

Participants mentioned that teaching materials are adapted mainly upon request, demonstrating the reactive nature of the service. Lecturers are not systematically informed about students' accessibility needs before classes begin. One participant emphasised that teaching materials should be made accessible earlier, for example through videos that combine subtitles and sign-language interpretation and transcribed lecture content, which would also benefit blind students. However, none of the participants mentioned dedicated resources or structured materials designed specifically for blind or visually impaired students, suggesting that accessibility efforts are mainly reactive and concentrated on auditory rather than visual adaptations.

Some academics, particularly in computing, recognise the importance of providing notes in advance, subtitles, and accessible formats, but face competing time pressures.

Lecturers frequently meet interpreters for the first time in class, without prior briefing or shared vocabulary preparation. One participant mentioned that, in an ideal world, lecturers would know months in advance what disabilities their students might have in order to prepare their classes to be more accessible; however, this is not the current reality. Considering the Deaf community, one participant mentioned that technical lectures (for example, Object-Oriented Programming) pose specific translation challenges as incorrect signing of terms such as class, function, or object can lead to misunderstanding. They also mentioned that early sharing of lecture notes and terminology lists would improve consistency, but it is not yet standard practice.

Tutorials and training sessions for using assistive technologies

None of the interviewees described any formal tutorials or training sessions for students or staff on how to use assistive technologies. One participant pointed out that while some technologies, such as loop systems, captioning, and speech-to-text tools, exist, both staff and students often lack awareness or knowledge of how to use them effectively. The participant is a hearing-aid user themselves and said to be unaware of which lecture halls

had loop systems or how to connect to them. This indicates that the availability of assistive technology is undermined by limited communication, inconsistent training, and an absence of institutional guidance. Overall, the interviews suggest that training on assistive technologies is insufficient, leaving students to rely heavily on personal experience and peer support.

Accessible examination formats for blind students

One participant mentioned that students registered with the DSS receive exam accommodations and adjustments based on their individual needs. These include measures such as extra time during exams and the coordination of interpreters or tutorial support sessions before assessments for students with disabilities. The interviewee described personally following up with students after receiving their exam results and arranging revision or refresher classes with interpreters to help them prepare for repeat exams when necessary. These examples show that exam adaptations at TU Dublin are handled in a personalised and flexible manner, coordinated by the DSS and support officers who ensure that students with disabilities are given fair opportunities to demonstrate their knowledge. The interviewee mentioned, however, that they currently manage 550 students with disabilities, highlighting how challenging it is to follow up and provide the personalised assistance they need.

Slovenia

Tutorials and training sessions for using assistive technologies

Training for academic staff is provided by the university on how to prepare accessible lecture materials. Additionally, there are handbooks available for teachers on the university's webpage:

Poučevanje študentov s posebnimi Potrebami (Teaching students with special needs)

Specialnopedagoški vidiki inovativnih pristopov k učenju in poučevanju študentov s posebnimi potrebami v visokošolskem prostoru (Special educational aspects of innovative approaches to learning and teaching students with special needs in higher education)

These documents provide recommendations for making the teaching materials accessible for both blind and deaf students, not specifically focusing on computer science.

Accessible examination formats for blind students

As in Poučevanje študentov s posebnimi Potrebami, Students are allowed more time to prepare, as reading audio or electronic texts is slower. Teachers should keep in mind that it takes time to convert material from print to audio or electronic format before students can begin studying/researching material.

The teachers should try to provide a quiet environment and use aids such as optical or electronic magnifiers, computers, etc., for written exams.

Conclusion

All three countries adapt teaching materials and examination formats for blind and visually impaired students mainly on a case-by-case or request-driven basis rather than through proactive universal design. Teaching materials are frequently converted into accessible formats such as screen reader-friendly documents or interpreted lectures, and all three acknowledge gaps in formal training and tutorials for students and staff on using assistive technologies; exam accommodations typically include extended time and alternative formats. Austria shows a predominantly reactive approach in which materials are adapted upon request, often in complex technical subjects, with no structured tutorials on assistive technologies and non-standardised exam adaptations that can create uncertainty for students. Ireland also works largely reactively, with accessibility needs not always communicated to lecturers in advance, limited awareness of available systems and specific challenges around consistent sign terminology for technical concepts in computer science, while a single support officer is responsible for a large number of students. Slovenia, in contrast, provides proactive, structured support through university-wide guidelines and staff training on accessible materials, complemented by handbooks and examination recommendations for blind and visually impaired students, though these measures are general rather than computer-science-specific.

3.2.4. Advising and Support Services

Austria

Dedicated contact persons or offices for blind and deaf students

Support for blind and deaf students at universities, technical universities, and technical colleges varies significantly, with many institutions still facing major challenges. While some universities have central contact persons for accessibility, specific offices or dedicated staff exclusively addressing the needs of blind and deaf students are often lacking. Technical universities and technical universities of applied sciences frequently rely on general service centres or initiatives, which are not always tailored to the specific requirements of this target group.

Training and coaching for teaching staff on accessibility needs

Training for teaching staff on accessibility is an area that requires further development at many institutions. Although there are awareness workshops and training sessions, they are often not specifically designed to address the needs of blind and deaf students. Some universities provide resources and consultations for teaching staff, while others have integrated mandatory didactic training that includes elements of accessibility. However, comprehensive and systematic training programs are still largely absent.

Mentoring programs and peer counselling initiatives

Mentoring programs and peer counselling initiatives are generally not specifically designed for blind and deaf students. While some universities offer general mentoring programs or peer networking opportunities, targeted projects addressing the needs of these student groups are rare. Peer mentoring projects for blind students or networking events for deaf students could play an important role but the latter one is currently implemented at only a few institutions.

Ireland

Dedicated contact persons or offices for blind and deaf students

One participant described the DSS as the main point of contact for all students with disabilities, while also mentioning the DAWN network, which links disability officers across Irish universities to share expertise and resources when supporting students with specific needs, such as deaf or blind learners. Another participant noted that within TU Dublin, a deaf staff member who uses ISL works in the DSS and helps coordinate support for deaf students, including communication with interpreters and academic staff. However, the participants acknowledged that awareness of available support is limited, and academics often discover that they have a student with disability only when they walk into the classroom. This reactive structure highlights the need for clearer communication channels and more visible points of contact for both students and staff.

Training and coaching for teaching staff on accessibility needs

All three participants emphasised a lack of formal training and coaching for teaching staff on how to accommodate students with disabilities. One interviewee described a situation where lecturers often receive no prior notice that an interpreter will be present in their class, leaving them unprepared to adjust pace or interaction styles. The interviewee strongly advocated for mandatory Deaf Awareness Training for all teaching and student-facing staff, suggesting that this could be delivered by organisations such as the Irish Deaf Society or CHIME (Ireland's National charity for Deaf and Hard of Hearing people). However, the participant noted that currently such training must be individually arranged rather than institutionally provided. Another participant also mentioned that while TU Dublin is supportive of accessibility, staff are overloaded and undertrained, which affects consistency in service delivery. No mention was made of training specifically addressing the needs of blind or visually impaired students, indicating a gap in staff development related to visual accessibility and inclusive teaching design.

Mentoring programs and peer counselling initiatives

Mentoring and peer support emerged as a strong theme across the interviews, especially for deaf students. One participant discussed their role in establishing a Deaf Peer Network – a new initiative designed “by deaf students, for deaf students” to provide academic mentoring, social connection, and shared problem-solving. This initiative is being

developed in collaboration with the DSS, external organisations like CHIME, and the Computing Learning Centre, which plans to train senior deaf students as paid peer mentors for first-year students. Another participant highlighted the importance of personal mentoring and follow-up, describing her practice of regularly checking in with students, arranging refresher tutorials, and offering tailored guidance. A third participant reinforced this by emphasising the value of individual feedback and emotional support, especially for students who may not disclose disabilities immediately. Collectively, these accounts illustrate a strong culture of informal mentoring and emerging structured peer networks, though there remains a need for broader institutional recognition and sustainable funding to expand these efforts.

Slovenia

Dedicated contact persons or offices for blind and deaf students

Each UL member institution (i.e. faculty) has a contact person who provides individual support and advice for students with disabilities. These contact persons, as well as other academic staff (if they want or need), receive training organized by the university.

Training and coaching for teaching staff on accessibility needs

While the focus is not specifically on blind students in computer science programs, there exists a Mobile Support program for the inclusion of students with disabilities and special statuses at the University of Ljubljana. It connects experts who provide counselling and training for UL members on inclusive practices for students with disabilities and special statuses in the study process. The experts involved in Mobile Support, among others, cover the following areas: blindness and visual impairment or visual function disorder, deafness and hard of hearing (partial or complete hearing loss), and deaf blindness. Support is provided through consultations on planning reasonable adjustments and developing inclusive teaching practices, as well as through training tailored to the specific needs of each UL member. The training program and its frequency depend on the needs of the UL member. The experts help teachers design and organise the lectures according to the special needs of students with disabilities.

Mentoring programs and peer counselling initiatives

There exists a tutor program for students with special needs as well as a student buddy system, through which students with disabilities receive support from peers.

Conclusion

All three countries provide dedicated contact persons or offices for students with disabilities and recognise the importance of training and peer support, although implementation and specialisation differ. Austria works with decentralised, general service centres that are rarely tailored specifically to blind and deaf students, offers largely inconsistent staff training and only limited, non-targeted mentoring or peer networking

initiatives. Ireland provides centralised support through the Disability Support Service and the DAWN network, including a deaf staff member using ISL and a new Deaf Peer Network initiative, but awareness among academics is limited and there is no formal, mandatory or vision-impairment-specific staff training. Slovenia has a more structured approach, with a designated contact person at each institution, university-organised training and the Mobile Support programme, as well as a tutor programme and a buddy system to provide peer support. The three countries thus employ different models for advising and support services: Austria relies on decentralised, general service centres with limited specialisation; Ireland works through a centralised Disability Support Service with emerging informal mentoring and new peer networks but without formal staff training; and Slovenia combines dedicated contact persons, systematic expert-led training and institutionalised peer support systems.

