

BIM EDUCATION - GLOBAL – 2024 UPDATE REPORT
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EXECUTIVE SUMMARY

In January 2014 NATSPEC issued the first version of a report summarising the status of BIM education in several countries and regions across the globe. The report has been updated and reissued each year since, with this report being version 11.0 of what is now an annual update to the original report.

Each year the countries and regions included in previous versions of the report are given the opportunity to update their section to reflect their current status of BIM education. In the updated versions since the original 2014 report, additional countries have provided input, expanding the scope of the original report. This eleventh edition of the report includes information from 23 countries/regions and for the first time, incorporates an update for Jordan.

As reported in previous years, the number of BIM courses being offered to Architecture, Engineering and Construction (AEC) students through higher education and technical training institutions (vocational education) continues to increase in most countries/regions. Some countries/regions have also reported the incorporation of BIM into the relevant course curricula at secondary education institutions. The collaborations between education institutions and industry organisations continue to strengthen, with many countries/regions seeing the importance of practical experience on nurturing workforce ready graduates.

Awareness of the application of BIM continues to rise and the content of courses being offered are constantly being adapted to suit changing technologies and meet the current

demands of the construction industry. There continues to be an increased interest in the integration of virtual reality with BIM for risk and construction management. Alongside this, artificial intelligence and sustainability are recurring topics in many countries/regions. The content of some BIM courses offered integrate these topics within their program. In some countries/regions, new BIM courses have been developed or are being developed to address these topics.

Many countries/regions have implemented or are in the process of implementing guidelines based on the ISO 19650 series, *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)*. Education institutions have continued to incorporate the ISO 19650 series in their curricula. The aim of this is to achieve standardisation and alignment of terminology and processes that will enhance information delivery and efficiency across the industry.

The buildingSMART International Professional Certification program continues to be implemented in many countries/regions. Other certification schemes for validating BIM knowledge also exist in some countries/regions. Generally, the number of individuals and organisations being accredited under the different certification schemes continue to grow.

INTRODUCTION

Question

In October 2013 Richard Choy (NATSPEC) sent an email to a global group of parties with an interest in BIM, asking for a brief paragraph outlining the current status of BIM education in each of their respective countries/regions. This question was interpreted in two ways, with the respondents either describing the current level of BIM awareness/use or the current level of training/higher education available. Some respondents also provided a much more detailed response than a brief paragraph.

Original report

A report summarising the responses received was compiled by NATSPEC and issued in January 2014. The report only included countries/regions from which a response was received and was based purely on the responses provided. It did not attempt (or claim) to fully research and document the status of BIM education/awareness in each country/region.

Updated report

The report has been updated and reissued each year since, with this report being version 11.0 of what is now an annual update to the original report. In the updated versions since the original 2014 report, additional countries have provided input, expanding the scope of the original report. This eleventh edition of the report includes information for 23 countries/regions.

Early in 2024 NATSPEC again contacted the respondents who had contributed to the previous versions of the report, offering them the opportunity to update their information. Where no response was received from a previous contributor, it was assumed that the status of BIM education in their country or region has remained unchanged. Where a response received only partially updated a section of the report, it was assumed that the remainder of that section was still current.

This report again summarises the responses received. As per previous versions, this report is based purely on the responses provided; it does not attempt to fully research and document the status of BIM education/awareness in each country/region.

BIM EDUCATION - BY COUNTRY/REGION

AFRICA

Education/Training

There is broadly a slow uptake of BIM in education institutions across Africa. The major challenges are related to the inadequate knowledge and exposure to BIM of University lecturers influenced by a culture of resistance to change. The status of BIM Education in the 5 regions in Africa are summarised below.

West Africa

Discourse on BIM in education is more popular in Nigeria and Ghana than in other countries in the region. There are no full courses or programs specially for BIM in this region. However, BIM is being taught as topics within courses in some of the tertiary institutions. BIM-related topics are also now increasingly being undertaken as research projects by undergraduate and postgraduate students in these countries. Also, the use of BIM tools for design in training undergraduate students is gaining momentum against the use of the traditional approach for architectural and engineering disciplines. Over the years, there has been a growing number of organisations providing training for students, professionals, and firms in this region. The BIM Africa Initiative has been pushing for BIM curriculums and working closely with some tertiary institutions across the globe.

Southern Africa

More South African institutions are involved in BIM education than other institutions in the region. There has been ongoing discourse on the need for the institutions to be producing BIM compliant graduates in the South African AEC industry (for further information on the country of South Africa refer to the **South Africa** section of this report). The BIM Academy Africa has been engaging with some of these institutions in implementing BIM curriculum to the institution's core curriculum. The introduction of BIM tools to students has been on the increase through stand-alone or short courses. Similarly, there are student's research on BIM-related topics at the undergraduate and postgraduate level in South Africa. BIM trainings are also provided for professionals through various bodies such as the African academy and BIM institute.

East Africa

The training of BIM in institutions across many Eastern African countries is still lagging. BIM education and training is mostly by software vendors and associations of built environment professionals, with little overlapping effect and engagements in tertiary institutions. Kenya and Ethiopia are experiencing the highest level of industry conversations on BIM strategies in the region. This is largely driven by membership-based organisations such as the Ethiopian Construction and Project Management Institute as well as the Architectural Association of Kenya.

Central Africa

Countries across central Africa have very little to no engagement with BIM across both industry and education. While individual expertise may exist, there are no industry engagements or interactions. With the majority of the countries having French as the official language, knowledge sharing with other African regions is largely hindered. The BIM Africa Initiative is now focusing on various engagements in French to ensure knowledge transfer to the vast African populace who do not communicate in English.

North Africa

There is a high level of educational engagements across many North African countries. One of such is Egypt, with the highest level of publications and academic research on BIM across the continent. The introduction of an M.Sc. in Integrated Engineering Design Management (IEDM) at Cairo University also exemplifies the strong training and education engagements in the country. Tunisia, Morocco and Algeria also have various levels of educational engagement, which is broadly driven by industry expertise overlapping to tertiary institutions.

Initiatives/Organisations

There are many organisations and bodies pushing for the adoption and implementation of BIM across Africa, as follows:

BIM Africa

The BIM Africa initiative is a non-profit civil society organisation formed to enable and regulate the adoption and implementation of BIM in the AEC industry across Africa. The African-wide advocacy for BIM adoption and implementation is reinforced by extensive

academic and market research programs, certification programs, round-table meetings, seminars and webinars, formulation of locally adapted standards, chapters, volunteering and professional development opportunities. Monthly roundtable and #BIMTalks are hosted by the organisation featuring experts from across the globe and conversations on digital construction. The organisation also initiated the Student Advocacy Program, designed to create BIM awareness amongst students of tertiary Institutions in Africa.

In collaboration with BIMcommUNITYAfrica, the initiative hosted BIMHarambee.Africa, the longest virtual BIM conference in Africa featuring 42 Presentations and Case Studies, 6 Learning sessions, 5 Panel discussions, 6 Discussion Forums, 58 Speakers, 2881 Registrations, 3300 Views, and 436 hours watched.

The Research and Development Committee of the organisation produced the first continental-wide report on BIM in Africa which features the summary of findings from the Africa BIM Survey 2020. A project showcase consisting of carefully selected projects across the various regions in Africa that have implemented digital technologies with details of implementation, challenges and lessons learnt, and experts' opinion consisting of articles from notable authorities on the central theme of digital construction.

The R and D committee also provides research support for students (Undergraduate and postgraduate) working on BIM related projects. The committee is presently working towards fostering research collaboration and supervision between BIM academics of African descent and tertiary institutions across Africa.

BIM Institute

The BIM Institute is one of the early non-profit companies advocating for the adoption and implementation of BIM across Africa. The institute has been working on the South African National BIM Guide in a bid to align itself with international standards. It hosted the 'BIM BAM BOOM' workshop in Durban, South Africa in 2017 which focused on BIM implementation and BIM case studies. Also, the organisation encourages BIM implementation through BIM competitions for architects, designers, and students.

In January 2019, a book titled 'BIM – It's your move' was published by BIM institute founder, Vaughan Harris. The book discusses the introduction of common global standards and modus operandi of use showing how Africa stands to benefit. The book contributes to the extant knowledge of BIM in Africa and encourages professionals to reinvent themselves. The institute also founded the BIM Academy Africa in 2017 which has been providing various BIM courses for professionals and students.

BIM Community Africa

The BIM community began in 2018 to encourage BIM adoption across the continent by providing information about technologies and solutions and allowing the community to choose what suited them and their context best. The organisation hosted the 'BIM unconference 2019' in Cape Town in collaboration with Aurecon and the University of Cape Town where issues surrounding collaboration, implementation of ISO, and BIM for FM were discussed passionately. In May 2020, the organisation started a BIM podcast that features information sharing, and conversations on BIM. Similarly, in collaboration with BIM Africa, the BIMHarambee.Africa conference was hosted. The conference was a month-long event that brought together BIM practitioners from related industries to learn, share knowledge, promote, and highlight BIM practices across the continents.

Awareness/Uptake

There has been an increase in the level of awareness and adoption of BIM across the African continent, though at a slow pace when compared to other continents of the world. The slow uptake of BIM in the African AEC industry could be related to the culture of the industry, lack of infrastructure, and lack of expertise. BIM Africa with collaboration from BIM practitioners and researchers across Africa produced the first African-wide report on BIM. The report provides the status of BIM on the continent and presents projects that have successfully implemented BIM.

The African BIM Report 2020 (ABR) had responses from 30 countries from all 5 regions on the continent. It is estimated that about 90% of the respondents are aware of BIM prior to participation in the survey. However, only 50% have implemented BIM at varying levels on their projects. In addition, BIM is becoming a buzzword among professionals, but the right

knowledge and expertise of BIM are still lacking. Many have the wrong perception of what BIM connotes and there is often a misrepresentation of BIM in the AEC industry which is not peculiar to Africa.

The major challenges facing the adoption of BIM on the African continent are:

- Lack of experts and training: There is inadequate trained professionals in the industry, although organisations and academic institutions are proffering short term (trainings, conferences, and seminars) in lieu of long-term solutions (BIM compliant graduates).
- Lack of government support for BIM: In most of the countries in Africa, there is largely a lack of government support for BIM. A few government institutions are however formulating policies and strategies in Ethiopia, Morocco, and Egypt.
- Cost: The high cost of BIM implementation is still a major challenge in Africa where most of the firms are small and medium-sized enterprises (SMEs).
- Lack of contractual framework: Extant contractual frameworks are not in tandem with the technological pace which often makes the execution of BIM difficult.
- No client demands: Although there is an increase in BIM awareness, this does not equate to BIM implementation on the continent. The government in most of the countries are the biggest client in the AEC industry and a lack of government support has a debilitating effect on the demand. There is a need for the government to be supportive of the BIM crusade in Africa.

ARGENTINA

Education/Training

BIM has not yet been a subject addressed by the official education plans. Even as we lack precise information, we know that very few secondary technical education proposals include parametric modelling of buildings as part of the curricular plan.

Based on a survey carried out in 2020 by the SIBIM (BIM Implementation System, on which we will elaborate), only twelve out of thirty-three universities in which the Architecture degree is taught - are offering some type of training linked to BIM, while the introduction of the subject in Civil Engineering careers is even lower.

The offering in universities is very varied. Only the University of Buenos Aires offers a "Specialisation Career in BIM" with an official title. This lasts two years and has been taught since 2017. As a direct antecedent, there was a one-year postgraduate course taught from 2013 until the specialisation career was approved. Since then, there has been a growing demand for the degree, which demonstrates the increased interest from the country's youngest professionals on BIM issues.

Other postgraduate training options available include: *Integration and collaboration in architecture projects* (National University of Litoral), *Introduction to BIM Systems* (National University of Tucumán), *Collaborative BIM Processes, BIM tools for sustainable design, and Building Information Modelling (BIM)* (National University of San Juan), *Diploma in digital technologies for Architecture* (National University of Córdoba), *Diploma in BIM implementation in works* (Agreement between the National Technological University and the School of Management of the Argentine Chamber of Construction), the executive program of *Higher Training in BIM* (University of Palermo), the executive program of *BIM methodology* (Argentine Catholic University – UCA), and *Diploma in Advanced Studies in BIM* (National University of Moreno).

BIM training at the undergraduate level, has been growing slowly and almost exclusively based on the personal initiatives of some professors who have the freedom to propose content for their undergraduate subjects (generally optional).

Of the eighteen different courses (sixteen Architecture and two Civil Engineering) at twelve universities where a survey was conducted, only one of these courses (at the University of Avellaneda) was included in the curriculum as a compulsory subject. In any case, the elective courses receive a large number of students since interest in learning parametric modelling of buildings is very high among students.

Finally, we also surveyed a dozen extracurricular courses taught at universities that were affected by the pandemic, during which they had to compete with a large amount of free content on social networks and the internet.

Initiatives/Organisations

Since 2013, the BIM FADU Academic Conference (Faculty of Architecture, Design and Urbanism at the University of Buenos Aires) has been held every year, with the participation of professors and professionals from all over the country with the aim of disseminating the BIM methodology from the academy towards all the productive sectors of the AEC Industry.

In 2016, from the awareness of various professionals and institutions in recognising the historical moment that the AEC industry is going through in Argentina and the opportunities offered by BIM in our context, the BIM Forum of Argentina was created, to become the organisation that leads the transformation of AEC processes for the generation of economic, environmental, and social benefits derived from the implementation of BIM.