3.2.4. Challenges and Areas for Improvement

Austria

Major challenges in supporting blind and deaf computer science students

The greatest challenges lie in supporting blind and deaf students in technical fields such as computer science. The absence of such students in some programs indicates existing barriers. Key issues include the lack of proactive communication about accessibility, the absence of specialized vocabulary in sign language, insufficiently trained interpreters for technical content, and the difficulty of making graphical content such as diagrams and charts accessible to blind students. Additionally, creating accessible teaching materials, particularly for technical subjects, remains a significant challenge.

Additional services needed to enhance accessibility

To improve accessibility, many institutions are planning additional measures. These include lowering thresholds for accessing support services, introducing standardized examination formats, developing specialized vocabulary in sign language, and providing tailored software for blind students. Some universities aim to expand accessible workstations, allocate more financial and human resources, and introduce mandatory training for teaching staff. The integration of AI technologies to automate the creation of accessible materials is also being considered as a future possibility.

Collaborations with universities, companies, and organizations

Collaboration with other universities, companies, and organizations is another important aspect. While some institutions already partner with external organizations to share resources and expertise, there is still potential to expand such partnerships. Collaborating with companies specializing in assistive technologies, in particular, could help develop innovative solutions.

Ireland

Major challenges in supporting blind and deaf computer science students

Across the interviews, participants identified several significant challenges in supporting blind and deaf students, particularly in technical disciplines like computer science. One participant highlighted the shortage of qualified ISL interpreters, especially those familiar with the technical terminology used in programming and engineering. As a result, deaf students often receive incomplete or inaccurate information during lectures, with interpreters misunderstanding technical words. Lecturers are rarely informed in advance when an interpreter will be present, leaving them unprepared to adapt their teaching style or classroom setup. For blind students, none of the participants reported having direct experience supporting them, implying that such students are either underrepresented or face barriers preventing them from enrolling. Overall, the challenges are both structural and communicative: a lack of planning, coordination, and expertise creates unequal learning conditions for students who rely on visual or auditory adaptations.

Additional services needed to enhance accessibility

The interviews consistently pointed to a need for more systematic and proactive accessibility services rather than the current reactive model. One interviewee proposed developing accessible digital learning resources, such as videos explaining key programming concepts with subtitles, sign-language interpretation, and transcription, which would simultaneously support both deaf and blind students. Participants also stressed the importance of training and awareness programs for lecturers, ensuring that staff understand how to work effectively with interpreters, communicate clearly, and adapt materials. Participants noted that while the DSS provides strong individual assistance, it depends heavily on personal initiative and one-to-one mentoring rather than structured institutional policies. They argued that accessibility needs to be more visible and better integrated into the university's daily operations – for example, through information flyers, clear signage, and awareness of assistive tools available on campus. More formal feedback systems and quality assurance processes were also seen as necessary to evaluate and improve existing supports.

Collaborations with universities, companies, and organizations

The already mentioned DAWN network currently connects disability officers across Irish universities to share resources, information, and expertise when supporting students with specific needs such as deafness or blindness. One participant mentioned working with external organisations like CHIME, a charity supporting the deaf community, to develop initiatives such as the Deaf Peer Network. This collaboration includes mentoring, social engagement, and opportunities for deaf students to develop leadership roles. Participants also referenced connections with other universities, such as Dublin City University (DCU)'s work on a STEM glossary for Irish Sign Language, which could be expanded to include computer science terminology. These examples show that collaboration already exists but remains fragmented and informal. Stronger partnerships with both academic and industry stakeholders, particularly in technology and assistive software, could help create shared

resources, standardised vocabulary, and sustainable pathways for inclusive education in technical disciplines.

Slovenia

Major challenges in supporting blind and deaf computer science students

When it comes to equality and inclusion, one of the weaknesses identified over the year 2024 was a poor level of awareness among staff about current rules and legislation concerning integrity, violence, equality, and inclusion. To tackle these, UL has proposed to enhance activities intended for greater awareness-raising among staff about current legislation and rules (emails, training, and other events), and provide information on options for support in the event of inappropriate behaviour (trusted persons, trustees, Student Ombudsman). This covers all study areas, as well as all types of disabilities, and does not focus on blind and deaf computer science students.

Furthermore, over the year 2025, UL conducted interviews with students with special needs in all UL member institutions. The results and the insights will be available in 2026.

Additional services needed to enhance accessibility

Identified needs for additional services will be presented in 2026.

Collaborations with universities, companies, and organizations

Collaborations with European institutions on promoting accessibility usually come from European-funded projects. The Faculty of Computer and Information Science is a partner in the Erasmus+ project Access2CS (A Computer Science programme for visually and hearing-impaired students).

Conclusion

All three countries see the very low presence of blind and deaf students in computer science as an indication of substantial barriers and recognise the need to move from reactive, case-by-case support towards more systematic accessibility. Shared challenges include staff training and awareness, creating accessible technical content (for example diagrams, charts and code) and developing specialised terminology, with collaboration with external organisations, universities and companies regarded as important. Austria highlights gaps in proactive communication, limited technical sign vocabulary and interpreter training, and difficulties in making graphical material accessible, and proposes standardised examination formats, more accessible workstations, tailored software and cooperation with assistive-technology companies. Ireland stresses shortages of ISL interpreters with technical expertise, a lack of advance information for lecturers and no reported experience with blind students, and calls for more accessible digital resources, mandatory staff training, visible everyday accessibility measures, formal feedback mechanisms and stronger collaboration with initiatives such as DAWN and CHIME.

Slovenia notes low staff awareness of equality and inclusion legislation and plans awareness-raising and training activities for all disciplines and disability types, informed by interviews with students with special needs whose results will guide future measures from 2026 onwards. Overall, the three countries face comparable challenges but differ in their priorities and collaborative approaches: Austria emphasises technical content accessibility and assistive technology development, Ireland focuses on interpreter training, lecturer preparation and the visibility of accessibility support, and Slovenia concentrates on staff awareness-raising and student feedback.

3.2.6. Evaluation and Feedback

Austria

Assessing the effectiveness of accessibility support services and collecting and integrating feedback from blind and deaf students

The evaluation of the effectiveness of support services is often conducted informally at most institutions. Feedback is typically collected through open communication with students, but formal evaluation processes are often lacking. Some universities plan to introduce structured feedback mechanisms to better measure the quality of their services and make targeted improvements.

Ireland

Assessing the effectiveness of accessibility support services

The interviews revealed that there is no formal quality assurance system in place for evaluating the effectiveness of accessibility supports at TU Dublin. While the DSS is viewed as supportive and responsive, its operations appear to rely on individual initiative rather than systematic assessment. For example, lecturers and tutors receive little information about whether the accommodations provided, such as interpreters or extra exam time, actually improve learning outcomes. One participant suggested that accessibility questions could be added to the university's formal QA surveys or built into course-level evaluations, but currently, there is no feedback loop connecting the DSS, lecturers, and interpreters, meaning issues often go unreported or unresolved.

Collecting and integrating feedback from blind and deaf students

Feedback from students with disabilities is collected informally, depending largely on the staff member involved. One participant mentioned that some students voluntarily send emails or testimonials to express satisfaction with the support they received, and that such comments are sometimes shared with line managers. However, there is no structured mechanism for gathering regular feedback from blind or deaf students, nor a system to ensure that this input informs policy or practice. As a result, while positive stories emerge anecdotally, there is no systematic evaluation or integration of student feedback into service improvement.

Slovenia

Assessing the effectiveness of accessibility support services

When it comes to accommodations for students with disabilities, there are certain discrepancies in the practice. Until recently, a student with special needs who applied for certain accommodations applied only once, upon enrolment, and these would remain valid throughout their studies. However, it can happen that, not knowing what they will need, students select accommodation that they, in practice they do not use. This also happens as a consequence of not being familiar with what the studies and classes will look like. Because of this, students now have the opportunity to update their required accommodations every year.

On the other hand, some students do not apply for special student status or special accommodations, even though they need them. This can happen due to insecurity, fear of being stigmatised, or being discouraged from continuing their studies. In practice, teachers help such students get accommodated when the need for this arises. At certain faculties that work with smaller groups of students, students with disabilities do not require an application for a special status. In such smaller groups, students with disabilities can be easily integrated into the study programmes and the study program can be more easily adapted.

Collecting and integrating feedback from blind and deaf students

In 2025, the UL carried out interviews with students with disabilities at different UL members, obtaining their feedback on challenges and difficulties they face, as well as additional needs they might have.

Conclusion

All three countries acknowledge that formal evaluation and feedback mechanisms for accessibility support services are limited and that feedback is often collected informally rather than through systematic processes. They also recognise a gap between providing services and assessing whether these actually improve outcomes for blind and deaf students. Austria and Ireland rely mainly on informal communication with students, with structured quality-assurance or feedback systems only partly planned or discussed. Slovenia has introduced a more structured, iterative approach by allowing annual updates of accommodation needs and using faculty-level flexibility, but formal outcome measurement remains limited in all three countries.

3.2.7. Future Perspectives: Desired improvements and future service developments

Austria

Future perspectives include improving accessibility, developing new support services, and fostering a cultural shift toward greater inclusion. Many institutions aim to remove barriers, expand individualized support, and raise awareness of both physical and psychological disabilities. Integrating accessibility into university policies and curricula is also seen as an important step. Overall, while progress has been made in supporting blind and deaf students, significant gaps remain. Through targeted measures, stronger collaborations, and the use of new technologies, universities, technical universities, and technical colleges can create a more inclusive learning environment.