In 2019, the Ministry of Public Works founded the SIBIM, a team of professionals who work on the definitions that will allow the contracting of public works using the BIM methodology. The SIBIM has drafted a large number of documents vital for the first experiences of BIM tenders carried out by the provinces of San Juan and Mendoza with the support of the SIBIM professional team.

That same year, the SIBIM organised the first meetings of the BGP (BIM Public Management) roundtable, a consensus space made up of representatives of the national, provincial, municipal and academic public sectors, which aims to promote the digital transformation of the public construction sector

through BIM. The BGP-table is organised into several working groups. Currently the Training Working Group is drafting a BIM guide for students in order to unify the basic criteria in all educational institutions in the country that wish to align under a general criteria.

Since 2020, the IRAM Institute (Argentine Institute for Standardisation and Certification) has been working on the translation of the ISO 19650 series, having concluded part 1 and is close to releasing a version of part 2 for public discussion.

Since 2022, the Professional Council of Architecture and Urbanism (CPAU) has organised introductory courses on BIM methodology that it offers free to enrollees. The Central Society of Architects (SCA) has also organised introductory courses on BIM methodology.

Since 2023, the Ministry of Public Works of Argentina, through SIBIM, launched the first four "pilot projects" to start implementing BIM in areas dedicated to road, water, transportation, and housing projects.

AUSTRALIA

Education/Training

There are 43 universities in Australia. BIM education, however, transcends the higher education sector and has been extended to vocational education and training institutions. A large part of BIM training and education occurs in industry by various training institutions, with various training and education subjects related to BIM also currently presented by Technical and Further Education (TAFE) colleges. Many TAFE colleges are providing courses where BIM is incorporated into the syllabus, and short courses related to BIM. As an example, in Western Australia, South Metropolitan TAFE runs a short course titled *Civil Construction - Structural Design, Model and Drafting skill set*; Box Hill Institute of Victoria provides *Advanced Diploma in BIM* along with several BIM-related short courses. Other professional institutes like buildingSMART Australasia (bSA) have also been active in BIM education. As a major development, bSA has launched the BIMcreds program, in the form of an online assessment process for BIM and DE professionals.

At present, most Australian universities include BIM within their courses, in the form of BIM-specific subjects or as a part of other subjects within their curricula. These courses are presented across various levels as defined by the Australian Qualification Level (AQF) framework (level 6 to level 9). Along with those, BIM-related short courses are also available for design and engineering consultancy, construction and trades, facilities managers, project managers and many other related professions. For example, a short course in Revit Architecture for 2D and 3D modelling is offered in Victoria University.

The rate of BIM integration hence shows outstanding progress, despite the challenges of the global pandemic in 2020. The Federal Government's higher education relief package has supported some universities to introduce a new range of courses in study areas that align with national priorities and feed into high-demand industries. Under this scheme, University of Western Australia offers an online course titled as *Graduate Diploma in Building Information Modelling*; University of South Australia offers 4th year BIM courses; Deakin university created a new *Graduate Certificate of Construction Management* where BIM is considered as one of four units; and Bond University offers BIM micro-credential subjects leading to a *Certificate of BIM/IPD*.

In the majority of BIM subjects currently offered at Australian universities, students are introduced to BIM authoring tools, mostly from the Autodesk Suite of BIM tools. They develop skills in using 3D modelling tools, and analyse data from 3D models for basic scheduling and cost estimation tasks. BIM courses offered by Western Sydney University cover design authoring, energy simulation, coordination, model validation and disciplinary model coordination.

Out of all the BIM-related subjects taught in universities, BIM documentation (80%) and 3D modelling (77%) are the most popular areas of BIM training offered to students. The assessment tasks of these subjects require students to apply their BIM knowledge to create simple BIM models of real-life projects. They are asked to develop 3D models and integrate BIM models with the time dimension to generate 4D, grasp 5D BIM via cost integrated modelling and produce technical clash detection reports. There are reports of applying collaboration tools like Revizto, BIM 360, Aconex and Procore in teaching collaborative problem solving in BIM subjects. All subjects employ a combination of different teaching delivery modes, including lectures and classes to teach theoretical and fundamental features, computer lab sessions and group activities for skill development in using tools and practical know-how of BIM tools, and ad hoc workshops on specific areas like BIM standards and specific software packages.

With the emergence of Digital Engineering (DE) in Australia, some institutions, have moved towards defining subjects that incorporate the fundamental aspects of DE. Examples are Swinburne University of Technology with training on the use of Virtual Reality (VR) and Augmented Reality (AR) for communication purposes (Unit: *Driving collaboration in projects*); Western Sydney University announcing training on DE, Blockchain, Artificial Intelligence and modern construction enterprises (Unit: *Smart construction*); and UNSW similarly offering advanced topics like Human-machine interaction and Advanced digital fabrication (Unit: *Design information management*). In Monash University, BIM-related training is provided in the undergraduate civil engineering and the Master of Professional Engineering courses.

Findings of research studies indicate that BIM education in Australian universities need to

include recent standards for information management, such as the AS ISO 19650 series. Some universities, such as Deakin and Bond have started incorporating the principles of AS ISO 19650. Competency in using these standards is much needed in the Australian AEC industry. This is currently an overlooked area and one which has received scant attention from BIM educators in Australian universities. Information management is embedded in Bond university's BIM/IPD degree, more specifically at the Master's level.

Of all the higher education institutions active in BIM education, only some have independent degrees in BIM or offer BIM as a specialisation or major within the list of their programs. Of these, universities such as Bond University and the University of Western Australia have reported independent BIM degrees.

Universities offer BIM education in the form of 76 different courses, which include 8 BIM-focused courses. The remaining are subjects not related to BIM, into which various dimensions of BIM are integrated. A total of 102 BIM related subjects are on offer as part of these 76 courses. However, only 5 universities offer BIM specific courses/programs at undergraduate and postgraduate levels. For example, Bond University and the University of Western Australia offer Master, Graduate diploma and Graduate certificates in Building Information Modelling and the University of Canberra, University of Melbourne, and Swinburne University offer a Major in specialisation courses in BIM at the undergraduate level. These, on some occasions, are offered as a part of other degrees. For example, Swinburne University of Technology planned to offer a BIM specialisation core unit from 2021, but later, this course transformed to a diploma with two out of eight units BIM related. It is a government funded 'higher apprenticeship' model, associated with Victoria's Big Build where students are in the work force, committed to Big Build projects.

In general, Australian universities take the three approaches discussed below when offering BIM education.

Approach 1

Refers to presenting subjects defined as standalone BIM units of study. Universities adopting this approach account for 50% of universities – 12 universities out of 24. The content of these standalone units might be

different to cover the different dimensions of BIM, in different universities. For example:

- University of Melbourne offers standalone subjects in Building Information 'Modelling' and 'Management'. It also offers micro certificates in BIM through the Faculty of Engineering and IT.
- Deakin University offers *Principles of Building Information Modelling*.
- Bond University offers *Building Information Modelling and Integrated Project Delivery*.
- Curtin University offers standalone BIM subjects in Building Information Management.
- The University of Western Sydney now has a new unit which is dedicated to BIM and digital technologies for construction. At Western Sydney University, a new unit *Digital Construction* is on offer, allocated to BIM and digital technologies in construction, for second year students in bachelor or construction management honours degree.

Approach 2

Refers to defining subjects that offer BIM-related training. Though BIM content is included in them, their titles and the focus of these subjects vary greatly across the various institutions. For example:

- Deakin University delivers planning and scheduling subjects with 4D BIM among the syllabus.
- The University of South Australia has taught BIM for building code checking (building surveying) since 2018, utilising Autodesk Navisworks in *Integrated Project* (4th year subject), with 4D and 5D BIM being taught too. In *BUIL 1021 Construction Communication*, an entry course for first-year students at the University of South Australia, 3D VR flyover simulations were used to help students understand and visualise 2D site plans.
- At the University of Melbourne, BIM is incorporated in *Construction Measurement*.
- *Digital Construction* unit at the University of New South Wales.
- Queensland University Technology *Advanced Building Documentation* unit.
- Subjects such as *Intellectual property rights (Data Exchange)* at Bond

University are devoted to micro-credential courses adopting the buildingSMART Australasia BIM framework.

- In RMIT University, BIM is included within budgeting and scheduling subjects.
- The University of Canberra introduced BIM in the subject *Interior Architecture Technology 3: Systems*. So too, BIM has been introduced in a wide range of subjects like building services, design team management and integrated technology.
- At Western Sydney University, the *Building Design Process* and *Smart Construction* units are, for the most part, focussed on BIM processes and tools for design, construction and operation. An one-year subject, *Building Design Project 1 and 2*, has been integrated with a new learning approach, BIMed 4.0, a transformational pedagogy for BIM-related curricula. The development of BIMed 4.0 aims to emulate industry BIM standards and protocols, as outlined in Digital Engineering - Transport for NSW, in both its delivery method and the philosophy of systemic transformation towards Construction 4.0. This new pedagogy is supported by a BIM common data environment (CDE), a feedback loop, multi-disciplinary pathway stages, and an Employer's Information Requirement (EIR).
- At Monash University, a new unit designed for master's students has been proposed, *Building Prefab*. In this unit, students explore prefab construction through a multidisciplinary approach, emphasising hands-on experience in building design and execution. The unit focuses on coordinating architectural, structural, mechanical, and electrical components using advanced BIM to develop modular, sustainable designs. Students will work collaboratively across disciplines to create a comprehensive BIM model, integrating analytical models for structural integrity and environmental sustainability. This capstone unit prepares students for the construction industry by teaching practical skills in prefab construction and multidisciplinary teamwork, culminating in a project that showcases their ability to develop efficient, sustainable building solutions.

Approach 3

Refers to the combination of Approaches 1 and 2. To date, this approach is not common in Australian universities. This represents another gap in BIM education across Australian universities, given that, according to research studies, the third approach is the most effective one in equipping students with BIM-related knowledge and skills, before graduation. Bond University introduced micro-credential *Intellectual Property Rights* within the BIM degree, which is further developed for students who continue to a Master of BIM/IPD. Apart from the BIM degree at Bond, these topics are touched on in Architecture, Construction Management and in Quantity Surveying. All 8 micro-credential subjects are available to undergraduate and postgraduate learners in AEC, planning and property students. The remaining 4 masters subjects are available to postgraduate learners as electives for Masters students from compatible degrees. However, pre-requisite knowledge of BIM management and technology is required.

In late 2019, the Australian BIM Academic Forum (ABAF), conducted a survey of all Australian universities active in BIM education, to provide an updated picture of the landscape of BIM education in Australia. The report, provides details of the current practices of BIM education and the various approaches for delivering BIM programs across Australian universities. The ABAF also ran interviews as part of the 2019 survey with experienced BIM educators. The outcome of the study revealed that despite the active shift towards including BIM into the curricula at Australian universities, several barriers hinder the effective integration of BIM into the courses across higher education in Australia. Findings identify four primary barriers to BIM education. These are:

- Issues related to the challenges of change management for revolutionising courses. That is, Australian universities still do not treat BIM/DE as an essential element of their programs. As a result, the commitment to change and allocation of resources to developing and improving BIM/DE-related subjects is missing at many institutions.
- Curriculum and content, where there is little space for BIM within the crowded existing programs. Changing the existing content requires much effort and is seen as demanding job for BIM champions.
- Educators with inadequate skill and knowledge of BIM. Many subjects and

units have been taught in traditional ways for many years. Educators find it a demanding and difficult task to update the content and learn the skills for using BIM in such subjects. Moreover, there is no time and workload allocated to this for educators.

- Lack of involvement of the industry and government in directing BIM education. Though this has changed in recent years, industry is still too busy and cannot effectively engage in developing content for Australian universities. Besides, universities have not succeeded in securing government support, and have failed in participating in a broader collaborative cultural shift across all higher education institutions in Australia. However, in 2023 some larger universities succeeded in securing government support under the micro-credential grants program. There is much room for strengthening industry connections, where universities acknowledge the importance of BIM/DE education and allocate resources and time to their staff members to develop BIM skills. There is a knowledge gap in the university sector about what BIM/DE actually is, particularly at the executive levels, hence the barriers to cultural shift.

NATSPEC has provided an *Introduction to BIM* presentation to undergraduate students at universities across Australia. NATSPEC also provides industry seminars on the use of the *NATSPEC BIM Project Inception Guide*, *NATSPEC National BIM Guide*, *NATSPEC BIM Management Plan*, the *NATSPEC BIM Object Properties Generator* and the *Open BIM Object Standard (OBOS)*.

A study conducted in 2021 highlighted the gap between what universities offer and what the industry needs. The study provided insight into the shortfalls of the current approach and offered recommendations for bridging the gap between university education and industry demands from graduates. Currently, the graduates' "ability" is limited to the recognition of BIM as a product. However, employers expect graduates to demonstrate both software skills and to have the capability to implement and engage with BIM as a process. Moreover, graduates appear to be significantly deficient in BIM protocols, collaboration and coordination, information workflows, and completion and handover procedures. Based

on the identified mismatch between graduates' ability and employers' demand, and the recommendation collected from employers to improve BIM education, a novel version of "T-shaped BIM professional," was presented. That is, a professional with a depth of knowledge in their area of expertise with the capability of expanding their breadth of knowledge across other skills or disciplines. The proposed framework is to be taken as the intended learning outcomes (ILOs) that inform improvements in university BIM education curriculum.

Studies of this nature are needed to provide a sound theoretical basis for informing curriculum developments and in particular, prescribing remedial solutions for addressing current deficiencies in BIM-related education in the domain of pedagogical strategies. In practical terms, the implementation of the "T-shaped BIM professional" can be expected to minimise the gap between curricula and industry practice. In so doing, this would enhance graduates' BIM-related Work Readiness (BWR) resulting in students graduating with BIM competencies better suited to industry expectations and practice.

Initiatives/Organisations

The BIM ecosystem landscape, and in turn BIM education and training, are constantly evolving in Australia. The most noteworthy development is associated with the emergence of the concept of DE, which has become the main target of all organisations and initiatives active in digitalising the Australian built environment. Recognising these developments and given the sheer size of investment in infrastructure projects in Australia, in November 2016, the Transport and Infrastructure Council endorsed the *National Digital Engineering Policy Principles*.

In September 2018, representative Australian universities announced the formation of the ABAF, to promote the academic aspects of BIM, driven by the growing BIM skill demands from the industry. The objective of the group is to gain higher and consistent levels of student competence in BIM in tertiary education in Australia, through raising BIM-related curricula standards and promoting research-informed BIM education.

With the emergence of DE in Australia, the aims and objectives of ABAF have evolved to address the requirements of DE adoption in

updating the current BIM-related curricula for Australian universities. As a result, ABAF supports the demand for BIM-ready graduates who go beyond dealing with BIM as a point solution and focus on effective management of data and information across wider generic construction fields and disciplines to cover the whole lifecycle of assets. Besides, ABAF recognises the need that BIM issues must become appealing to academic disciplines outside the built environment.

The mission of ABAF is to:

- Foster integrated collaborative efforts for enhancing the quality and consistency of BIM-related curricula.
- Create a dynamic collaborative group to enhance and promote teaching, education, learning and research, linking the research and teaching aspects of BIM.
- Develop minimum requirements for BIM-related curricula, with the objective of bridging the gap between BIM university education outcomes and workplace performance requirements.
- Provide a collective voice to contribute to policy issues, funding priorities and agenda setting.
- Establish an open medium for communication across tertiary education in Australia, thus, facilitating the sharing of knowledge; experience; case studies; views, etc.
- Collaborate for joint learning-based activities, competitions, games and research projects, both in Australia and internationally.

Another major player in the education domain is buildingSMART. Its *National BIM Initiative* – report to Federal Government (2012) identified 6 key areas in need of attention to drive the construction industry forward and facilitate broadscale BIM adoption. Chief among all was the crucial role of attention to multi-disciplinary BIM education. In recent years, therefore, buildingSMART Australasia has joined the training and education movement in Australia by introducing the BIMcreds initiative that offers a mechanism for assessing competency in BIM and DE. BIMcreds has recently been integrated into the bSI Professional Certification - Foundation (PCERT) Program which provides a global benchmark for openBIM competency assessment.

In 2019, buildingSMART Australasia officially started accrediting three postgraduate university programs in BIM and Integrated Project Delivery (IPD) offered by Bond University, as the first of its kind. This is seen as an effective measure towards closer engagement of the industry in developing and evaluating BIM-related training at Australian universities. Apart from the Masters degree at Bond University, students also undertake a 14 week capstone BIM applied research project in their final term with a BIM industry partner. Currently there are 3 PhD researchers covering the topics of digital twinning, environmental assessment for refurbishment, and scan to BIM process framework. Bond University also offers a full scholarship for a PhD in BIM research through the Center for Comparative Construction Research.

Other key players include the Australasian Procurement and Construction Council (APCC) and the Australian Construction Industry Forum (ACIF). They jointly published the *Framework for the Adoption of Project Team Integration (PTI) and BIM* at the end of 2014. Education and training is a key theme of this framework. As a result, APCC and ACIF established a BIM education working group to develop a framework and objectives for training providers. This was released early in 2017 and titled *BIM Education and Skills Framework*. In essence, the BIMcreds knowledge testing tool, as discussed above, has been developed by buildingSMART to compliment the APCC/ACIF framework.

The Australasian BIM Advisory Board (ABAB) was founded in 2016 by APCC and ACIF, together with the key standard-setting bodies, NATSPEC, buildingSMART and Standards Australia, to promote best practice and consistent approaches to BIM standards, requirements, and methodologies. The Board links industry leaders and expertise from government, industry and academia. ABAB have created the *ABAB Digital Roadmap Generator* and published a further six documents:

- *BIM Process Consistency: Towards a Common Framework for Digital design, Construction and Operation.*
- *Asset Information Requirements Guide – Information required for the operation and maintenance of an asset.*
- *Digital Twins – Position Paper.*
- *Australian BIM and Digital Engineering Education – Position Paper.*

- *Harmonisation of Building Information Modelling and Digital Engineering Services Procurement – Guide.*
- *The Australasian BIM Benefits Reporting (ABBR), Guide to Information Collection.*

Awareness/Uptake

BIM is being widely used on projects in Australia and by Australian consultants working on overseas projects. The use of BIM for FM/operations/maintenance is occurring on more and more projects across Australia. Examples are large-sized projects like the Opera House, Pyrmont Bridge, and Sydney Metro Northwest in Sydney. The trend of BIM use is not limited to large capital cities, as the same trend can be observed across all states and territories. Many projects in South Australia and Western Australia are associated with mature levels of BIM use. High-profile infrastructure projects like the New Royal Adelaide Hospital and Perth Children's Hospital Project are among these. BIM is also trickling down to smaller consultants and smaller projects; it is in fact seen as the new norm.

The widespread growth of BIM among practitioners provides educators with ample opportunities. That is, universities can rely on experienced practitioners in the industry to deliver specific subjects of BIM. This can address many barriers that thwart BIM education by Australian universities, as discussed above under the four primary barriers to BIM education found from the 2019 ABAF survey. Despite the need for further education, some universities are reporting slow uptake in further education.

The *NATSPEC National BIM Guide* was updated in 2023 to align with the AS ISO 19650 series and is increasingly adopted across industry and government both as a framework for building projects as well as within education programs. Two new BIM Executional Plan (BEP) templates were published in 2024, the *Pre-appointment BEP template* and the *Delivery team BEP template*. BIM object creation tools such as the *NATSPEC BIM Properties Generator* and the *Open BIM Object Standard (OBOS)* are also both being used.

The NATSPEC BIM website, accessed by clicking on the BIM logo on the NATSPEC homepage (www.natspec.com.au), is a useful resource for general information on

BIM, BIM R&D projects and the numerous BIM guidelines that are available. The recently published NATSPEC BIM Execution Plan templates may also be accessed through the NATSPEC website.

The NATSPEC BIM documents are specifically referenced in QLD, NSW and VIC BIM policy documents. Considering the breadth of important stakeholders NATSPEC represents, the NATSPEC BIM documents remain the most accepted, widely used set of BIM guidelines in Australia.

CANADA

Education/Training

The number of colleges and universities offering BIM programs in the last couple of years has increased in Canada, both at the undergraduate and graduate levels, in Engineering and Architecture departments. This is in addition to the numerous BIM courses offered by continuing education departments at many institutions. As well, private initiatives are offering online and face to face training sessions on subjects ranging from collaboration to execution plans to a specific BIM subject matter. Several construction associations have also launched their own training programs, focusing on their perspective.

The goal of the buildingSMART Canada (bSC) and Canada BIM Council (CanBIM) Education Committee is to support and aid the development of BIM educational initiatives in Canada, to ensure that a consistent and relevant BIM education and training landscape responds to, meets, and is relevant to the realities of an ever-evolving industry.

In a focussed effort to enrich the Canadian BIM-ecosystem, the *CanBIM Professional Certification Program* was launched in 2014, with the intention of understanding BIM-related skills and knowledge as well as professional competencies and capabilities in the AEC industry, in order to provide a point-of-reference and benchmarking to inform educational and training objectives. This program spawned the emergence of the *CanBIM Foundations Certification Program* which, through the establishing of course and program outcomes, assists educational institutions in aligning curriculum in response to industry needs and expectations. To date, the *CanBIM Foundations Certification Program* has certified upwards of 30 national and international BIM-related courses or programs. A further goal of the bSC/CanBIM Education Committee is to provide a national and international benchmark for openBIM training.

Initiatives/Organisations

bSI Professional Certification Program

bSC launched its Professional Certification program across the country in 2020, with several training providers. Formerly known as Qualification Program, this program will attest to the knowledge of the candidates through an online test provided by buildingSMART International (bSI).

The aim of the program is to provide standard essential knowledge of Open BIM and data management. It provides clear standards and promotes quality training by supporting and accrediting training content that meets a defined body of knowledge. Most importantly, it provides the standards upon which training organisations can develop their course content. This structure ensures fundamental knowledge is acquired and it allows for a uniform online testing certification for individuals. It will therefore guarantee a benchmarked level of knowledge across the country and the world.

bSC also relays information about the COBie certification offered by bSI. The international scope of these programs is complementary to CanBIM's certification program at the national level. The buildingSMART Program is a proof of competence for professionals working with BIM. Certified professionals can demonstrate their knowledge is consistent with international standards and best practices.

Practice Manual

The *Canadian Practice Manual for BIM* was launched in 2017 and continues to provide direction on the application of BIM practices and processes in Canada. It is being used to develop Module 6 of the Learning Outcome Framework. The practice manual is multi-disciplinary, multi-volume and is a comprehensive guide that reflects both international best practice as well as the use of BIM in Canada. It builds on the Roadmap to deliver value to industry.

CanBIM Certification

The *CanBIM Certification Program* continues to be well supported. It was launched in 2014 with the objective of bridging BIM education and the AEC industry's implementation and use of BIM through the pursuit of excellence in certification. The pillars of the *CanBIM Certification Program* are:

- Professional Certification: A tiered, four-level certification program for BIM Professionals assessing knowledge, skill and professional workplace experience.
- Foundations Certification: Assessment and certification of courses and/or programs offered by:
 - . Educational Institutions both private and public.
 - . AEC industry training providers for industry professionals.

- Company/Organisation Certification: Assessment and certification of BIM-enabled companies and organisations.
- Provision of guidelines for a Continued Professional Development framework for certified individuals.

Satellite Sessions

These sessions are a joint event where CanBIM/bSC, industry partners and academia present on relevant topics within the host region. These events are intended to bridge the gap and unite the interests between academia and industry. The host academic institution has the opportunity to highlight its BIM related programs, a student from the host school is invited to present a BIM-relevant topic and the remainder of the agenda is filled out with industry leaders from the host region. It is an opportunity to educate and connect all stakeholders over the course of an evening, while also showcasing the latest developments of the educational institutions across Canada.

Student Affiliate Memberships

CanBIM/bSC now have 20 post-secondary education institutions in its membership. As a CanBIM/bSC member, educational institutions can offer FREE student affiliate membership to all their students. The student affiliate membership opens up opportunities for students to engage with industry leaders across Canada and globally. Students can participate on and engage with one of the following nine CanBIM/bSC committees:

- Technology Committee.
- General Contractors Committee.
- Trades Committee.
- Designers Committee.
- Owners Committee.
- Education, Research & Certification Committee.
- International Committee.
- Legal Committee.
- Marketing Committee.

Students are asked to participate in a monthly call to help keep the committees organised through meeting minutes and agenda creation and dissemination. Students are also asked to participate in working on various industry-based tasks giving them direct exposure to the challenges facing our discipline-based committees. Further to the CanBIM/bSC committees, students are continuing to engage as volunteers at the CanBIM/bSC regional and

satellite sessions. This is a great networking opportunity to be at an event meeting the industry leaders and learning from the many presentations and panel discussions about the most relevant subject matter.

Student Connect: An Online Networking Platform

Student Connect is an online portal hosted on the CanBIM/bSC website. This portal allows students to log in and explore industry-based research opportunities made available by CanBIM/bSC members. These research opportunities are posted within the portal by CanBIM/bSC member companies looking to investigate the value proposition for market ready technologies. Students volunteer or apply to be hired, as research interns, to help deliver on the research goals around the technology or project.

Additionally, CanBIM/bSC offer functionality within the same portal for Students to upload a profile and store information and documents relating to their background and experience. This is a place where students and employers can connect for the purpose of research and or potential employment opportunities.

CanBIM/bSC are working to create opportunities to deliver significant value for students, educational institutions and its industry members.

BIM Training: Course Directory Quebec

It is wise to list the BIM training courses offered in Quebec to document the beginning of a process that ultimately aims to mobilise, empower, and enhance the skills of stakeholders in the construction industry. A centralised directory will contribute to creating cohesion within a diverse range of offerings and will help users find training courses that meet their needs.

This directory is useful to educational institutions and training companies who wish to have an overview of the BIM training offerings. The identification and categorisation of training programs according to standardised criteria has highlighted the breadth of the existing offerings and helped identify gaps. This information has been useful in assessing whether the training programs cover all the topics to be addressed within the context of a digital transformation that affects the entire industry.

A working group composed of representatives from the industry, educational institutions, and public clients was formed with the aim of strategically structuring the training offered. The group set a four-step work plan to be executed over a period of three years:

1. Identify all existing training programs in Quebec.
2. Identify the needs of the industry and public employers.
3. Identify missing training programs in the existing offerings.
4. Establish typical training paths aligned with the principles of the Roadmap.

The directory created includes training courses offered in Quebec by recognised educational institutions or associative organisations (professional associations). The total number of courses and training programs identified was 113. In addition to this, there are courses offered on a customised basis by private companies registered in Quebec. The training courses offered by solution providers or software developers, as well as information capsules or seminars published on streaming platforms were not considered in the creation of this directory.

Some preliminary observations have been made by examining the directory of existing training programs. For example, there is a lack of diversity in teaching methods, as most courses are delivered online. Furthermore, there are few courses focused on interdisciplinary management compared to technical courses focused on operations and asset maintenance. Stakeholders involved in the creation of the directory acknowledged that the courses currently offered do not meet all the needs of the industry.