Ireland

The interviews highlighted a shared desire among participants to see accessibility move from a reactive to a proactive model within TU Dublin. One participant advocated for a whole-university approach in which accessibility is embedded in planning, timetabling, and staff training rather than addressed only when a student with a disability enrolls. Participants called for mandatory or at least strongly recommended training on deaf awareness, inclusive communication, and the use of assistive technologies. They also suggested developing permanent, reusable teaching materials such as videos that include subtitles, sign-language interpretation, and transcripts, which could support both deaf and blind students. Improved coordination between the DSS, academic departments, and interpreters was seen as essential to ensure consistent support. Furthermore, participants envisioned expanding mentoring initiatives, such as the Deaf Peer Network, and introducing structured feedback systems to evaluate accessibility measures over time.

While all participants expressed commitment to supporting students with disabilities, they acknowledged several unresolved issues that hinder progress. Issues among these are the shortage of qualified interpreters, the absence of standardised procedures for when interpreters are unavailable, and limited institutional awareness of accessibility resources. Participants noted that communication gaps between departments, disability services, and teaching staff often result in delayed or inconsistent accommodations. For blind students, the lack of direct experience and established practices leaves a significant gap in provision. One participant also emphasised that disability supports and facilities remain largely invisible across campus, suggesting the need for clearer information and visibility of available services. Overall, the interviews reveal a strong foundation of goodwill and individual effort but point to the need for sustained structural change, better planning, and stronger institutional accountability to make accessibility a consistent and integral part of university life.

Slovenia

Accessible university study programs can be presented in high schools that already have career counselling. Prehod Mladih is a project that provides counselling and support to young people regarding the choice of studies. UL can collaborate with such programmes, showcasing and promoting accessible higher education among high school students in Slovenia.

3.3. Summary and Conclusions

3.3.1. Austria

Interviews with the five service centres and GeStu initiatives at universities and universities of applied sciences reveal that support for blind and deaf students in Austria is present but still has significant gaps in many areas. Particularly in technical fields such as computer science, which are often visually intensive and complex, students with disabilities face numerous barriers. These challenges affect both the availability of resources and institutional structures and processes.

A central issue is the lack of standardisation in support. Many universities adopt a reactive approach, addressing barriers only on an individual basis. This often requires students to take the initiative to communicate their needs and seek support. For example, a technical university of applied sciences provides occasional aids such as a "blackboard camera" but lacks a comprehensive strategy to systematically address the needs of blind and deaf students. Similarly, a university provides digital teaching materials but does not have specialised programmes or comprehensive support structures.

A technical university, together with a GeStu initiative, stands out positively for its collaboration with external organisations and the provision of interpreters and accessible materials. Particularly, this GeStu initiative demonstrates how structured and centralised support can effectively promote blind and deaf students. However, challenges remain, such as adapting complex technical content (e.g., diagrams, mathematical formulas) and the limited availability of specialised software.

Another obstacle is the insufficient integration of accessibility into university structures and curricula. While some universities offer courses on accessible construction or rehabilitation technology, there is a lack of programmes specifically tailored to the needs of blind and deaf students in technical fields. This is also reflected in the low enrolment numbers: at one university and one technical university, no blind or deaf students are enrolled in computer science, highlighting the existing barriers. In contrast, a technical university supports three blind students and one deaf doctoral candidate in computer science, showing that targeted measures can promote participation and success.

The interviews also highlight that technical support is often inadequate. Accessible computer workstations are limited at many universities, and students frequently have to rely on their own devices. Specialised software, which is essential for blind students, is only sporadically provided. Additionally, structured training sessions to teach students how to use assistive technologies are lacking. This leaves many students dependent on their own prior knowledge, which is not always sufficient.

Another key issue is the lack of systematic feedback collection and integration. Many universities collect feedback informally, limiting the ability to make systematic

improvements. A structured feedback culture could provide valuable insights to better understand and address the needs of blind and deaf students.

3.3.2. Ireland

The Irish interviews reveal a university system in transition: dedicated staff and promising initiatives coexist with persistent structural and technological barriers. TU Dublin demonstrates strong individual commitment to supporting students with disabilities, but institutional frameworks remain fragmented. A more coordinated, well-resourced, and proactive approach, encompassing interpreter training, staff awareness, technological integration, and systematic feedback, will be crucial to ensuring equitable access for all students, particularly in demanding and technical fields.

3.3.3. Slovenia

The University of Ljubljana has established a comprehensive framework of support services to promote equal participation of students with disabilities across its study programs, including computer science. Existing measures, such as dedicated tutors, faculty contact persons, yearly accommodation reviews, and university-wide training for staff, demonstrate a strong institutional commitment to accessibility and inclusion. Technical and pedagogical supports, though unevenly implemented across UL members, provide essential tools for navigating coursework and assessments, while peer-based programs further enhance students' day-to-day academic and social integration.

At the same time, the report highlights several areas where improvements are still needed. Key challenges include inconsistent awareness of accessibility policies among staff and the absence of computer science-specific accessibility initiatives. Furthermore, variation in how accommodations are granted or used, along with hesitancy among some students to apply for special status, indicates that more proactive communication and supportive processes are necessary. Ongoing university-wide interviews and upcoming analyses will provide valuable insights for refining these practices.

Looking ahead, UL has significant opportunities to strengthen accessibility in computer science education through deeper collaboration with external partners, expansion of inclusive teaching practices, and early engagement with prospective students. With continued investment and structured development of support systems, UL can further enhance the learning environment for blind and deaf students, helping ensure that all learners can participate fully and successfully in their academic journeys.

3.3.4. Conclusions

All three countries acknowledge that support for blind and deaf students exists but remains incomplete, especially in technical fields such as computer science. They recognise that many measures are still implemented reactively on an individual basis and highlight the need to embed accessibility more systematically into university structures, curricula and

staff training, while structural barriers continue to limit equitable access. Austria is characterised by fragmented, largely reactive arrangements in which students often have to take the initiative, with structured services such as GeStu alongside gaps in technical content adaptation, specialised software, technical support and systematic feedback. Ireland appears as a system in transition, with strong individual commitment and promising initiatives but persistent structural and technological barriers, including interpreter shortages, a lack of standardised procedures and limited visibility of accessibility resources, and therefore calls for more coordinated, well-resourced and proactive approaches. Slovenia presents a more developed framework at the University of Ljubljana, with dedicated tutors, faculty contact persons, annual accommodation reviews, university-wide staff training and peer-based programmes, but still faces uneven staff awareness, a lack of computer-science-specific measures, variation in practice and student hesitancy to apply for special status. Overall, Austria works with fragmented and reactive systems needing consolidation, Ireland combines committed actors and coordination networks with a need for deeper institutional embedding, and Slovenia has a relatively comprehensive framework requiring continued refinement and targeted initiatives in computer science, while all three underline that sustained structural change, better planning and stronger institutional accountability are essential to make accessibility an integral part of university life for blind and deaf students in computer science.

3.4. Focus on Blind and Visually Impaired Students in Computer Science

The analysis of support services across Austria, Ireland, and Slovenia reveals that blind and visually impaired students face distinctive challenges in computer science and technical fields, with significant gaps in accessibility provision. This chapter synthesises findings specific to this student population, examining enrolment patterns, technical support, teaching adaptations, and institutional readiness across the three countries.

3.4.1. Enrolment and visibility

Blind and visually impaired students are very rarely enrolled in computer science programmes in all three countries, and in some Austrian institutions none are currently registered. Where targeted support exists, individual participation is possible, but overall numbers remain extremely low and indicate substantial access barriers rather than a lack of interest or ability. Slovenia provides the most concrete enrolment data and shows that even in a more structured support environment, blind and visually impaired students make up only a small fraction of the computer science student body.

3.4.2. Technical support and assistive technology

All three countries provide standard assistive technologies such as screen readers and magnification software, but the provision is often passive and relies on students' own equipment and initiative. Austria and Ireland have introduced individual tools and devices in computer science settings, yet these are not always fully integrated into teaching or widely used, and comprehensive specialised software solutions are largely absent. Slovenia has invested more systematically in physical and digital adaptations and has developed Online Notes, an automatic speech-to-text and translation system coordinated with the Faculty of Computer and Information Science, representing an innovative discipline-related tool. Across all three contexts, fully accessible, university-wide computer workstations are missing, leaving students to depend on personal devices and creating financial and practical barriers.

3.4.3. Teaching materials and course content

Teaching materials and course content are typically adapted on request rather than being designed for accessibility from the outset, which places additional responsibility on students and reinforces reactive practices. Austria and Ireland mainly convert existing materials into accessible formats case by case, while Slovenia is working on university-wide guidelines and training for accessible materials, including for online platforms, though these measures are not specific to computer science. All three countries report particular difficulties in making highly visual components of computer science, such as diagrams, data structures and programming environments, accessible to blind and visually impaired students, and dedicated resources for these challenges are still limited.

3.4.4. Examination accommodations

Examination accommodations for blind and visually impaired students generally include extended time and alternative formats, but procedures differ and are only partly standardised. In Austria many exam arrangements are negotiated individually and can be a source of uncertainty for students. In Ireland personalisation is possible but constrained by staff capacity; and in Slovenia guidance exists on providing adapted conditions and additional preparation time, although discipline-specific solutions for practical programming assessments are not yet established.

3.4.5. Staff training and peer support

Staff training and awareness specifically related to blindness and visual impairment in computer science are underdeveloped in all three countries. Austria and Ireland report few structured training opportunities focusing on visual accessibility, and general disability training rarely addresses discipline-specific needs. Slovenia offers broader staff development through the Mobile Support programme and faculty-level contact persons, but training content remains largely general and not tailored to computer science. Mentoring and peer support structures exist in some areas, particularly for deaf students, yet there are no dedicated peer programmes for blind and visually impaired students in computer science in any of the three countries.

3.4.6. Institutional approaches and future directions

Austria, Ireland and Slovenia demonstrate commitment to inclusion and have developed important elements of support for blind and visually impaired students, but institutional approaches to accessible computer science are still emerging. Austria needs more systematic provision of specialised tools, accessible workstations and standardised procedures; Ireland faces challenges in visibility, coordination and capacity despite strong individual engagement; and Slovenia's more comprehensive framework would benefit from clearer computer-science-specific measures, stronger staff awareness and targeted outreach. All three countries highlight the importance of closer collaboration with external organisations, companies and other universities, and of using student feedback to guide future improvements for blind and visually impaired students in technical disciplines.