Awareness/Uptake

Jurisdictions have taken an interest in implementing BIM practices and requirements in official policies and public contracts. It is the case both at the federal and provincial levels, with Quebec, Ontario and Alberta as the main players. The federal government is now considering whether to mandate or encourage BIM processes in public procurement procedures and is currently polling industry players.

Other important progress has been made in Quebec, where an industrial cluster was put in place to unite the value chain stakeholders and provide a forum with a plan to encourage best

practices with regards to digital processes. This cluster brings together professional associations of architects, engineers, contractors and unions which have highlighted that education institutions at all levels must integrate digital practice and collaboration. One key focus is to better train workers and professionals to be able to master collaboration tools and practices with regards to data management in a life cycle management perspective.

There is a global trend that sees governments and public owners as influential actors capable of influencing the adoption of industry-wide innovations. The government of Quebec supports this trend by promoting the implementation of BIM among various public owners in the province. The Quebec infrastructure plan for 2022-2023 included nearly \$150 billion in infrastructure investments over the next 10 years.

Six of the largest public owners in Quebec, namely the *Société québécoise des infrastructures (SQI)*, the *ministère des Transports et de la Mobilité Durable du Québec (MTMD)*, the *Société d'habitation du Québec (SHQ)*, *Hydro-Québec (HQ)*, the City of Montreal (VMtl), and the City of Quebec (VQc), have developed and implemented the Government Roadmap for the implementation of BIM in projects. The Roadmap identifies the actions, divided into six axes, to be undertaken by all stakeholders involved in the life cycle of Quebec's public built assets.

The lack of training and skills is one of the main factors slowing down the implementation of BIM in the industry. Recognising the importance of skills development for the success of the initiative, the Quebec government has targeted the training aspect and integrated it into Axis 2 of the Roadmap. This axis is devoted to the mobilisation, empowerment, and skill development of stakeholders. It examines, among other things, the impact that changes brought about by BIM have on a wide variety of tasks and processes.

Increased cooperation is necessary to develop a coherent training offering across Quebec and meet the needs of a vast industry with diverse requirements due to the extent of tasks impacted by BIM and the variety of disciplines involved in the production and management of digital information. Over the next year, an industry wide survey will be conducted to

identify stakeholder skills needs and determine the gap between the skill requirements and training currently available.

CHILE

Education/Training

The latest survey conducted by Planbim in 2021 on *Advances in the inclusion of BIM in undergraduate programs in Chile* revealed that from 2016 to 2021, there was substantial progress in the adoption and application of BIM in construction related careers in Chile. This evolution was observed both in programs taught by universities (52.7% in 2016 to 83.5% in 2021), and in professional institutes and technical training centers in the country (15.2% in 2016 to 79.7% in 2021). Data from this survey and its comparison with previous years were compiled in the document *First Report of the BIM Observatory: Advances in the inclusion of BIM in Higher Education, 2016-2021* that was published by Planbim in June 2022 (www.bit.ly/41WT4le).

The Observatory, which examines the evolution of the introduction of BIM in undergraduate education, provides academic institutions and industry in general with relevant and necessary information for decision-making around the teaching of BIM in the country. In addition to showing quantitative data, the publication contains information about the qualitative aspects of current BIM teaching. It sets out the barriers and benefits perceived by teachers and administrators in the process of incorporating BIM into academic curricula. This allows academic institutions to detect trends and plan education strategies in the medium and long term. Finally, the Observatory seeks to facilitate a broader and more productive conversation between teachers and professionals about the inclusion and improvement of BIM education in the curricula. The report emphasises that the dialogue between all actors is essential for BIM education to advance aligned with the digital transformation needs of the industry.

Regarding graduate education, the availability of courses and training continues to grow in quantity and new approaches. According to a survey carried out by Planbim at the beginning of 2023, there were 155% more BIM diploma programs than in 2016. The emergence of programs focused on strategic issues for the implementation of BIM stands out.

At the secondary education level, the e+bim project - led by Planbim and the Ministry of Education, with the support of professional associations, academic institutions, and private companies – focuses on two aspects: the

preparation in BIM of students and teachers in the short term, and the formal incorporation of BIM in the curricula of high schools in the long term. The first pilot of this curriculum update was implemented in 2023 and aimed to include BIM within the Technical Drawing program. This adaptation was developed between 2020 and 2021 by a team of teachers and industry experts from Planbim, the Ministry of Education, educational corporations (COREDOC and COMEDUC), and professional institutes (DUOC UC and INACAP).

The private sector has also developed several activities related to education in the past years. One of them was a lecture series called *How is BIM taught in Chile?*, developed by BIM Forum Chile's Technical Education Group. This group is mainly comprised of academics from universities and professional institutes interested in promoting BIM education and research in the country. After these open sessions, in 2023, they published a document that compiled the experience of 24 universities and professional institutes that introduced BIM in the undergraduate curricula of Architecture, Engineering and Construction careers (<https://bimforum.cl/download/publicacion-como-se-ensena-bim-en-chile-2-edicion-actualizada/>). The report notes that each institution has adopted a different strategy for including BIM, adapting to its mission and the formative purposes of its curriculum. The strategies can be grouped into three categories:

- (i) The modification and adaptation of existing subjects.
- (ii) The creation of new, either compulsory or elective, subjects.
- (iii) The integral introduction of BIM in the core subjects, claiming a more complete and comprehensive vision of its impact on the curricula.

In this sense, the various strategies set out in the document constitute a catalog of options, which can be used as a reference by other careers that are beginning their inclusion of BIM. Additionally, almost all the institutions that reformulated their curricula have used the BIM Roles Matrix prepared by Planbim, as a guide to define the competencies that students must acquire, according to the role they will play in their future professional practice.

Another action led by the Education Group was the second version of the BIM

Collaboration Competition. The objective of this competition was to promote the use of BIM methodology and technology for the collaborative development of construction projects in the academic field, at an undergraduate level. This contest allowed 20 teams to have a first approach to collaborative and multidisciplinary work, in addition to complementing their formal learning with more practical experience.

Initiatives/Organisations

Planbim

Planbim is a 10-year State initiative (2016 to 2025) promoted by the Economic Development Agency (CORFO) and created within the framework of the Strategic Program for Productivity and Sustainable Construction, Construye 2025. In 2022, Planbim continued promoting BIM methodology at the industry level and supported public organisations in their implementation of BIM in a standardised way. The initiative also completed the development of the two BIM Observatories mentioned in this report, to understand and gather information regarding the impact that the establishment of BIM as a public policy has had, both at the level of public projects tendered and at the academic level. This work was presented at a hybrid-format seminar organised by Planbim in April 2022, that was attended by 650 people.

National BIM Survey

During the second semester of 2022, the Faculty of Architecture and Urbanism at the University of Chile conducted the fourth National BIM Survey (www.bit.ly/3l4mAev). This periodical study aims to characterise the adoption of BIM in the private sector, namely in architecture, engineering, and construction companies in Chile. The survey, which had responses from 1252 professionals, showed that 80% of respondents had some experience using BIM, and that half of them considered themselves regular users. The comparison between the percentages of total users in the 2022 survey with data from the three previous surveys (2013, 2016, and 2019) shows that the use of BIM in the private sector continues to grow each year. According to the survey, in the nine years since the first study, regular users increased from 23% to 41%, occasional users from 14% to 31%, and indirect users grew from 2% to 8%, which yields a total growth from 39% to 80% users.

The study also assessed user feedback regarding the BIM Standard for Public Projects. More than half (~53%) of those who use the Standard agree or strongly agree that it is useful for both public and private projects, optimises information flows, and facilitates collaboration between different professionals.

ISO publications – NCh

Through a mirror committee created by the National Institute for Standardisation (INN), in the past years Chile has adopted and published: NCh ISO 12006-2 and 3, NCh ISO 29481-1 and 2, NCh ISO 19650-1, 2, 3 and 5, and ISO 16354. In 2023, the committee worked on adding ISO 19650-4 to this list.

Also, as a member of the ISO/TC59 SC13 Committee, the country has been part of the development of international standards: ISO 19650-1, 2, 3, 4 and 5, ISO 16354, ISO 23262, ISO 29481-3, ISO 12006 3 and ISO 12911. Currently, the national committee is participating in the study of ISO/DIS 7817.

BIM Observatory: Study of Public Tenders with BIM in Chile, 2013-2020

The *First Report of the BIM Observatory for Public Projects* is a document developed and published by Planbim Corfo in April 2022 (www.bit.ly/3yqkJUu). It presents the results of the analysis of 1990 tenders for projects executed between 2013 and 2020 by the ministries of Public Works, Health and Housing, and the Administrative Corporation of the Judiciary Power.

The study showed that the percentage of public tenders requiring BIM has grown steadily since 2013. Despite this increase, the number of projects remains low, reaching only 7%. However, when analysed from the perspective of the amount of investment, this 7% of projects represents 70% of the estimated expenditure for the 1990 tenders examined. This shows that BIM is being used in higher complexity projects that involve a greater expense for the State. The data also confirms the launch of the BIM public mandate in 2016 has led to an increase in the number of BIM projects. This can be seen especially during the years 2016, 2017, and 2018, when the number of tenders requiring BIM doubled each year.

Regarding the qualitative aspect, the specificity of the requirement and the standardisation of the requested information progressed during the studied period. This shows that the strategy of promoting BIM by the State and the creation of a BIM standard has had a positive impact on the organised adoption of BIM in the country.

Publication of BIM Indicators

During the first half of 2023, Planbim planned to publish the Information Impact Indicators. These indicators focus on evaluating the fulfillment of the objectives related to BIM, and therefore, the benefits derived from the application of the selected BIM Uses to meet these objectives.

In the proposed methodology, KPIs are established as metrics to evaluate the performance of a process in which BIM has been introduced, compared against a dataset of a baseline or a defined goal. This helps understand whether BIM has an impact on achieving the objectives originally set, and whether its introduction has helped improve the projects processes and information, in comparison to similar projects of the same organisation.

Connecting the indicators to the purposes of BIM allows measurement efforts to be focused on those benefits that come exclusively from BIM Uses, and for which reliable data can be collected.

This set of indicators will become part of the tools that Planbim publishes to support public institutions and industry in general, such as the BIM Standard for Public Projects, the MIDE Entity Matrix, the MIBIM Maturity Matrix, and the different BIM Guides.

Awareness/Uptake

Chile has taken important steps towards establishing BIM as a common practice in the industry. Both Observatories mentioned above report on this progress. In academia, progress has been made in the adoption and application of BIM in undergraduate programs related to the field of construction between 2016 and 2021. For this, higher education institutions have employed multiple approaches for incorporating BIM into curricula. However, the subjects where BIM has been included in undergraduate programs are still linked to software and representation applications. Therefore, the teaching of fundamental

methodological issues, such as implementation strategies and standards management, has been relegated to the background.

At the graduate level, there seems to be awareness regarding the need to generate training for the different professional roles in the industry. Academic institutions have begun offering diploma programs focused on the direction and management of projects with BIM. This complements the broad range of modelling and coordination courses available.

In the public sector, studies show that the requirement of BIM has increased steadily since 2013, both in the proportion of tenders that request it and in the amounts of investment. This demonstrates that the launch of the BIM public mandate in 2016 has become a stimulus for the requirement of BIM public projects.

Finally, the private sector has also made progress in this area, as evident from the results of the National Survey which showed that BIM has strongly penetrated different areas and professionals.

CHINA

Education/Training

BIM education in national higher education institutions: Professional curriculum design

BIM talent is currently cultivated in Chinese colleges and universities through setting up BIM courses, offering BIM majors, establishing BIM studios and research centres, as well as organising BIM competitions in collaboration with enterprises and industry associations.

To adapt to the demands of current development trends, each university and college have formulated relevant training programs and reform measures, gradually shifting from traditional single-theory teaching to incorporate practical teaching. This is primarily reflected in integrating BIM-related foundational courses into existing teaching procedure, enhancing the student's basic abilities in operating BIM software, and training their practical application skills through actual project cases.

The BIM course settings in ordinary undergraduate institutions refer to the *National Standards for Teaching Quality of Undergraduate Majors in Ordinary Higher Education Institutions*, with introduction to BIM and BIM application related courses set up in 19 civil engineering and architecture majors.

According to the latest revisions of the *Brief Introduction of Vocational Education and Professional Teaching Standards for Higher Vocational Schools*, in the curriculum design of secondary vocational, higher vocational diploma, and higher vocational undergraduate programs, most majors directly incorporate BIM application capabilities into the main professional competency requirements. For example, among the 34 majors in the civil engineering and architecture category of higher vocational diploma programs, 33 majors have set up BIM application related courses as either fundamental or core courses.

Some BIM-related courses currently offered include *BIM Architecture*, *BIM Municipal Engineering*, *BIM Quantity Surveying and Costing* and *BIM Construction Organization Design*. The majority of BIM courses primarily focus on BIM scenario applications. In some cases, within the curriculum of other courses related to next-generation information technologies, BIM technology has been integrated with construction management and intelligent operation and maintenance.

Regarding the duration of BIM course, 30% of schools have been offering these courses for over 6 years, while 40% have been offering them for 4 to 6 years.

As of December 2023, 104 undergraduate institutions nationwide have established majors in *Intelligent Construction*, while the *Intelligent Construction Technology* major has been provided in 115 higher vocational colleges. Within these majors, courses such as *Artificial Intelligence*, *Intelligent Machinery and Robotics*, and courses related to other emerging construction technologies are offered, which can be combined with BIM technology to conduct practical training in construction management.

BIM education in national higher education institutions: University-enterprise collaboration talent cultivation mode

According to the actual demands of the construction enterprises, universities and colleges have entered into cooperation agreements with relevant enterprises to explore collaborative models for cultivating BIM talent. Under these agreements, universities are responsible for providing venue support while both parties jointly provide equipment and software, forming a "factory in campus" mode, which focuses on cultivating versatile talents who possess both engineering capabilities and BIM skills. The BIM talent training base in universities and colleges have introduced a working mechanism of mutual recruitment of personnel simultaneously. The base designers serve as part-time professional teachers, while the universities and colleges select full-time teachers from the School of Architecture and Engineering to manage the bases together with the technical directors of the bases. Both parties implement embedded teaching based on the progressive levels of student BIM competency, allowing students to participate in actual projects and gain opportunities to collaborate with BIM experts and design masters, which not only enhances the application level of BIM tools, but also addresses the shortage of BIM talent in enterprises. Furthermore, it helps students understand the importance of solid theoretical foundations, promoting their diligent study of theoretical courses.

Major universities in China are also actively responding to the scheme adjustments in the construction industry by adding BIM-oriented engineering master's programs in the field of architecture and civil engineering. These

master's programs collaborate with BIM training companies to incorporate case analysis content and research topics relevant to actual engineering projects in the curriculum, assisting trainees in mastering knowledge related to BIM technology development and tightly integrating it with frontline engineering practices. On the one hand, this enhances the advanced nature of BIM education in terms of technology and its practicality in engineering. On the other hand, it promotes the development of versatile talents in the BIM profession.

Enterprise BIM talent development: Establishment of a comprehensive knowledge base and learning platform

In response to business and talent functional requirements, construction-related enterprises have established internal knowledge bases and offline study halls as well as online cloud-based learning platforms. These platforms have been tailored to the necessary occupational knowledge and skills in the BIM-related industry standards, policies and regulations, engineering project BIM technology application solutions, BIM software product development or customisation, and BIM team building and operational management. Through a combination of centralised training and self-directed learning, this approach not only enhances the digital literacy of traditional technical professionals but also enriches the theoretical knowledge reserves of innovative and integrated talents in three aspects: BIM technology application, management and operation, and enterprise development strategies.

Enterprise BIM talent development: Practical mentoring and project review and assessment

Using actual enterprise projects as a carrier and adopting the "mentor-apprentice system" for comprehensive practical mentoring and guidance is another crucial aspect of BIM talent development. By dissecting and reproducing typical work scenarios in actual projects, collectively summarising effective implementation management experiences, and identifying shortcomings, employees gain a deeper understanding of BIM technology in practice. At the same time, joint benchmark project site visits with peer companies facilitate active exchange and learning of excellent technical applications and management experiences, helping employees improve their coordination capabilities. This process contributes to an adaptive and standardised enterprise-level methodology system for digital

engineering implementation and administration.

Enterprise BIM talent development: Talent development model with close integration of industry, academia and research

In order to comprehensively nurture BIM talent, construction enterprises also need to collaborate with various resources from the government, universities and other parties to build key construction industry informatisation laboratories, postdoctoral workstations, local and corporate BIM research centers, etc., to jointly carry out talent development initiatives. Actively participating in BIM competitions, industry conferences and forums helps in keeping updated with current industry trends, facilitating the transformation of the latest research results into practical productivity. In addition to improving enterprise talent and competitiveness, it can also promote innovative development in the construction industry.

Initiatives/Organisations

In 2023, industry associations, societies, and alliances in China's BIM field experienced significant growth in terms of membership, membership structure, event organisation and industry influence. Corporate membership not only includes traditional construction enterprises such as architectural design, construction, and supervision enterprises, but also includes enterprises closely related to BIM technology such as software development, consulting services, and education and training. Individual membership not only includes professionals such as architects and engineers, but also government officials, researchers, teachers and students in colleges and universities. The diverse demographics have enriched the resources and impact of activities organised and provides a broader platform for communication activities. In terms of activity organisation and industry influence, China's BIM industry associations, societies, and alliances have expanded the country's recognition and influence in the international BIM community by continually strengthening exchanges and cooperation with relevant domestic and foreign institutions, enterprises, and higher education institutions.

Policy status analysis

In 2023, China successively issued multiple policies and measures to promote BIM application and talent development,

intensifying efforts to implement BIM technology.

Policy status analysis: National level

At the national level in 2023, relevant departments released policies such as the *Guideline on Building the Great power of quality*, the *Notice on Promoting Standardization, Regulation and Facilitation of Approval for Engineering Construction Projects* and the *Notice on Carrying out Pilot Reforms of Digital Management throughout the Lifecycle of Engineering Construction Projects*. These policies focus on strengthening the promotion of BIM technology application in the following areas:

- Deepening the integrated application of BIM throughout the lifecycle of construction projects, emphasising the extensive use of BIM technology in design, construction, operation, and maintenance stages.
- Promoting BIM digital delivery and intelligent review, reinforcing the implementation of reviews and acceptance work based on BIM models during design, construction, and operation stages.
- Encouraging and supporting enterprises to develop BIM software with independent intellectual property rights, conducting pilot applications, and promoting the integration of BIM technology with new technologies such as AI, IoT and 5G.

Policy status analysis: Provincial and Local Level

In the context of the country's promotion of BIM application, BIM has become a hot spot for the development of the construction industry in various provinces and cities in 2023. The promotion and application of BIM in some cities are as follows:

- Beijing has issued BIM-related policies to encourage the establishment of a collaborative work platform for the integration of BIM with information technologies such as the Internet of Things and big data, and to promote the application of independent and controllable BIM technology. In 2023, Beijing has solicited and approved 26 BIM application demonstration projects, leading the wide application of BIM in construction projects.
- In order to accelerate the application of BIM technology in various fields,

Shanghai has issued relevant policies and explored the integrated application of BIM with advanced green technology, Internet of Things, smart parking and so on. In 2023, Shanghai held the *Digital Construction Cup Digital City Construction Achievement Competition*, covering projects in more than 20 fields including rail transit, ports, bridges, tunnels, highways, and buildings. It promoted the in-depth application of basic digital technologies represented by BIM technology in various fields of smart cities and provided strong technical support for Shanghai to build an international digital capital.

- In 2023, Shenzhen released the *Action Plan for the Construction of Shenzhen Digital Twin Pioneer City (2023)*, proposing construction contents such as "using refined BIM models as 'cell units'", "digital twin data and application supermarkets", and "digital twin data systems", to empower the construction of smart cities with high quality BIM technology. In 2023, Shenzhen organised the first *Pioneer Cup Digital Twin Innovation Application Competition* to solicit works from all over the world, promote industry exchanges and cooperation, and cultivate highly skilled BIM talent.

Analysis of current standards: National and industry standards

With BIM as the data base, the application of CIM scenarios in smart cities has expanded. In 2023, relevant national departments released a number of standards and specifications for smart city applications, extending from the intelligent application of a single building to the construction of smart cities. These include:

- *Smart city - City operation indicator system - General framework* GB/T 43048-2023.
- *Smart community infrastructures – Guidelines on data exchange and sharing* GB/T 43245-2023.

Analysis of current standards: Provincial and local standards

Cities have also issued BIM policies based on standards and specifications in construction to reflect engineering practices and requirements specific to their municipal's infrastructure. Some examples include:

- Sichuan Province: *Highway Engineering Information Modeling Regulations Part*

1: *Unified Technical Requirements* DB51T 3092-2023.

- Jilin Province: *Standard for Design Application of Municipal Engineering Information Model* DB22T 5147-2023.
- Anhui Province: *Technology Specification for Application of Highway Engineering Building Information Modeling* DB34T 4393-2023.

On the basis of BIM data, some cities have begun to pay attention to the quality of BIM models and have successively studied and released relevant BIM audit specifications. Some examples include:

- Guangdong Province: *Model Delivery Specification for Construction Drawing Review on City Information Modeling Platform* DB4401/T 228-2023.
- Jiangsu Province: *Intelligent Review Specification for Construction Drawing Information Model of Building Engineering* DB3201/T 1143-2023.
- Hubei Province: *Specification for Review System of Building Information Modeling - Part 1: Standard for Technical Review* DB42T 2064.1-2023.

Awareness/Uptake

It is projected that by 2030, the BIM market in China will reach 37 billion yuan. However, the talent gap in BIM is still widening, indicating a broad employment outlook for professionals in BIM-related fields.

With the extensive implementation and promotion of BIM technology in China, a good ecological environment for BIM application has gradually formed, but there are still some challenges and shortcomings. The SWOT method has been used to summarise and analyse this below.

S - Strengths

China has implemented a series of policies and technical standards to promote the research and application of BIM technology, providing fertile soil for the development of BIM ecology in China. Thanks to these policies, China's demand for digitalisation of engineering projects have exploded, and at the same time, it has achieved a leap forward in standardisation, scientific research and innovation, and talent training. A number of BIM software with independent intellectual property rights continue to be developed,

accelerating the high-end development of BIM technology in the field of domestic construction engineering.

W - Weaknesses

Although a range of BIM software has been developed in China, the hardware supporting BIM applications is still insufficient, including key components such as servers, graphics processors, and scanning equipment, making it difficult to meet the needs of large-scale BIM applications. There is a shortage of relevant technical talents. To a certain extent, this restricts the wide application of BIM-based engineering projects.

O - Opportunities

The Chinese government has issued development strategies such as "dual carbon" and "information innovation" to guide the construction industry in the direction of industrialisation, digitalisation and intelligence. The State has given strong support for innovative research and development in integrating BIM, AI, 5G, robotics, etc., providing strong support for comprehensively improving the intelligent application of construction projects.

T - Threats

Although BIM technology has been widely adopted in the fields of construction and municipal engineering, many key technical difficulties and challenges still need to be overcome, which will require continuous in-depth research and technological innovation. At the same time, "talent is the primary productive force", the training of professional and technical personnel and interdisciplinary BIM experts is an urgent task, and it is urgent to establish a multi-level BIM talent echelon to meet the growing demand of the market for BIM applications.

CZECH REPUBLIC

Education/Training

In the Czech Republic, there is generally a lot of BIM education and training through seminars, workshops and presentations led by CAS (Czech standardisation agency), CzBIM (Czech BIM Council), universities, companies, software vendors, technical chambers, etc. in several recent years. But, in 2020 these activities were reduced or postponed due to COVID-19 restrictions during the spring and autumn seasons throughout society, including in high schools and universities. Some of them were switched to online conferences, seminars or workshops, but unfortunately not all of them. Although these restrictions partly continued in 2021, people already got used to online training, conferences, etc. and digitalisation and BIM have made progress.

In November 2019, CAS published the *BIM EDU* report, which described the state of teaching at the Czech public universities. The focus was on the 5 main Czech universities where AEC is taught. The leading Czech technical universities have been implementing BIM in their curriculum over the last few years. This was done mainly as standalone subjects or as innovations of the regular ones. The content of the subjects vary depending on the branch of study at both undergraduate and graduate levels. There is an effort to find interactions between subjects and connect them together, in addition to existing individual subjects focused on 3D CAD SW, or other special subjects. This implementation of interconnections between subjects or fields (to collaborate) is also one of the biggest obstacles of BIM implementation into teaching. However, nowadays a shift can be seen in this area where new programs of study focused on BIM are emerging – for example, the Technical University of Ostrava, Faculty of Civil Engineering launched a two-year master's program, which emphasises the coordination of construction processes in the BIM information environment within the digitisation of construction, in the fall of 2021. Other obstacles stated in the report were for example: lack of standardisation of BIM in the Czech Republic (it's still going on), insufficient qualification of teachers, lack of study materials and models of sufficient quality, lack of money. Universities also connect more with professionals in both research and educational areas.

BIM is also being implemented in secondary education (especially at technical high schools)

mainly in 3D CAD based subjects. In 2019, there was also a significant shift around updating the Framework Educational Programs (RVP). Within these, proposals for the update of the RVP were prepared so that secondary schools with a construction focus have the opportunity to adapt BIM to their school educational programs with effect from the school year 2021/2022.

Initiatives/Organisations

CzBIM – Czech BIM Council (www.czbim.org)
CzBIM is a non-profit organisation focused on the support of BIM implementation in the Czech Republic. It assembles professionals from both companies and individuals active in the BIM area (around 80 members at the end of 2021). The main goals are popularisation, education, standardisation and implementation of BIM. CzBIM hosts an annual conference titled 'BIM DAY'. There were several documents published and many others have been prepared under its wings. It also plays a key role in the negotiation with ministries and standards bodies.

It resulted in success in 2017 when the Czech government approved a BIM implementation document which covers a strategic plan for the next 4 years. The main goal was to prepare the Czech construction environment for BIM - aiming to the beginning of 2022 when big public projects should use BIM (this document is called *BIM Policy 2022*).

The Czech BIM Council decided to establish a branch of buildingSMART in the Czech Republic at the end of 2020. This was realised in 2021. The main reasons were an openness to international cooperation and standardisation, to gain and share information, certification, etc.

CAS – Czech standardisation agency, BIM Policy 2022 (www.bimkonceptce.cz)

CAS – Czech standardisation agency is a funded organisation of the Czech Office for Standards, Metrology and Testing (ÚNMZ). At the end of 2017, CAS established a new department to execute the tasks of the *BIM Policy 2022* (www.bimkonceptce.cz). The BIM Policy is a strategic plan determining the direction of the Czech Republic in the field of BIM and related topics within 10 years (until 2027).