3.4.7. Summary

Blind and visually impaired students remain clearly underrepresented in computer science across all three countries, despite existing legal frameworks, institutional commitments and general disability support services. Central challenges include limited use of proactive universal-design approaches, gaps in technical infrastructure and specialised software, insufficient staff training and discipline-specific measures, and a lack of dedicated mentoring or peer support structures for this group. Slovenia has a comparatively structured framework with systematic investment in accessibility and tools such as Online

Notes, but still needs more computer-science-specific initiatives and stronger staff awareness; Austria shows promising individual examples and interest in new technological solutions, yet lacks coordination and standardisation; and Ireland, although it has a comprehensive disability support infrastructure, shows little documented engagement specifically with blind and visually impaired students. To improve accessibility in computer science, all three countries would benefit from more proactive accessible design of teaching and assessment, targeted investment in discipline-specific assistive technologies, structured staff training on visual accessibility and strengthened mentoring and support structures for blind and visually impaired students.

4. Systematic Literature Review on Institutions Supporting Visually Impaired and Blind Students

The systematic literature review section analyses research on institutional conditions, support structures, and learning environments for blind and visually impaired students in higher education. It identifies recurring barriers, promising practices, and gaps in institutional provision, with particular attention to technological, pedagogical, and organisational factors relevant for computer science and related disciplines.

4.1. Methodology

4.1.1. Introduction

This section outlines the systematic approach taken in conducting the Access2CS literature review. The goal was to establish a clear, accountable, and transparent methodology, as recommended by Gough, Oliver, and Thomas (2012).

To inform this review, several texts were consulted, including Kitchenham and Charters (2007), the EPPI-Centre (2006), Angela et al. (2022) and Kirwan et al. (2018). Kitchenham and Charters (2007) served as the primary guide, with the following steps adapted from Kitchenham and Charters presented as sub-headings to describe the workflow:

Specification of the Research Question

Development of a Review Protocol

Identification of Relevant Research

Selection of Primary Studies

Data Extraction and Monitoring

Additionally, the PRISMA flowchart (Moher et al., 2009) was used to visually map the flow of information through each stage of the systematic review process.

4.1.2. Specification of the Research Question

The PICOC framework (Population, Intervention, Comparison, Outcome, Context) was used to guide the formulation of the literature review questions and to develop the search string strategy (Kitchenham & Charters, 2007).

TABLE 2 PICOC FRAMEWORK (KITCHENHAM AND CHARTERS, 2007)

	Description	PICOC example	Synonyms	Detailed keywords
Population	Can be a specific role, an application area, or an industry domain.	Blind students, Visually impaired students	STEM students	
Intervention	The methodology, tool, or technology that addresses a specific issue.	Support services, Teaching methods	Assistive technologies	Screen reader*, braille displays
			Inclusive teaching methods	UDL, universal design, design for all / design4all
			Institutional support services	Learning centre, exam accommodations, service centres
			Emerging technologies	Virtual Reality VR,Augmented Reality AR,Coding Assistants,Github Copilot, Google ML Enhanced Code Completion
Comparison	The methodology, tool, or technology in which the *Intervention* is being compared (if appropriate).	Not applicable		
Outcome	Factors of importance to practitioners and/or the results that *Intervention* could produce.	Accessibility	Barriers, Experiences, Guidance for teachers	
		Solutions		
Context	The context in which the comparison takes place. Some systematic reviews might choose to exclude this element.	Computer science Education	Third-level education tertiary education higher education higher education University college	

The aim was to ensure that the body of reviewed literature collectively addressed the review questions (see below), rather than generating multiple, separate answers (Gough, Oliver, and Thomas, 2012).

Which technologies and teaching methods have been used in making computer science education accessible for blind and visually impaired students?

The following Sub-section Review Question (SRQ) was also devised:

RQ1. What are the existing barriers, guidance, and solutions for blind and visual-impaired students?

4.1.3. Development of a Review Protocol

A protocol was developed, which included:

- Selecting academic databases
- Documenting the search strings used against said databases.
- Defining inclusion/exclusion criteria

The following section, Identification of Research, provides a detailed account of these components.

4.1.4. Identification of Research

The selected databases included: Scopus, Web of Science, ACM Digital Library, and ERIC. These were chosen for their relevance to both education and computer science disciplines.

A search strategy was developed to achieve a balance between **specificity** - retrieving highly relevant studies - and **sensitivity** - ensuring broad coverage of the topic (EPPI Centre, 2006). Keywords including *'blind', 'computer science', 'assistive technology', 'higher education'*, and *'barrier'* were derived from the PICOC framework.

These keywords were then expanded using synonyms and logically structured using Boolean operators. An initial query (see below) was run on the Scopus database, which returned 1,638 articles. However, an early review of the retrieved articles revealed a high number of false positives, particularly due to ambiguous terms like *"blind"* and *"STEM"* (Science, Technology, Engineering and Mathematics), which were frequently associated with blind studies in stem cell research—unrelated to the intended focus.

To address this, the search query was iteratively refined. The final version (Version 5) of the Scopus query is detailed below, incorporating additional filters and structural adjustments to improve precision:

(TITLE-ABS-KEY((("visually impaired" OR "blind" OR "partially sighted" OR "low vision") AND ("computer science" OR "computer science education" OR "programming" OR "coding" OR STEM OR "applied science") AND ("higher education" OR "universit*" OR "college" OR "tertiary education" OR "third level"))) AND ABS(("assistive technolog*" OR "screen reader*" OR "braille" OR "universal design" OR "design for all" OR "inclusive education" OR "UDL") OR ("teaching method*" OR "pedagog*" OR "instructional strateg*" OR "co-design" OR "participatory") OR ("barrier*" OR "challenge*" OR "experience*" OR "accommodation*" OR "support service*"))) AND (LIMIT-TO (LANGUAGE,"English")) AND (EXCLUDE (DOCTYPE,"cr")) AND (EXCLUDE (SUBJAREA,"MEDI") OR EXCLUDE (SUBJAREA,"NURS") OR EXCLUDE (SUBJAREA,"HEAL") OR EXCLUDE (SUBJAREA,"VETE"))

This refinement process was repeated – though to a lesser extent – across the other selected databases to further improve the accuracy and relevance of the search results. 1,694 articles were uploaded to the AI-SLR Rayyan Management software.

The final number of articles 1694, retrieved from each database is as follows.

TABLE 3: NUMBER OF ARTICLES RETRIEVED

Database	Type	Numbers
Scopus		82
ACM		1487
Web of Science		47
ERIC		78

4.1.5. Selection of Primary Studies

A total of 48 articles were identified as potential duplicates, and 25 were subsequently verified and removed, leaving **1669 articles** for abstract screening for relevance. The process is documented below.

SCREENING WORKFLOW (USING RAYYAN)

The articles were randomly divided among five pairs of reviewers, with each pair assigned 334 articles, ensuring that each article was reviewed twice by the same two reviewers.

Reviewers were tasked with screening the title and abstract of each article based on the following research question:

"Which technologies and teaching methods have been used to make computer science education accessible for blind and visually impaired students at the third level?"

Articles were reviewed blindly in Rayyan's blinded mode, so that reviewers could not see each other's decisions.

Inclusion Criteria

While reviewing each article, reviewers assessed whether it addressed the following:

- Third-level (higher education)
- Computer Science or STEM students
- Blind or visually impaired students

For each assigned article, one of the following Rayyan labels was applied to the article

- Include – if the article clearly addresses all three criteria
- Exclude – if the article clearly does not address the criteria
- Maybe – if uncertain; in this case, add a note explaining your reasoning

At the conclusion of the screening process:

- The "blind review" option on Rayyan was disabled.
- Articles with conflicting decisions (i.e., disagreements between reviewers) were identified.
- Each reviewer was asked to resolve conflicts in their assigned articles in collaboration with their designated second reviewer.

All included articles were initially labelled as "Selected in Abstract Screening." As a result, the full text of 122 articles was uploaded to the Rayyan tool for further review. These were supplemented by 31 additional sources labelled as *grey literature*, which were selected by the team as important to include. This brought the total number of articles included in the full-text review to 157.

These articles were then divided among team members who categorised them into three themes: (1) Teachers: UDL, (2) Teachers: CS, and/or (3) Institutions. Some papers were classified under more than one theme. During this phase, some articles were further excluded as they did not meet the inclusion criteria.

An Excel file was created containing three corresponding sheets:

- Sheet 1 – Institutions: 29 papers
- Sheet 2 – Teachers: UDL: 69 papers
- Sheet 3 – Teachers: CS: 54 papers

These papers were then assigned to eleven team members for analysis. The three categories reflect the main perspectives of the review: institutional structures, teachers' use of UDL, and teachers' work in specific CS domains. While all three categories were screened and coded using the same methodology, this report focuses on Institution related findings; the analysis of the Universal Design of Learning and Computer Science studies will be presented in a separate report.

4.1.6. Data Extraction and Monitoring

To facilitate the thematic analysis of these papers, each reviewer was instructed to examine their assigned papers with the primary and sub-research questions in mind:

Which technologies and teaching methods have been used to make computer science education accessible for blind and visually impaired students? Additionally, they were asked to address two sub-questions: What are the existing barriers, available guidance, and proposed solutions for blind and visually impaired students?

Reviewers were asked to focus on how each paper addressed these questions and to capture their insights using the following headings.

Technologies; Barriers/Challenges (e.g., technological, social, or communicative); Methodology (including limitations and whether studies were tested at third level); Subject and Domain Problem (e.g., Software Engineering, UML); Pedagogical Approaches and Assessment; and Support, Services, or Training.

The authors summarized the findings from each paper using a structured template that focused on technologies, barriers, methodologies, pedagogical approaches and support structures.

Reviewers were also encouraged to identify and document other categories and relevant subcategories within the aforementioned themes.

Sixteen papers were subsequently removed during this process as not being relevant.

These summaries served as the basis for the literature review report. The process is documented below in a PRISMA Flow Document (Moher et al., 2009).

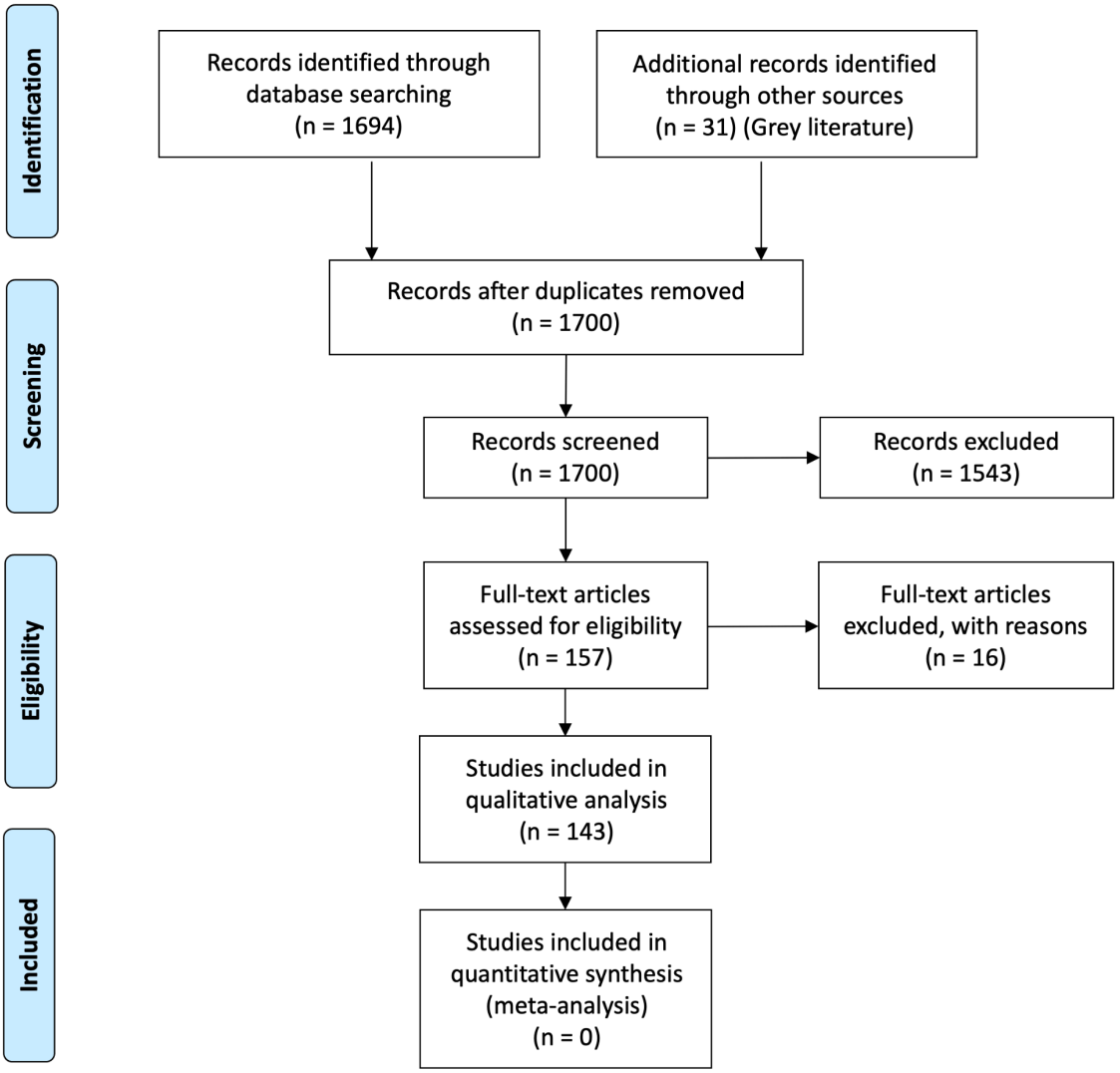


FIGURE 1 PRISMA FLOW DIAGRAM (MOHER ET AL., 2019)

4.2. Barriers and Challenges in Higher Education

The literature reveals interconnected barriers that impede the full participation of blind and visually impaired students in higher education. These challenges span multiple dimensions of the educational experience, from technological limitations to institutional practices and social attitudes.

4.2.1. Technological and Interface Barriers

Contemporary higher education increasingly relies on digital platforms and specialized software applications that often lack adequate accessibility features. Shinohara et al. (2020) identified significant challenges with domain-specific tools, noting that many research tools such as MATLAB and NVIVO were not accessible, limiting students' ability to conduct independent research. The study revealed that blind and low vision doctoral students in computing frequently encountered inaccessible research tools, forcing them to develop custom scripts for data analysis when standard tools proved unusable.

Programming environments present particular challenges for visually impaired students. Stefik et al. (2017) documented extensive accessibility problems with commonly used educational platforms, finding that Code.org's online tools, including the Internet Simulator, text compression widget, pixelation widgets, App Lab, and encryption widget, were not compatible with screen readers. The study also revealed that all commonly used K-12 programming tools, including Scratch, SNAP!, and Alice, were inaccessible to blind students, creating barriers to computer science education.

Virtual classroom platforms pose additional technological barriers. Schäkel and Köhlmann (2015) conducted a technical analysis of four virtual classrooms (Blackboard Collaborate, WebEx Meetings, Talking Communities, and BigBlueButton) and found incomplete accessibility support across all platforms. Their evaluation revealed common issues including incomplete keyboard support, inaccessible graphical information, and missing descriptions for user interface elements, even when accessibility properties were technically available.

4.2.2. Institutional and Systemic Barriers

Educational institutions often struggle with systemic barriers that hinder their ability to provide timely and effective accommodations for blind and visually impaired students. Butler et al. (2017) documented significant resource constraints in Australian universities, noting that accessible materials often take 6-8 weeks to produce, disadvantaging students who cannot access course content simultaneously with their peers. The study found that a single disability liaison officer may support up to 800 students, creating capacity constraints that particularly affect students requiring specialized accommodations.

McCall (2019) identified inefficient disability services offices as a persistent institutional barrier, documenting cases where delays in accessible materials and trust issues between

students and instructors created ongoing challenges. The longitudinal study revealed that some students were forced to drop courses due to lack of institutional support, highlighting the consequences of inadequate accommodation systems.

Bonfim et al. (2021) documented systemic institutional barriers in Brazilian higher education, including lack of specialized support centres, insufficient staff, delays in material adaptation, lack of accessible physical spaces, and inadequate tutoring systems. Their qualitative study with eight visually impaired participants revealed that institutional barriers often compound other challenges, creating multiple layers of disadvantage for students.

4.2.3. Pedagogical and Curricular Barriers

The heavy reliance on visual representations in higher education, particularly in STEM fields, creates pedagogical barriers for blind and visually impaired students. Tekane and Potgieter (2021) documented specific challenges in biological sciences education, noting that mathematics and statistics posed major accessibility challenges due to their abstract, symbol-heavy content. Their case study revealed that traditional teaching styles, particularly in mathematics where lecturers develop theorems and demonstrate problem-solving on boards or projected devices, excluded blind students from following instruction.

Kulkarni et al. (2021) identified significant pedagogical barriers in electrical and computer engineering education through autoethnographic research. The study documented difficulties with complex visual circuit schematics containing tens of components, which were difficult to retain as mental models, and the inability to revise schematic notes effectively without visual anchors. Laboratory activities presented additional challenges, with safety concerns limiting hands-on participation and inaccessible CAD-based simulation software requiring visual drag-and-drop interactions.

Assessment methods present persistent pedagogical barriers across disciplines. Stefik et al. (2017) noted that College Board practice examples for computer science assessments were purely visual with no alternatives, and accommodation guidelines for performance tasks remained unclear. The study highlighted conflicting Braille maths standards (Nemeth vs. Unified English Braille) as creating additional barriers for students in standardised assessment contexts.

4.2.4. Social and Attitudinal Barriers

The literature documents social and attitudinal barriers that affect blind and visually impaired students' experiences in higher education. Bonfim et al. (2021) identified pervasive ableism and discriminatory attitudes from professors and peers as significant barriers, including colleagues refusing to work with visually impaired students and assumptions of incapability. Their study revealed that these attitudinal barriers often prove more challenging to address than technical or pedagogical obstacles.

Butler et al. (2017) documented attitudinal barriers amongst academic staff, finding that many academics were unaware of the needs of visually impaired students or unwilling to adapt their teaching methods. The study revealed that these attitudes often stemmed from lack of knowledge rather than deliberate discrimination, but nonetheless created significant obstacles to student success.

Safety concerns create another category of social barriers, particularly in laboratory settings. Isaacson et al. (2003) noted that both faculty and students with blindness or low vision often fear injury during laboratory activities, which can discourage participation in STEM fields. This fear-based approach to safety can limit opportunities for hands-on learning that is crucial for scientific understanding.

4.2.5. Access Differential and Equity Issues

A significant theme emerging from the literature concerns the access differential between accommodations theoretically available and those actually received by blind and visually impaired students. Shinohara et al. (2020) introduced the concept of "access differential" to describe the significant gap between access available to sighted peers and blind/low vision students, including limited tool options and inaccessible course materials. Their study documented "inequitable access" where accommodations provided were often inadequate, requiring students to create their own workarounds, which added significant time and effort to their academic work.

The study also revealed that students were often responsible for identifying their own accessibility needs and advocating for accommodations, which was particularly challenging for new or unfamiliar tasks. This self-advocacy burden creates an inequitable situation where blind and visually impaired students must invest additional emotional and cognitive resources in obtaining basic access to educational opportunities.

McCall (2019) documented similar equity issues in the transition to higher education, noting initial reluctance amongst students to seek accommodations due to negative secondary school experiences and stigma concerns about peer perceptions. The study revealed that even when accommodations were available, students often faced department-level resistance that created ongoing barriers to full participation in their chosen fields of study.