In 2018, there were 6 workgroups established:

- Pilot projects.
- Procurement, project management and contracts.

- Data and information standards.
- Documents for estimations.
- Education, public relations.
- Terminology and standards.

In 2019, the next workgroups were established: Facility management, PS LEG - for legislation and imposing a BIM obligation and also an interdepartmental workgroup led by the Ministry of Industry and Trade (www.mpo.cz) for coordination between all significant stakeholders during the BIM Policy implementation (ministries, authorities, state organisations, universities, professionals chambers, and organisations), which has around 30 members.

In April 2019, the Ministry of Industry and Trade recommended the use of IFC format for information transfer during the whole building lifecycle.

In autumn 2019, CAS prepared a set of workshops on different BIM topics, concluded by the BIM summit conference. The obligations to use BIM standards from 2022 were introduced during this BIM summit. The investors of public projects financed from public resources, above a specified value (note: the limit set for 2020 - 2021 was 5 350 000 €) will have to use some of the BIM standards. These include CDE - common data environment, Information model using the *Construction Data Standard*, and BIM protocol.

In 2020, many changes in legislation and supporting tools aiming towards electronic communication and digitalisation in the building industry were realised or started. The Czech building law was changed in the area of building permit processes, which are allowed to be submitted fully electronically from July 2023. From that date, it should be easier and faster for builders to gain building permits, because of a new “builder's portal”. Builders can communicate and gain all permissions from all authorities through the portal. The government also approved the establishment of data repositories usable for BIM, as well as interconnection of BIM and digital technical maps. Another new regulation is, for example, the obligation to use an electronic construction diary for above-limit public projects from 2021.

However, in 2022 there was a change of government, and this new government will be making some changes to the building laws in 2023. The changes will be released in 2023.

However, it is likely that the July 2023 date noted above will be delayed.

CAS introduced and - after a comment procedure - published a number of documents and methodologies, such as: *BIM protocol*, which is to be used as an annex to the contract, properties of CDE, etc.

The *BIM Policy 2022* including schedule was updated in 2020 (for years 2021 – 2027), and the government adopted the document at the beginning of 2021. Some dates, including obligations of using BIM were postponed due to new knowledge and also for coherence with the law of electrical building permit. The new obligations of BIM usage will apply from July 2023 with gradual effect.

In the fall of 2021, CAS published the first version of the *Construction Data Standard* for buildings, to the level of building permit. Viewing the standard, exporting to xls and ifc formats are available on the website: <https://dss.koncepcebim.cz/>. Subsequently, in 2022, CAS published the next version of the *Construction Data Standards* for buildings, to the level of detailed designs, and several updates to former standards.

SFDI - The State Fund for Transport Infrastructure (www.sfdi.cz)

The State Fund for Transport Infrastructure is an important organisation that supports BIM. SFDI in cooperation with the Ministry of Industry and Trade, the Ministry of transport, Czech standardisation agency and other organisations published Regulation for information modelling of buildings (BIM) for transport infrastructure construction in October 2020. This document is similar to documents like the Code of Practice (CoP) and Employer's Information Requirement (EIR). It defines minimum required information to be contained in BIM models at different design phases - Data Standards for roads and railways (approved in 2021 and updated in 2022), specifies formats (IFC), units, etc. It was introduced on the basis of experience from pilot projects and is used for other pilot projects.

ÚRS CZ a.s (www.urs.cz)

This report was written by the author employed by a company ÚRS CZ a.s, a private organisation dealing with standardisation and providing SW tools in the area of cost estimations, cost calculations and management. ÚRS CZ is a producer of the price database ÚRS and several software (KROS 4, BIM platforma, Kubix, etc.) The

company cooperates with partners developing or providing software for designs, provides complex BIM tools for cost estimations of buildings, and organises training and seminars. ÚRS CZ also cooperates with the Czech standardisation agency, cooperates with ministries, and is a member of Czech BIM Council.

Awareness/Uptake

Both public and private investors started pilot projects to try BIM. There is an increasing cooperation between significant Czech organisations on pilot projects for both infrastructure and buildings. Some of the big contractors are running their own pilot projects. There is a visible shift from "I would like to do BIM" to "do and try BIM", do projects in 3D CAD SW and add useful information, collaboration, try open format such as IFC. However, this is a slow process and many people are still a bit afraid of BIM, or they are just waiting. The main reasons are the difficulty and costs caused by switching to other SW and processes, the need to go through related education/training, lack of BIM projects, and lack of Czech BIM standards (the first one was issued only at the end of 2021). In general, there are BIM projects currently running in the Czech Republic and the number is increasing, however 2D is still used for the majority of projects.

The increasing attention of manufacturers of materials and products can be seen. They want to be prepared and they are thinking of how to implement information about their products into 3D CAD and other SW. There is also an increased interest in the area of facility management and the usage of BIM, which has resulted in the development of new SW tools and methodologies.

A rising consciousness of BIM in the Czech Republic is also supported by the need of society to search for modern technologies and their use. In addition to BIM, there is an awareness of the need for electronic communication and digitisation.

FINLAND

Education/Training

Universities and Universities of Applied Sciences (UAS) provide BIM education for their students. All civil engineering students currently study BIM to some extent as part of their professional courses. The main focus is on open BIM based design in different disciplines, but more and more BIM principles are also taken into account in project management courses. In many universities, basic BIM studies are offered in the first year of the education program. Some UAS also provide whole bachelor's degree for Architectural education where the key areas are modelling (BIM) and model utilisation, visualisation, renovation, maintenance of buildings, lifecycle thinking and energy efficiency. BIM is also one part of infrastructure design courses such as road design and geotechnics. In many universities, cooperative BIM based project works have been used as a good way to learn open BIM workflow.

In many regions of Finland, some UAS have introduced BIM for companies, public sector clients and officials in research, development, education and training projects. These projects have been funded by the EU, government, and private sector. In these projects, new BIM education, training methods, learning materials and learning platforms have been developed for various groups such as designers, clients, contractors, house owners, public building permit and fire safety, and other officials. An ongoing project in 2023 was the international BENEDICT project in which the University of Tampere is a partner. The main goal was to specify the requirements for a common, openly accessible and flexible BIM-enabled Learning Environment (BLE). In two other projects, the goal was to implement BIM based digital twins of houses. These projects were the EKKIRA-project hosted by LAB UAS and the Karelia UAS Digital Twin-project. Metropolia University of Applied Sciences has also started RADIAL-project. The focus of this project is to develop as-built BIM model workflows.

Many UAS offer courses for postgraduate and further education students. For example, Metropolia UAS offers:

- BIM Basics Online (3 ECTS).
- BIM Coordinator (15 ECTS).
- BIM Coordinator for infra (15 ECTS).
- BIM for building permit authorities (5 ECTS).

- BIM Basics for infra production (2 ECTS).
- The basics of BIM-based zoning (5 ECTS).
- BIM for contractors (6 ECTS).
- BIM Basics for builders (3 ECTS).
- BIM-based building surveying (3 ECTS).
- BIM consulting for companies.

Some of these courses are also available for graduate students. Some vocational education institutes also provide BIM education as one part of studies and continuing education related to BIM.

All vendors (Solibri, Autodesk, ArchiCAD, Trimble, Novatron, Symetri, Arkance Systems, Cadmatic, etc.) are providing BIM training for their own software solutions. Large companies such as Skanska, YIT, NCC, SRV (construction) and Senaatti (state client office) arrange focused in-house training as required in co-operation with universities and UAS's.

Initiatives/Organisations

There are several initiatives taking place in Finland. Key initiatives include:

- buildingSMART Finland has about 120 company members and activity takes place in four industry groups (Knowledge and Change Management, Building, City Planning and Infrastructure) and their subgroups.
- COBIM, the national common BIM requirements, was published by buildingSMART Finland in March 2012 and is now in widespread use. English, German, Estonian and Spanish translations of the requirements have also been completed. In 2014 it was updated with a new part on "*The use of BIM models for building permitting*", and in 2016, four Annex for building owners were published. In 2021, the *Guidelines of geotechnical BIM* were published. Common BIM requirements for infrastructure projects were also published (*Common InfraBIM Requirements*). The last version was published in 2021 by buildingSMART Finland. The need for updating these national requirements and guidelines are recognised and the update process has started as part of national RYTV development project. In the future, these requirement and guidelines will be more and more connected to European standards. For example, new national

guidelines for clients will be based on ISO 19650.

- The development of the Finnish LandXML based data format for neutral BIM data exchange for infrastructure (Inframodel) will continue.
- KIRAHub continues as a new association in the footsteps of former KIRA-digi, the Government's key project, which involves ministries, municipalities and the KIRA forum. The aim is to create an open and interoperable information management ecosystem and harmonised practices for the built environment.

Awareness/Uptake

BIM is now in everyday use in Finland. Large firms such as Skanska, NCC, YIT, SRV and others use BIM for 100% of their own production. Public sector clients are using BIM more and more in their building projects. Many public clients have developed their own detailed BIM requirements for project participants.

In Finland BIM always means using open standards: IFC for buildings and LandXML/inframodel for infrastructure, and open formats for city models. The first developing steps of implementing IFC to infrastructure projects have also started.

Learning Outcomes (LO) matrices related to BIM and energy-efficiency - including principles of performance based and collaborative, sustainable construction, were published in the international BIMEET-project 2020 (*BIM-based EU-wide standardized qualification framework for achieving energy efficiency training*), in which Metropolia UAS and the Technical Research Center of Finland (VTT) worked as partners. The work has continued in the INSTRUCT project (*Evidence based market and policy instruments implementation across EU to increase the demand for energy skills across construction sector values chain*) with the same partners and RIL, the Finnish Association of Civil Engineers. The INSTRUCT project also developed eLearning modules on BIM based EPC, and EE simulations using the LO framework for defining curricula. Further LOs were put in use as a set of competence requirements (CR), divided in skills-knowledge and competences, (S-K-C). The S-K-C sets can be used as part of skills verification methods for the experts on building projects, as part of the procurement process. Links:

<http://www.bimeet.eu/publications.html>,
<https://instructproject.eu/>.

Collaboration with other EU projects and buildingSMART International, focusing on education and professional certification systems, is part of an ongoing effort to develop EU wide course content and delivery methods. Participants from the Technical Research Center of Finland (VTT) and Metropolia UAS are recent committee members for “CEN/TC 442/WG 8 - Competence” that aims to define general level concepts for the requirements of competence, knowledge and skills related to information management enabled by information modelling. The European level concept and technical specification will guide national level BIM competence development strategies and definitions of usable LO frameworks.

Also, other new practical uses of BIM have been found in many recent open BIM R&D projects in Finland. For example, how models can be used to ensure the safety of buildings. As a result of new use cases, very different new needs to BIM competences are recognised and new types of BIM education and training methods should be introduced.

EU research project ACCORD (Automated Compliance Checks for Construction, Renovation or Demolition Works) aims to digitalise permit and compliance processes using BIM and other data sources to improve the productivity and quality of design and construction processes. ACCORD project is developing the digital building permit and compliance verification processes and technologies with the help of 12 use cases. <https://accordproject.eu/scenarios/>. Information packages on its adaptation and implementation have been developed to raise awareness and have been disseminated through open webinars.

The Finnish State BIM Strategy can be recognised based on the ongoing legislative and development projects of the Ministry of the Environment in Finland. BIM objectives of this reform are as follows:

- Building Permits are applied for using BIM or other machine-readable formats.
- Design and as-built BIM models are stored on the national database.
- The building owner is responsible for updating the register about repairs that do not require a permit.

- Machine-readable operating and maintenance manuals are required for new buildings.

The Finnish Ministry of the Environment is renewing the current Building Act, which will come into effect in 2025. The new law aims to create machine-readable building information to be stored in national database (RYTJ). The top-down development has started many R&D projects in order to define “to-be” BIM based permitting process with data needs and the steps towards ACCC (automated code compliance checking). RAVA3Pro-project was led by the City of Helsinki and funded by the Ministry of Finance to digitalise and automate the building permit processes of municipal building control. The project included 23 Finnish municipalities and ended in 2023. The results will be implemented in KIRAHub.

This reform will cause plenty of new needs for BIM education. An extensive BIM training for building permit authorities is needed. Metropolia UAS has organised BIM basics and BIM coordinator courses for building permit professionals. This reform also needs to be taken into account when national common BIM requirements are updated.

buildingSMART Finland and Building Information Model Ltd. launched *Information Standardization for the Built Environment - project program (RYTV)* in 2022. The goal for the project program is to standardise BIM in Finland. BIM standardisation for the built environment creates more sustainable, dynamic, and systematic modes of operation in AECO. The main principle of the RYTV project program is to generate a strong foundation for the sustainable growth and development at the organisational, industrial, and societal levels. In 2024 RYTV project program and its goals are more current than ever because the new Building Act will be implemented in 2025. This Act will have an effect on built environment and openBIM because after January 1st, 2025, building permits are to be submitted as interoperable models or otherwise machine-readable format. Therefore, construction companies must implement openBIM in their planning. buildingSMART Finland encourages that the new Building Act supports standardised BIM and wide implementation of machine-readable materials. The new Act also creates a demand for wider BIM education.