4.3. Understanding the Diversity of Visual Impairment: Blind versus Low Vision Students

4.3.1. Differences and Accessibility Needs

The needs of blind and visually impaired (low vision) students differ significantly, especially in the use of assistive technology, the challenges of handling visual data and the requirements for accessible technologies. While blind students are dependent on non-visual methods, visually impaired students can often use visual aids to make content partially accessible.

Blind students rely primarily on screen readers (programmes that read the text on a screen), Braille materials (writing in tactile form) and auditory aids to access course content (Ali, 2002; AHEAD, 2006). Tactile graphics (raised representations that can be felt with the fingers) and verbal descriptions play a central role in conveying graphic content (Butler et al., 2017).

In contrast, visually impaired students often use magnification software such as ZoomText or MAGic (programmes that enlarge screen content), large monitors and highly contrasted materials to make the most of their impaired vision. (Hahn et al., 2016; Holt et al., 2009). These aids help them to better recognise text and images by adapting the display to their individual needs.

4.3.2. Challenges with Visual Data

Blind students face major barriers when using visual data and graphical content, as many tools and platforms are not designed to be accessible. They often resort to individual adaptations such as custom scripts (self-created programmes that automate certain tasks) to make content accessible (Shinohara et al., 2020).

Visually impaired students can sometimes use visual data with magnification aids or other visual adaptations, but also encounter limitations, especially with complex graphical representations such as diagrams or tables (Shinohara et al., 2020). This content is often not optimised for magnification, making it difficult to use.

4.4. Technologies and Assistive Tools

The technological landscape for supporting blind and visually impaired students in higher education encompasses a diverse array of tools and solutions, ranging from established assistive technologies to emerging innovations that leverage artificial intelligence and human-computer interaction advances.

4.4.1. Screen Reading and Text-to-Speech Technologies

Screen reading software represents the foundational technology for blind and visually impaired students' access to digital content in higher education. Ali (2002) identified JAWS (Job Access with Speech) as a primary tool that converts text into speech, making it easier for visually impaired students to access digital content. However, Bonfim et al. (2021) noted that screen reader software was often inadequate for mathematical symbols and conventional mathematical language, creating significant barriers in STEM education.

Multiple studies documented the use of various screen reading technologies across different contexts. Stefik et al. (2017) mentioned JAWS, NVDA (PC), and VoiceOver (Mac) as primary screen readers for accessing digital content in computer science education. Kulkarni et al. (2021) specifically noted the use of JAWS and NVDA in electrical and computer engineering contexts, though both were found to have limitations when working with specialized technical software.

Text-to-speech capabilities have been integrated into various specialized applications. Isaacson et al. (2003) described the development of Sci-Voice Talking LabQuest, a text-to-speech screen reader software application specifically designed to enable students with blindness or low vision to independently access scientific data collection and analysis. The system allowed students to collect data, plot graphs, and compose laboratory reports using integrated external Vernier probe ware.

4.4.2. Specialized Mathematical and Scientific Tools

Mathematical content presents unique accessibility challenges that have driven the development of specialised tools and notation systems. Ali (2002) documented the use of Nemeth Braille as a special system designed for mathematics, including symbols, notations, and interpreters to help visually impaired students understand mathematical concepts. The study also identified the MathType System as a tool for processing and writing scientific and mathematical equations.

More advanced digital solutions have emerged for mathematical accessibility. Gardner (2002) presented several innovative tools from the Oregon State University Science Access Project, including the Tiger Tactile Graphics and Braille Embosser for embossing grayscale images and braille labels, and the Accessible Graphing Calculator (AGC) that converts visual graphs to audio tone plots. The study also introduced DotsPlus Braille as a

symbol-rich alternative to standard braille that is easier to learn and more intuitive for blind users familiar with visual math symbols.

LaTeX has emerged as a particularly important tool for mathematical accessibility. Tekane and Potgieter (2021) noted that LaTeX was required for both reading and writing mathematical assessments, though it proved extremely time-consuming and was unsupported by standard screen readers like JAWS. Bonfim et al. (2021) recommended LaTeX language as a potential accessibility tool for mathematical content, offering dialogical features for both sighted and visually impaired students.

4.4.3. Tactile and Haptic Technologies

Tactile technologies provide crucial non-visual access to spatial and graphical information that remains challenging to convey through audio alone. Ali (2002) documented the use of Braille abacus and Braille charts for basic mathematical operations like counting, place value, addition, and subtraction. The study also mentioned tactile graphics as raised diagrams that provide spatial information through touch.

Holt et al. (2009) described the use of Braillenote Apex BT 32 devices that allow students to take notes in Braille and access course materials through refreshable Braille displays. The study also documented raised-dot printers and embossers for creating tactile graphics of diagrams and figures, making visual content accessible through touch.

More advanced tactile technologies have been developed for specific applications. Kulkarni et al. (2021) described the use of tactile symbol cards representing electronic components for understanding small circuits, and mentioned 3D printed tactile circuit tools and adaptive add-ons with Braille labels. Higgins et al. (2020) documented the use of 3D printing and digital fabrication tools for creating customized assistive technology, including successful creation of tactile campus maps for blind students.

4.4.4. Remote Access and Magnification Solutions

Remote access technologies have proven particularly valuable for students with varying degrees of visual impairment. Hahn et al. (2016) provided extensive documentation of remote access solutions, describing TeamViewer and AnyDesk as tools for remote access to computers that enable visually impaired students to work on pre-configured interfaces optimised for their needs. The study noted that these solutions eliminate the need for adaptation to new configurations whilst providing access to specialised software.

Screen magnification represents another crucial category of assistive technology. Hahn et al. (2016) described ZoomText as screen magnification and screen reader software that allows visually impaired users to magnify content and access information effectively. However, the study also documented challenges with high magnification reducing the remaining visual field, making it difficult to maintain screen orientation and observe relationships between data points.

The integration of hardware solutions has enhanced magnification capabilities. Hahn et al. (2016) documented the use of large external monitors, including 27-inch and 65-inch 4K monitors, to provide larger visual fields and reduce the need for high magnification. Stehling et al. (2015) mentioned various auxiliary equipment including magnifiers, magnifying glasses, cameras, and reading devices as supporting technologies for visually impaired students.

4.4.5. Universal Accessibility Technologies

Some technologies and approaches aim to cater for both blind and visually impaired students. Examples include the Sci-Voice Talking LabQuest (a device that outputs scientific measurement data acoustically) and text-to-speech software (programmes that convert written text into speech). These technologies are designed to be usable by both groups, regardless of the type of impairment (Isaacson et al., 2003). Nevertheless, the literature often emphasises that the needs of the two groups are different and require specific adaptations (Banks et al., 2024; Kato & Shimakage, 2020).

4.4.6. Emerging and Innovative Technologies

Recent developments in artificial intelligence and machine learning have introduced new possibilities for accessibility technology. Yuksel et al. (2020) described a Human-in-the-Loop Machine Learning (HILML) system that combines automated generation with human editing for video accessibility. The system integrates Microsoft Azure Video Indexer API for video scene segmentation, Pythia Deep Learning image description generation model for automated text generation, and IBM Watson text-to-speech API for converting descriptions to audio.

Innovative hardware solutions continue to emerge for specific accessibility challenges. Kato and Shimakage (2020) presented OTON GLASS as a toolkit designed to assist visually impaired individuals in reading text and navigating environments. The system includes hardware components like a camera module, Raspberry Pi, and speaker module, along with software for text recognition and voice feedback, featuring real-time communication via WebRTC and customisable APIs for specific user needs.

Do-it-yourself assistive technology creation represents an emerging trend in accessibility innovation. Higgins et al. (2020) documented the use of consumer-grade 3D printers (mentioned at $150 cost) for low-cost assistive technology production, TinkerCAD 3D modelling software for accessible design, and PolyCam iPhone application for scanning clay models into 3D files. The study demonstrated successful creation of five functional DIY-AT devices, including tactile campus maps and various mobility aids.

4.5 Pedagogical Approaches and Assessment Strategies

The literature reveals a spectrum of pedagogical innovations and accommodation strategies that support blind and visually impaired students' learning in higher education. These approaches range from established universal design principles to innovative adaptations of traditional instructional methods.

4.5.1. Universal Design for Learning Framework

Universal Design for Learning (UDL) emerges as a foundational framework for creating inclusive educational environments. Banks et al. (2024) emphasized UDL as a framework that focuses on flexibility in teaching methods, materials, and assessments to accommodate diverse learners, aiming to create inclusive learning environments that address the unique needs of each student. The study advocated for formative assessments that allow students to demonstrate learning in various ways, which can be particularly beneficial for blind and visually impaired students.

Gilligan (2019) detailed the three core UDL principles of engagement, representation, and expression, emphasizing flexible learning environments accommodating individual learning differences and multiple means of engagement, representation, and expression in course design. The study highlighted inclusive course design and delivery approaches, including problem-based learning and collaborative learning methods that benefit all students whilst specifically supporting those with visual impairments.

Ali (2002) recommended the Universal Design for Instruction (UDI) approach, noting that this method ensures teaching strategies are inclusive and benefit all students, including those with disabilities. The study emphasized that UDI principles, when properly implemented, reduce the need for individual accommodations by building accessibility into the structure of educational programs.

4.5.2. Multimodal and Adaptive Teaching Methods

Effective instruction for blind and visually impaired students typically incorporates multimodal approaches that combine tactile, auditory, and when applicable, visual elements to convey complex concepts. Tekane and Potgieter (2021) documented the need for significant adaptation of teaching materials and methods to suit non-visual learning, including the use of one-to-one tutoring sessions to reinforce lecture content and continuous feedback and adaptation of teaching methods based on student needs.

Gardner (2002) implied a shift towards inclusive design where teaching materials can be universally accessed without bespoke adaptation, integrating tactile, auditory, and digital methods to support multisensory learning. This approach reduces the burden on individual instructors whilst providing more consistent access to educational content.