The RYTV project program has multiple beneficial effects on BIM education. Joint information standardisation enables smooth and wide information and knowledge sharing. Additionally, within the field of BIM standardisation there is a necessity to enhance research and learning. Therefore, the program supports more improved BIM education on the university and industry levels and an adoption of international BIM standards. RYTV project program has a goal to publish new national common BIM requirements for the built environment, and this also includes education, competence development and change management. Later this year, a RYTV project focusing on national BIM competence will be launched. Simultaneously, the development of defining BIM expertise and national level learning outcomes are buildingSMART Finland's focus, and this work is being carried out in buildingSMART Finland's Knowledge and Change Management group. See link for more information about RYTV project program and buildingSMART Finland https://buildingsmart.fi/en_GB/rytv.

The national KIRA growth program covers the growth opportunities and measures for the sustainable development of the Finnish real estate and construction sector. The aim of the growth program is to create a shared mindset and direction towards growth, as well as to commit the real estate and construction sector to the measures of regenerative growth and direct long-term financing, to target-oriented development. One goal is to digitise buildings and processes as well as ensure a reliable and secure data stream throughout the life cycle of the built environment, while taking new business opportunities into account.

Over the next few years, a lot of development work will be done at the national level for the widespread introduction of BIM practices in new use cases, and in connection with that, the development of competences in different ways. The aim is to have more and more international cooperation, and to utilise bSI standards and tools, as well as CEN TC/442 standards.

The research projects and standardisation work have formed a foundation for a national level BIM certification system based on LO/CR framework. This project (in planning phase) is part of the buildingSMART Finland development program and will focus on four use cases where competence requirements and/or learning outcomes are adapted:

- Competence verifications.
- In-house training planning.
- Harmonisation of the offerings of BIM continues education courses and BIM software courses.
- Supporting BIM education (modularising, program planning, development of learning material).

Different levels of BIM courses/training will be planned and executed based on the learning outcomes.

FRANCE

Education/Training

The National Education authority in France anticipated the reform of technical graduates in 2011, making BIM compulsory in the Architecture and Construction domain. More and more technical and professional high schools advocate the use of BIM in the realisation of projects. Thus, during internships, students bring their own digital skills to companies, while they learn more about business know-how.

In 2020, buildingSMART France created an "OpenBIM LABEL" for the initial education and lifelong learning program. The aim of this label was to promote a real "OpenBIM" approach inside the learning system. This label was based on 6 items: the project component, interoperability, tools, process, innovating transition and OpenBIM ecosystems.

Nowadays, buildingSMART France has joined the BSI individual certification program. More information is available on <https://buildingsmartfrance-mediaconstruct.fr/>.

Since 2020, 15 training organisations have been accredited under the "OpenBIM LABEL" program, and France currently has 11 organisations accredited to deliver the buildingSMART International Professional Certification.

Initiatives/Organisations

buildingSMART France (association created in 1989, becoming the French Chapter of buildingSMART International [bSI] in 1996) and MINnD (a national research project started in 2014), offer guides for good practice and concrete experiments to make BIM operational. Their work also contributes to standards development, carried out internationally, for which France remains an active contributor to the definition of standards, useful and applicable to the construction industry.

In terms of contributions, bSFrance initiated, in 2020, the *aVenir BIM* trophies, to reward the research of French stakeholders, regardless of the level of their diplomas. bSFrance is also working on labelling training.

EduBIM, stems from the Research project MINnD, stands for the main French event dedicated to Education and Research around

BIM and digital the mock-up. It also stands for a network of trainers, researchers, and professionals from the construction industry. A growing network that encompasses all education level (universities, engineers, architecture schools, etc.) and subsectors (construction, public works, social sciences, etc.). In 2023, the theme was "Computational BIM from data to AI". More information is available at <https://edubim.fr/>.

Awareness/Uptake

In France, the construction industry remains very heterogeneous in terms of integration of digital technology and BIM, due to the fragmentation of the player types, which are mainly SME's.

According to the latest study published by the government's plan for the adoption of BIM by 2022:

- 48% of construction industry players say that BIM is a strategic issue for their company.
- 66% of professionals working with BIM are convinced of its benefits and effectiveness.
- 17% have implemented BIM actions in their company.

The most common level of BIM maturity observed among French construction companies is level 2. It is estimated that 35% of real estate companies use BIM and 50-60% of construction companies work with this process.

GERMANY

Education/Training

The number of colleges and universities in Germany offering BIM programs has increased in recent years. This applies to both bachelor's and master's programs in engineering and architecture faculties. In addition, many BIM courses are offered by construction industry associations and chambers. Likewise, there are numerous private initiatives on the market that offer online and classroom training on digitalisation topics in general and BIM in particular.

The Jade University of Applied Sciences in Oldenburg observed the state of BIM education in the years of 2014-2016, a period in which the implementation of BIM started in all of the surveyed federal states, both in university curricula and in further education. Here, differences with other European countries emerged. In England for example, a large number of BIM master's degree programs consider the BIM methodology in the entire life cycle of the building object. Compared to this, in Germany only individual modules on BIM were integrated into the curricula of the universities.

In general, the majority of BIM education and training concepts in Germany focused on the use of specific BIM software. The application of the actual methodology, the changed communication structures within the framework of an OpenBIM concept, was far behind in international comparison.

Initiatives/Organisations

BuildingSMART Germany aims to support and promote the development of BIM education initiatives in Germany. This is to ensure that a consistent BIM education landscape emerges in this country.

bSI Professional Certification Program

With its Professional Certification Program (bSI PCert), buildingSMART International offers a globally valid quality benchmark for evaluating and comparing knowledge and competencies in Building Information Modelling. In Germany, buildingSMART Germany cooperates with the Association of German Engineers (VDI). Together they have developed the guideline VDI/bS-MT 2552 8.1, as the basis for this program. Sheet 8.2, also a joint product of buildingSMART and VDI, has also been published. Within the framework of this

certification program, buildingSMART itself does not offer any training or courses, but rather defines minimum requirements of course content and learning outcomes, regulates the approval of training providers as well as the testing and certification of individuals. For the actual professional training the training provider is responsible.

The bSI PCert has a two-tier structure. The first level of the buildingSMART certification program - the Professional Certification - Foundation - aims to provide a common understanding of BIM fundamentals. It is designed to provide basic knowledge in Building Information Modelling and to test and certify the acquired knowledge by means of a central, internationally coordinated examination. This basic program has been offered to training providers in Germany since May 2018 as the buildingSMART/VDI Certificate BIM Qualifications - Basic Knowledge. Approximately 40 training providers, including universities, private trainers, chambers and companies, have since offered this certification to their training participants in Germany. More than 2500 participants have been certified so far. The second phase, the advanced level called Professional Certification - Practitioner, is expected to be offered in 2022. It focuses on teaching application-related BIM skills.

In addition to buildingSMART Germany, there are other institutions in Germany that pursue the goal of advancing digitalisation in the construction industry and supporting companies in the construction industry in this process.

Mittelstand 4.0 Centre of excellence Planning and Building

Since 2018, the Mittelstand 4.0-Kompetenzzentrum Planen und Bauen has been working in Germany with the aim of supporting the digitalisation and networking of medium-sized companies in the value chain of project development of planning, construction and operation. This centre of excellence is funded by the German Federal Ministry for Economic Affairs and Energy as part of the funding priority "Mittelstand-Digital - Strategies for the digital transformation of business processes".

The overriding concern of the centre of excellence is to promote the increased use of the BIM method as well as to achieve a

successful implementation of digital planning methods in the construction industry. This means that the BIM debate among builders, project managers, architects, engineers and software developers is to be extended to the phases of project development and operation. In this way, related sectors of the banking, insurance and real estate industries, facility management and the skilled trades are to be made aware of the new possibilities.

Planen-bauen 4.0 GmbH

Planen-bauen 4.0 GmbH has been coordinating and accelerating the digitalisation of the German construction industry since it was founded in 2015. It supports the federal government's BIM pilot projects in the areas of building construction, road, rail and waterways. In addition, the company is involved in numerous national and international projects for the standardisation and implementation of the model-based way of working.

BIM Deutschland

The German federal government wants to accelerate and actively shape the digitalisation of business processes in the construction industry. For this reason, the Federal Ministry of Transport and Digital Infrastructure, together with the Federal Ministry of the Interior, for Construction and Home Affairs, founded BIM Germany in the summer of 2019 as the center for the digitalisation of construction. The most important goal of BIM Germany is to create coordinated and uniform specifications in infrastructure and high-rise construction. All information and tools developed are to be made available openly and free of charge.

Awareness/Uptake

Building Information Modelling as a planning method does exist in Germany. Nevertheless, studies show that many companies do not use this method or use it insufficiently. This entails the risk that they jeopardise their competitiveness because they lose touch with new business areas. The demand from private clients for the use of BIM is still low. Increasingly, however, more and more tenders are calling for digital design and construction.

In Germany, the federal government is now taking on a pioneering role. In the future, BIM will be increasingly used in the awarding of public contracts for federal infrastructure construction and infrastructure-related high rise construction. The biggest challenge here is the lack of rules and standards. That is why,

at a hearing in the German Bundestag in January 2020, representatives of business, science and associations called for reliable framework conditions to be created for planning and construction companies in the digitalisation process.

HONG KONG

Education/Training

The Construction Industry Council (CIC) continues to promote and facilitate wider adoption of BIM and construction digitalisation and related technologies in architecture, engineering, construction, and operations, as well as formulate strategies for market transformation and promote cross-discipline collaboration in the industry. The CIC maintains its momentum in BIM education, training, certification and accreditation, developing standards and other publications, research and development (R&D) and promotion in pursuit of these abovementioned objectives, with significant achievements in 2023.

The School of Professional Development in Construction (SPDC) is the professional education arm of the Hong Kong Institute of Construction (HKIC) under the CIC and was established to provide professional and continuing education pathways for industry practitioners in construction. SPDC has been developing various professional education and development programs in construction, in particular in the areas of Construction Digitalisation, Industrialisation, Innovations and New Technologies. Particularly, SPDC has offered a wide range of programs covering BIM Manager, BIM Coordinator, BIM Modelling and BIM Viewer. These programs enable the construction practitioners to pursue relevant and recognised qualifications not only satisfying industry's needs, but also providing them with continuous learning opportunities and pathways for their career and professional advancement in construction.

The CIC worked closely with local higher education institutions and conducted yearly BIM education surveys to facilitate broader education of BIM in construction related disciplines. For the fifth year, the CIC BIM Competition continued to promote the practical uses of BIM through a collaborative and competitive learning approach among higher education students. The theme of this year's competition is *Sustainable Design of the Construction Innovation Campus*.

The CIC BIM Certification and Accreditation Schemes aim to ascertain the competency of BIM personnel and the quality of local BIM training courses. The Certification Scheme for BIM Personnel aims to set standards and ensure relevant construction professionals and

practitioners have appropriate skill levels and competency for the jobs. The Accreditation Scheme for BIM Training Courses aims to ensure the scope, contents and quality of the BIM teaching will meet the industry's needs, uphold the accreditation quality of BIM training, and facilitate practitioners to obtain certification of their competence by the CIC. Since the launch of the Schemes, approximately 630 BIM managers, 760 BIM coordinators and 250 CCBC(Associate) have successfully received certification from the CIC. Additionally, 19 BIM manager courses and 29 BIM coordinator courses have been accredited by the CIC.

To cope with the surging demand for BIM Viewers, the CIC also developed a *Teaching and Learning Kit* for BIM Viewer training, available in both self-learning and instructor-led training. A new BIM Viewer platform was introduced in 2023, achieving a total of four different BIM Viewer platforms together with an openBIM (IFC compatible) platform. Since its launch in 2021 up until the end of 2023, over 27,770 individuals have completed the online training and received the BIM Viewer certificates. BIM Viewer Training Kit download link: <https://bim.cic.hk/en/resources/publications?cate=52>.

In 2022, the CIC launched the signature Master Class series for industry practitioners. Since its kick-off, the CIC has offered the *Master Class on Digital Twin*, *Master Class on AI for Construction*, *Master Class on Common Data Environment (Project managers)* and various other master classes that promote construction safety and advanced technologies.

In 2024, the CIC will continue to consolidate training needs from the industry and collaborate with the School of Professional Development in Construction and Construction Digitalisation training service providers to offer necessary training courses. In addition, the CIC launched the *CIC Master Class on Digital Twin* in January 2024 and will revamp and offer the *CIC Master Class on AI for Construction* with the latest Large Language Model (LLM) technologies in Q3 2024.

The CIC signed various Memorandum of Understandings (MoUs) with local HEIs as well as technology partners, including MIT Hong Kong Innovation Node and Sensetime Group Limited to jointly promote the adoption of

innovative construction technologies and drive digital transformation for the Hong Kong construction industry. In 2023, the CIC co-organised the *Construction SafetyHACK 2023: Future of Construction Safety* Hackathon event with MIT Hong Kong Innovation Node and Hong Kong Productivity Council. The event brought together university students and professionals from various backgrounds to explore innovative ideas and leverage new technologies to create "Zero Accident" construction sites.

Initiatives/Organisations

To further accelerate construction digitalisation and popularise the use of digital twin in the industry, the CIC established the CIC Digital Twin Hub. The CIC Digital Twin Hub, transformed from the CIC BIM Space, providing a collaborative platform and an array of technological showcases to facilitate knowledge exchange, nurture talent and inspire innovation in the field of digital twin and construction technology. The newly established CIC Digital Twin Hub consists of four key areas, including Showcase Area, Smart Site Construction Management Corner, Multi-purpose Area and Digital Twin Lab. It provides a variety of functions, such as digital twin experience sharing sessions, group guided tours and advisory workshops.

Other than the activities in the CIC Digital Twin Hub, a total of 46 webinars were organised throughout the year, covering various Construction Digitalisation related topics, such as BIM Talks, webinar series on Common Data Environment (CDE), Smart Site Safety System (SSSS) and Artificial Intelligence (AI), successfully attracting over 39,000 attendees.