Collaborative learning strategies emerge as particularly effective for supporting blind and visually impaired students. Kulkarni et al. (2021) described successful implementation of collaborative pair work in laboratory settings and think-talk-through methodology for conceptual understanding. However, the study noted the importance of careful facilitation to ensure equitable participation and avoid creating dependency relationships.

4.5.3. Assessment Accommodations and Alternative Evaluation Methods

Assessment practices represent a critical area where traditional approaches often fail to accommodate blind and visually impaired students effectively. The DAWN Handbook (Kennedy et al., 2008) documented various accommodation strategies, including provision of extra time, use of a scribe or reader, and access to computers with assistive technologies during exams. The guidelines also emphasized modifications to assessment methods, such as replacing visual-heavy tasks with alternative formats to ensure equitable evaluation.

AHEAD (2006) provided comprehensive guidance on assessment accommodations, recommending allowing extra time for exams, providing alternative formats such as Braille, large print, or audio, and permitting the use of assistive devices like screen readers or voice recognition software during examinations. The guidelines also suggested offering alternative assignments to demonstrate knowledge when specific tasks are inaccessible to students with visual impairments.

Tekane and Potgieter (2021) documented successful modification of assessments to allow for verbal responses or use of assistive technologies, noting that flexibility in evaluation processes was essential for ensuring equitable assessment of learning outcomes. The study emphasized the importance of maintaining academic rigor whilst providing appropriate accommodations.

4.5.4. Accessible Material Preparation and Delivery

The advance preparation of course materials in accessible formats emerges as a critical factor in successful accommodation provision. The DAWN Handbook (Kennedy et al., 2008) emphasized providing lecture notes and reading lists in advance to allow time for conversion into accessible formats, using plain language and summarizing key points during lectures, and ensuring that all students benefit from accessible teaching strategies.

AHEAD (2006) documented the importance of providing lecture notes, handouts, and examination papers in accessible formats such as enlarged text, Braille, or digital formats that can be converted by students using assistive technologies. The guidelines also emphasized the use of audio materials and electronic resources to support learning.

Holt et al. (2009) described comprehensive material preparation strategies, including the provision of detailed notes with equations and diagrams for conversion into Braille, and the use of tactile graphics, sonification, and oral explanations to convey complex physics

concepts. The study emphasized that successful material preparation requires close collaboration between instructors, disability services, and students.

4.5.5. Laboratory and Hands-On Learning Adaptations

Laboratory and experiential learning activities present unique challenges for blind and visually impaired students, requiring innovative adaptations that maintain safety whilst enabling meaningful participation. Isaacson et al. (2003) emphasized hands-on learning approaches that focus on active participation in laboratory activities to build self-confidence and foster teamwork. Their study of the NFB Youth Slam found that 88% of participants felt part of a team, compared to only 46% during secondary school science activities.

Kulkarni et al. (2021) documented successful maker-based approaches with hands-on lab experiences designing real-life devices, including solar-powered chargers and electrocardiogram wave generators. The study described weekly lab sessions emphasizing theory-to-practice connections, though it noted that safety concerns with soldering limited hands-on participation for blind students.

Stehling et al. (2015) developed comprehensive adaptations for hands-on robotics courses, implementing experience-oriented learning models with a four-phase course structure including introduction, construction, programming, and reflection/evaluation phases. The study found that visually impaired students required approximately four times longer to complete hands-on activities compared to sighted students, but could achieve equivalent learning outcomes with appropriate support and modified pacing.

4.5.6. Graphic Content and Inclusion

The accessibility of graphical content remains one of the biggest challenges. Blind students often rely on verbal or written descriptions to understand graphical information such as diagrams or maps. Alternatively, they can use tactile graphics that make the content tangible (Butler et al., 2017).

Visually impaired students, on the other hand, prefer magnification aids to view graphic content directly on the screen. These aids enable them to recognise details that remain inaccessible to blind students. However, graphic content is often not optimised, making it difficult for both groups to use.

4.6. Institutional Support, Services, and Guidance

Support for blind and visually impaired students at universities includes a variety of measures ranging from technical aids and institutional support to individualized support. The provision of resources as well as the training of teaching staff and the promotion of independence play a central role. In order to better understand the challenges faced by this group of students, it is important to look at the different areas of support in detail.

4.6.1. Technical Support and Aids

Blind and visually impaired students benefit from a variety of technical aids that make it easier for them to access teaching materials and participate in academic life. The most important aids include Braille writing devices, scanners and embossing devices, which enable blind students to convert texts into tactile Braille or create them themselves. These devices are particularly helpful when working on course materials and administrative tasks, as they allow students to work independently (Ali, 2002).

Another key tool is screen readers, which are programmes that read aloud the text displayed on a screen. This technology enables blind students to use digital content such as emails, websites or documents. Screen readers are particularly important as they provide access to digital platforms and learning materials that are essential in today's higher education. In addition, there are Braille displays that convert digital texts into Braille. These devices have a tactile surface on which the Braille characters are displayed using small, movable pens. This allows blind students to read texts without having to rely on acoustic output, which is particularly helpful in quiet environments or when working on complex content.

In addition, there are alternative input devices that have been specially developed for the needs of blind and visually impaired people. These devices replace conventional keyboards or mice and enable intuitive operation of computers and other technical devices. Such technologies are particularly important in technical subjects such as computer science, as they enable students to actively participate in courses and projects (Burgstahler et al., 2012).

In addition, customised solutions can make it much easier to use technologies. For example, user interfaces can be preconfigured so that font sizes, colours and contrasts meet the individual needs of students. These adjustments ensure that content is easier to read and the use of devices is less strenuous. Such preconfigured settings save students time, as they do not have to be made manually each time they use them, and help them to concentrate better on their academic tasks (Hahn et al., 2016).

4.6.2. Institutional Support Structures

In addition to technical aids, universities offer a range of services to ensure accessibility for students with disabilities. Disability Support Services (DSS) play a central role in this. They

analyse individual needs to determine the specific requirements of students. They help to apply for funding for assistive technologies and work closely with academic departments to ensure that necessary adaptations are implemented (DAWN Handbook, 2008).

Another important area is equipping libraries with assistive technologies. Many universities offer soundproofed booths, height-adjustable desks and specialised equipment to facilitate access to learning materials. These facilities allow students to work in a quiet and ergonomic environment that is tailored to their needs (AHEAD, 2006).

Another key role is played by a Disability Coordinator who is responsible for providing accessible materials in a timely manner and identifying resources for students. These coordinators often work closely with faculty and other departments to ensure that students receive the support they need (Holt et al., 2009).

4.6.3. Training and Professional Development

Teacher and student training is crucial to creating an inclusive learning environment. Teachers are trained to create accessible lectures and materials. This includes, for example, providing lecture notes in accessible formats and using clear, verbal descriptions for visual content. Such measures are particularly important to ensure that blind and visually impaired students have the same access to information as their sighted peers (Holt et al., 2009; AHEAD, 2006).

In addition, interdisciplinary workshops involving accessibility experts, teachers and medical professionals encourage the development of innovative solutions to support students with visual impairments. These workshops provide a platform for the exchange of ideas and the development of new approaches to improve accessibility in higher education (Stehling et al., 2015). Awareness campaigns highlight the benefits of assistive technologies and promote their wider acceptance. They sensitise teachers and students alike to the importance of accessibility and inclusion (Hahn et al., 2016).

4.6.4.Individual and Peer Support

In addition to institutional programmes, individual tutoring and peer support also play an important role. Personal tutors and visual describers support blind students during lectures and laboratory sessions by describing visual content and helping with tasks. This support is particularly important in courses with a high visual component, such as science or technology (Tekane & Potgieter, 2021; Kulkarni et al., 2023).

Professional mentors are another valuable resource. These are experienced people who accompany and support students during their educational journey. These mentors are often themselves people with a visual impairment who have already successfully completed a degree programme or a professional career. They share their experiences, give practical tips and serve as role models to show students how to overcome challenges. In addition, professional mentors can also be experts from relevant fields who help

students with their academic and professional orientation. For example, programmes such as AccessComputing connect blind and visually impaired students with computer science professionals to help them prepare for the transition to the world of work (Isaacson et al., 2003; Burgstahler et al., 2012).

Collaboration with fellow students, for example in lab groups, is also critical to success in courses that include visual content. Peer support not only promotes learning success, but also social interaction and integration into the university community (Kulkarni et al., 2023).

4.6.5. Guidelines and Standards

Compliance with accessibility standards and the application of universal design principles are essential to creating an inclusive learning environment that meets the needs of all students. Universal design is a concept that aims to design products, environments and materials in such a way that they can be used by as many people as possible without additional adaptations. This means that learning materials and digital platforms are developed from the outset to be accessible to people with different abilities, limitations and needs. One example of this is the use of clearly labelled graphics that are understandable for both sighted and blind or visually impaired students. Flexible learning materials, such as scalable font sizes or customisable contrasts, can also help to ensure that content remains accessible to all (Banks et al., 2024; Burgstahler et al., 2012).

Established standards such as the Web Content Accessibility Guidelines (WCAG) are a central component of the implementation of accessibility. These guidelines define how websites and digital content should be designed to be accessible to people with disabilities. This includes, for example, requirements for the readability of texts, the usability of websites with the keyboard and the provision of alternatives for visual or audio content, such as image descriptions or subtitles. The User Agent Accessibility Guidelines (UAAG) complement these standards by focussing on the accessibility of software and browsers. These guidelines ensure that digital platforms and materials are usable for all students, regardless of their individual abilities (Moreno et al., 2008; Schäkel & Köhlmann, 2015).

Another important principle is the provision of clear and understandable communication channels between students, teaching staff and the relevant accessibility services, such as Disability Support Services. This includes, for example, the timely provision of information about accessible materials, the opportunity to discuss individual needs and ensuring that students know who to contact if they have problems. Clear communication is crucial to ensure that students' needs are recognised and addressed at an early stage (Butler et al., 2017).

In addition, it is recommended that universities regularly review and adapt the accessibility of their materials and platforms. This can be done through feedback from students with disabilities, who can provide valuable insights into the actual usability of the resources

provided. Such feedback helps to identify weaknesses and make continuous improvements.

4.6.6. Challenges in Support Service Delivery

Despite the existing support systems, there are still challenges. Many disability support services are overloaded due to increasing demand, which requires a redesign of funding models (Banks et al., 2024). Teachers need more training in inclusive teaching methods and the use of adaptive technologies to meet the needs of students (Butler et al., 2017). Close collaboration between students and teachers is necessary to identify and remove barriers at an early stage (AHEAD, 2006).

4.7. The Voice of Students and Their Lived Experiences

The perspectives and experiences of students with disabilities, particularly blind and visually impaired students, are crucial to better understanding the challenges and barriers in education. Their voices offer valuable insights into the reality of accessibility and inclusion and show how they are actively involved in shaping solutions. Three key themes are highlighted below: autoethnographic and phenomenological insights, self-advocacy and empowerment, and identity and representation.

4.7.1. Autoethnographic and Phenomenological Insights

Students with disabilities often share their personal experiences to raise awareness of barriers and inspire change. These perspectives offer a unique insight into the challenges they face.

An example of this is the description of barriers in electrical and computer engineering education from a first-person perspective. These reports show how difficult it is for blind students to gain access to practical laboratories and technical tools, which are often visually orientated. Such experiences make it clear that accessibility in these areas still needs to be greatly expanded (Kulkarni et al., 2023).

Long-term interviews with students who describe the transition from school to university show how difficult it is for many to find their way in a new environment. It is a major challenge when support systems are lacking or not sufficiently tailored to students' needs (McCall, 2014).

In addition, there are examples of student-led activism projects where students overcome institutional barriers through DIY (Do-It-Yourself) solutions and personal initiative. These projects show how students use their own agency to develop creative and cost-effective solutions that benefit not only themselves but also their community (Higgins et al., 2025).

Interviews with students in STEM (maths, science, technology) subjects highlight that many of them are either made invisible or are overly focussed on. These experiences make their integration into the academic community more difficult and highlight the need to find a balance between support and equal treatment (Bonfim et al., 2021).

4.7.2. Self-Advocacy and Empowerment

A key aspect of the experience of students with disabilities is the development of self-advocacy and empowerment skills. These skills are often crucial to overcoming barriers and navigating an often non-accessible environment.

Many students develop their self-determination and self-advocacy not through formal training but through informal contexts. This shows how important it is to create spaces where students can strengthen their skills in a supportive environment (McCall, 2014).

Another example of empowerment is the economic self-determination enabled by low-cost DIY solutions. Students develop their own assistive technologies that not only fulfil their own needs, but also benefit their community. These solutions promote exchange and solidarity within the community (Higgins et al., 2023).

Participation in design processes gives students a sense of technical self-efficacy and pride. By being actively involved in the design of technologies, they not only gain practical skills but also confidence in their own abilities (Yuksel et al., 2020; Higgins et al., 2023). Another important point is to recognise students' individual agency in defining their needs and aesthetic preferences. Students often have specific requirements for assistive technologies that go beyond pure functionality. For example, aesthetic aspects such as the customisation of devices to personal preferences can play an important role (Higgins et al., 2023).

4.7.3. Identity and Representation

The identity and representation of students with disabilities play a crucial role in their experiences and success in education. Visible role models and positive representation can boost self-confidence and change the perception of disabilities in society.

Visible role models in STEM careers can promote interest in these subjects among students with disabilities while positively influencing the attitudes of professors and fellow students. When students see successful professionals in their field, it boosts their confidence in their own abilities (Bonfim et al., 2021).

Cultural representation also plays an important role. Assistive technologies can be designed to reflect the cultural identity of the user, for example through devices that take into account natural hair colours and textures. Such customisations promote a sense of belonging and individuality (Higgins et al., 2023).

Community building and solidarity are also important aspects. Through shared experiences of accessibility, students can build a strong community that provides emotional support and practical help. These communities are often critical to overcoming challenges and navigating the academic world (Higgins et al., 2023).

Finally, it is important to recognise that varying degrees of visual impairment require personalised solutions. Universal approaches are often not sufficient to meet the individual needs of students. Instead, technologies and support measures should be flexible and customisable (Kulkarni et al., 2023; Stehling et al., 2015).

4.8. Synthesis and Key Findings

The literature highlights a critical gap between accommodations that exist in theory and those that blind and visually impaired students actually receive, often described as an access differential where technologies and support systems do not reliably translate into equitable access. This gap is linked to constraints in disability services, incompatibilities between assistive technologies and discipline-specific software, delays in preparing accessible materials and the expectation that students themselves identify and communicate their accessibility needs. At the same time, the evidence shows that blind and visually impaired students require differentiated technological and pedagogical approaches that go beyond general measures, with individual accommodations tailored to the type and degree of visual impairment, the specific demands of particular disciplines and personal learning preferences. Barriers are multi-layered, as technological obstacles intersect with institutional procedures, teaching practices, social attitudes and wider structural inequities, so that effective accessibility work must address all of these dimensions rather than isolated technical fixes. Student agency and self-advocacy are crucial in revealing barriers and driving solutions, but relying on students to carry this responsibility creates an inequity and underlines the need for institutional systems that anticipate, identify and address barriers proactively.

4.9. Conclusion

Supporting blind and visually impaired students in higher education requires a comprehensive, coordinated approach that links technological infrastructure, institutional processes, pedagogical practice and cultural change; the evidence shows that effective inclusion is achievable, but it depends on deliberate commitment and adequate resources. At the technological level, institutions should prioritise compatibility between discipline-specific software and mainstream assistive technologies, support the rapid development or adaptation of custom solutions where necessary, and invest in emerging tools, including artificial-intelligence-based and human-in-the-loop systems that can enhance accessibility. At the institutional level, universities need to ensure sufficient staffing and resourcing of disability support services, establish proactive systems for providing accessible materials, create clear communication channels between students, academic staff and support units, and regularly collect and respond to feedback from students with disabilities. At the pedagogical level, faculties should embed universal design principles while retaining flexibility for individual accommodations, develop discipline-specific strategies for making complex visual and symbolic content accessible, and use collaborative learning approaches that share responsibility for inclusion across the learning community. At the cultural level, institutions can strengthen inclusion by highlighting the achievements of students and professionals with visual impairments, offering sustained professional development on inclusive teaching, and fostering student communities that encourage solidarity, exchange and collective problem-solving. Taken together, these measures form a comprehensive, student-centred approach that enables higher education institutions to move from formal commitments to accessibility towards genuinely inclusive practices in which blind and visually impaired students can participate fully in academic life and prepare for successful careers.

5. Overall conclusion and implications for Access2CS

The desk research, qualitative interviews and systematic literature review together show that legal frameworks and institutional commitments to inclusion exist in all three countries, but that blind and visually impaired students in computer science still face substantial and often avoidable barriers. Across Austria, Ireland and Slovenia, support structures, assistive technologies and teaching adaptations are present yet remain fragmented, reactive and only partly tailored to the specific demands of technical disciplines.

For Access2CS, these findings underline the need to design computer science guidelines and related institutional guidance around proactive accessibility, discipline-specific solutions and close collaboration between disability services, academic staff and students. This includes embedding universal design principles and assessment, ensuring compatibility between core computer science tools and assistive technologies, strengthening staff development and peer support, and using student feedback to drive continuous improvement. Taken together, the three strands of evidence provide a shared foundation for developing more inclusive institutional practices and a model of computer science education that is explicitly designed for blind and visually impaired students.

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8. Appendix: Guiding Questions for Qualitative Interviews

General Questions

- What support services are available at your university for blind students?
- What support services are available at your university for deaf students?
- Are there specific activities / study programs focused on accessibility at your university?
- Are there specific activities / study programs focused on accessibility in computer science?
- How many students are currently enrolled at your university, particularly in computer science programs? *[If you do not have the current numbers, please estimate as concise as possible]*
- How many blind and deaf students are currently enrolled at your university, particularly in computer science programs? *[If you do not have the current numbers, please estimate as concise as possible]*

Technical Support

- Are there social security measures providing Assistive Technology and support to people / students with disabilities in your country?
- Are there technical aids you as university provide for blind students?
- Are there technical aids / personal assistance you as university provide for deaf students?
- Are there publicly available accessible computer workstations at your university? If so, how are they equipped?
- Is there specific software that is suitable for or used by blind students? Which? Please explain how it works.

Teaching and Learning Support

- How are teaching materials made accessible for blind computer science students at your university?
- How are teaching materials made accessible for deaf computer science students at your university?
- Are there tutorials or training sessions specifically designed for blind students to help them use software and technical aids?
- Are there tutorials or training sessions specifically designed for deaf students to help them use software and technical aids?
- How are accessible examination formats for blind students designed and implemented?

Advising and Support

- Is there a dedicated contact person or office that provides individual support and advice for blind students?
- Is there a dedicated contact person or office that provides individual support and advice for deaf students?
- Is teaching staff specifically trained to understand the needs of blind students in computer science programs? How? How long?
- Is there ongoing support / coaching of teaching staff? How? How often?
- Are there mentoring programs or peer counselling initiatives for blind students?

Challenges

- What do you see as the biggest challenges in supporting blind students in computer science / computer science courses?

- What do you see as the biggest challenges in supporting deaf students in computer science / computer science courses?
- What additional services would you like to be implemented to further improve accessibility?
- Are there collaborations with other universities, companies, or organizations to promote accessibility in computer science education?

Evaluation and Feedback

- How do you evaluate the effectiveness of your accessibility support services?
- Do you regularly gather feedback from blind / deaf students? If so, how is this feedback incorporated into the development of your offerings?

Future

- What would you wish for the future development of the service to best support blind and deaf students? / Is there anything important you'd like to add, or have we missed anything that you think should be addressed?
- Is there anything else you would like to mention?

We appreciate the valuable support you have given us. Thank you very much.