The CIC completed the final version of *Reference Materials of BIM Harmonisation for Digital Hong Kong*. The document aims to identify appropriate additional information requirements of BIM models for reference by the industry (both public and private sectors), and in support of the Government's initiative of developing Common Spatial Data Infrastructure (CSDI) and Smart City and to satisfy the use cases identified in the *Report on 3D Spatial and BIM Data Use Case Requirements* of the Hong Kong Construction Industry published by the CIC in 2021. The reference materials will be published in 2024 after incorporating comments from key stakeholders.

We will also continue to collaborate with industry stakeholders and relevant government

departments to identify and develop quick win BIM-related digital solutions such as plugins, through consultancy services or R&D projects, to harness the power of digitalisation in Hong Kong.

JAPAN

Initiatives/Organisations

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) established the *BIM guidelines for government buildings* in 2014. The focus was on the use of BIM, from the schematic programming phase to post-project maintenance.

As mentioned above, BIM utilisation started in the national government building procurement field, but CIM (Civil Information Modelling and Maintenance) which is BIM of the civil engineering field began in earnest. CIM aims at new construction linked with robot introduction ICT, IoT, AI, and are redefined as *i-Construction* with the goal of increasing the productivity of the construction sector by 20% no later than 2025. *i-Construction* in public procurement up to now was defined by the Cabinet Office as one of the government growth strategies in 2016. In 2018, the Cabinet Office announced that it will aim to realise *Society 5.0* aiming for a data-driven society as a next-generation social vision.

In the roadmap prepared for government growth strategies in 2019, BIM in private construction will be promoted by 2025, and the goal is the same as *i-Construction*, that is, 20% productivity improvement.

To achieve BIM promotion in the private construction sector, the BIM Promotion Roundtable was established under MLIT, Housing Bureau Building Guidance Division in April 2019. At the BIM Promotion Roundtable, 5 WGs on the following themes were set:

- Establishment of standard BIM workflows.
- Development of an object library.
- BIM support for building confirmation.
- Investigation of quantity survey and building classification code for BIM.
- Development of common data environment (CDE).

The BIM Promotion Roundtable revised the standard BIM workflow and released the 2nd edition in 2022. From FY2020 to 2022, the MLIT Housing Bureau Building Guidance Division conducted a demonstration experiment with a total budget of 600 million yen with the purpose of demonstrating and improving the workflow. Based on the results of these efforts, the MLIT took measures to accelerate the social implementation of BIM,

and a subsidy of 8 billion yen was secured to support the use of BIM for SMEs, and a total of 900 million yen was budgeted over three years as a BIM comprehensive promotion project.

As for the MLIT's measures related to the BIM comprehensive promotion project, it has stated that it will begin a trial application of BIM building confirmations by 2025, with full-scale implementation around 2028. The Building BIM Promotion Roundtable has decided to establish a task force-type study system in addition to subcommittee-by-subcommittee studies and has established a Building Confirmation TF, Standardisation TF, and also a Strategy WG as a management organisation.

As technology development for *i-Construction*, research and development investment is being carried out by the Public/Private R&D Investment Strategic Expansion Program (PRISM), a budget of 2.3 billion yen was spent on R&D investment in FY2022. In this R&D, a BIM object library as a providing environment and a draft code of practice for BIM building confirmation was developed. PRISM will finish at the end of FY2022, and by that time the goal is to develop a common BIM usage environment for building production. The next phase of the R&D program is now under preparation. The name of the program is BRIDGE (programs for Bridging the gap between R&D and the *IDEal* society (*Society 5.0*) and Generating Economic and social value). The public call for R&D themes was scheduled in April 2023, and the selection of themes was scheduled for June 2023.

Awareness/Uptake

Most parties including contractors, designers and constructors engaging in private sector buildings and government agencies participate in the BIM promotion roundtable and make very enthusiastic arguments for promoting BIM.

The role of the consortium is growing with respect to PRISM and BRIDGE R&D investment. The BIM Library Consortium was established for the development of the BIM object library before starting PRISM investment, and a research committee was established for the BIM building confirmation for PRISM investment, and the related construction related organisations, private companies involved in design, construction and parts production, and software vendors cooperated with the consortium and

committee. They are working to develop a common BIM usage environment.

JORDAN

Education/Training

BIM has not been officially integrated into the core curriculum of higher education institutions, leaving a significant gap in formal academic exposure to this crucial aspect of modern architectural and engineering practice. Despite this, there has been considerable enthusiasm and proactive engagement with BIM tools and methodologies, particularly within architectural colleges and departments. These departments have established robust partnerships with industry giants like Autodesk, providing students with opportunities to acquire certification and hands-on experience with BIM software. This initiative reflects a strong belief among students that proficiency in BIM will enhance their job prospects and enable them to contribute more effectively to the architectural and engineering fields.

However, the discourse around BIM has been predominantly confined to the realm of architecture and design, sidelining other critical disciplines such as civil, mechanical, and electrical engineering. Recognising this imbalance, some progressive institutions, such as Al-Ahliyya Amman University, have begun to broaden the scope of BIM education. They aim to encompass engineering disciplines by focusing on its multifaceted applications, including project management, aligned with ISO 19650 standards.

At the forefront of integrating advanced technological tools into engineering education, the Faculty of Engineering at Al-Ahliyya Amman University has embarked on a significant update to its Civil Engineering Department curriculum. This update introduces undergraduate students to the practical applications of BIM tools, marking a pivotal shift towards more interactive and industry-relevant learning experiences. Within the unit named *Civil Engineering Modeling and Drawings*, the curriculum now incorporates Autodesk Revit for structural design, transitioning to Robot Structural Analysis for comprehensive structural analysis. This educational strategy is designed to bridge the gap between conceptual design and practical analysis, preparing students for the complex demands of the civil engineering field.

Further expanding the curriculum's scope, the unit *Computer Applications in Civil Engineering* has been tailored to leverage the common data environment offered by Autodesk BIM

360. This approach not only facilitates a hands-on learning experience in design and analysis but also promotes collaboration and active feedback, closely mirroring the collaborative workflows prevalent in today's engineering industry. Beyond structural modelling, the focus expands to include infrastructure and civil works design, utilising BIM tools not just as conceptual aids but as integral parts of the design, analysis, and project management processes.

Additionally, the *Construction Project Management* unit has been specifically designed to explore the advantages of 4D BIM in project scheduling and cost estimation. This focus allows students to directly apply their theoretical knowledge to practical, real-world project management scenarios, thereby enhancing their understanding of project lifecycle and delivery principles.

The *Contract, Specifications and Quantities* unit has been enriched with the principles of BIM to offer a forward-thinking perspective on construction management and economics. This strategic integration focuses on the transformative potential of BIM to streamline quantity take-offs and cost estimation processes, providing a more accurate, efficient, and automated approach to managing project finances. By leveraging BIM technologies, students gain insights into how digital models can significantly improve the precision of quantity surveys and cost control, setting a new standard for budgeting in construction projects.

Furthermore, this unit explores the relationship between BIM methodologies and international contract standards, particularly from the perspective of delivering digital models. Students are introduced to the concept of the 'kit-of-parts' approach and its relevance to prefabrication and modular construction, emphasising how these methods can influence contractual arrangements and project delivery. This approach not only aids in understanding the structural aspects of building manufacturing but also in grasping the legal and procedural frameworks governing modern construction projects.

By dissecting the intersections between BIM, contract specifications, and quantity surveying, the course equips students with the skills needed to navigate the complexities of contemporary construction management,

ensuring they are well prepared to contribute to the industry's future with innovative solutions and a deep understanding of digital engineering principles.

In addition to foundational coursework on BIM technologies, the Faculty of Engineering at Ahliyya Amman University has introduced an innovative unit within its civil engineering program titled *Special Topics in Civil Engineering*. This advanced unit is specifically designed to explore the cutting-edge applications of BIM tools in the realms of prefabrication, modularity, and regulatory compliance, emphasising the 'kit-of-parts' approach. This method, which breaks down complex structures into manageable, prefabricated components, represents a significant leap forward in construction efficiency and sustainability. Central to this unit is the application of Autodesk's latest software, Informed Design, which supports the students' understanding of modular construction from both a standards-based and a practical perspective.

By focusing not just on the modelling aspects but also on understanding the regulatory and standardisation processes involved in prefabrication and modular construction, the course aims to provide a comprehensive view of this innovative construction methodology. Moreover, *Special Topics in Civil Engineering* delves into the utilisation of BIM tools for enhancing sustainability in construction projects. It introduces students to the principles of digital engineering, enabling them to apply these concepts towards achieving greater efficiency and sustainability through automation. This part of the unit not only broadens students' understanding of BIM's capabilities but also encourages them to consider the environmental impact of their designs.

For postgraduate studies, particularly within the *Master of Structural Engineering and Project Management* program at Ahliyya Amman University, the integration of BIM marks a pivotal advancement in engineering education. The program introduces specialised units that delve deeply into the theory and practice of BIM, digital engineering, and the intricacies of international construction contracts, offering a comprehensive overview of BIM's application in the modern construction industry. One of the key units, *BIM Theory and Practice* is designed to guide students through the entire lifecycle of BIM operations. This

includes everything from crafting the initial business case to applying BIM in real-life scenarios. It emphasises the importance of understanding ISO 19650 standards for information management and provides practical, hands-on experiences that enable students to adeptly manage projects using BIM technologies. This dual focus ensures that graduates possess a robust understanding of both the theoretical underpinnings and practical applications of BIM, preparing them for leadership roles that require both management and technical expertise.

Another critical unit, *Digital Engineering and Structured Data for Semantic Interoperability* investigates the essential role of structured data in digital transformation within the construction industry. It focuses on achieving semantic interoperability through the Common Data Model (CDM), equipping students with the knowledge to use tools like data flow diagrams, taxonomy, and entity relationship diagrams effectively. Practical applications, such as parametric design with BIM visual programming tools like Revit Dynamo, are included to help students apply structured data concepts in real-world projects, enhancing their capabilities as digital project managers.

Additionally, the *Model International Construction Contracts* unit explores the integration of standard forms of contracts, such as FIDIC, NEC, and JCT, with BIM processes. This unit sheds light on the contractual dimensions of BIM, preparing students to manage the legal and procedural aspects of international construction projects. By examining how BIM methodologies align with contract protocols, the course provides students with a holistic understanding of the intersection between advanced technologies and traditional contract practices, further enriching their skillset for managing complex projects on a global scale.

NETHERLANDS

Education/Training

BIM is taught in all three technical universities of the Netherlands at both bachelor and master levels. All 14 universities of applied science with a built environment department are organised in the BIM Education Network by the national Building Digitisation Council (BDR). The network aims to exchange and develop educational approaches, experiences, and teaching materials. In practice, the member universities tend to stick to their own approach.

The Netherlands has over 40 institutions for intermediate vocational education (ROC's). BIM adoption by these institutions is also rising.

There are many commercial post-educational training providers, often connected to software companies. Their training is often considered to be more up to date than the courses taught in formal education.

In general, it is noticed that there is an abundance of education and training at the level of mastering specific (software) tools. There are considerably less courses focussing on roles, such as modeller, work planner or BIM coordinator and there is a fundamental lack of approaches that place the building process at the core, and how digitisation changes that process.

Initiatives/Organisations

The BDR is the successor of the former Building Information Council (BIR) and aims to develop strategic policies for BIM in the construction and civil works industry.

In 2019, the *DigiDealGO* was launched as an initiative to speed up the digitisation of the built environment. One of its main objectives is to foster the development of a digital framework for the built environment (DSGO).

The BDR's BIM Education Network was created in 2013 to raise BIM awareness among lecturers. In 2017 the network presented its first version of the minimum BIM level for BIM knowledge graduates of all 14 universities of applied science. The BIM Education Network organised its first annual BIM education conference in 2017. This conference was successfully repeated in 2018 and 2019.

Awareness/Uptake

There is strong growth in the diversity of educational offerings. In particular the essential 'soft skills' and organisational change are increasingly being discussed. There is also a strong undercurrent in the development of BIM-based quality assurance.

The development of knowledge leaflets by the BIR has helped create greater awareness in the industry about opportunities and possibilities created by using BIM. At this moment 5 knowledge leaflets have been developed and translated into English.

NEW ZEALAND**Education/Training**

buildingSMART Australasia has introduced the PCert course, a new international standard for BIM training. While NZ institutions currently do not offer this training, Australian universities and training providers provide these certified courses with international accreditation from buildingSMART. The NZ tertiary education sector has embraced BIM, incorporating BIM-specific content into their curriculum.

Local Revit User Groups in Auckland, Wellington, and Canterbury continue to host industry events and practical learning sessions. The national group BIMinNZ organises industry and learning seminars predominantly in Auckland, with recent events focusing on IFC and ISO 19650 discussions.

Initiatives/Organisations

In early 2023, MasterBIM introduced the Properties Selector tool, now available for free as open-source software in New Zealand. This tool aligns with Waka Kotahi (NZ Roads) and the NZ Waters standards, allowing users to select and save property characteristics as custom schemas. Key features include working with metadata schemas, exporting data in various formats, and supporting standards such as CBI, OBOS, NZ Asset Metadata schema, IFC, and COBie. For more information, visit: <https://bim.masterspec.co.nz/>.

The New Zealand BIM Handbook version 4.1, was released in November 2023, incorporating industry feedback to serve as a valuable resource for BIM practitioners in New Zealand. This edition emphasises alignment with ISO 19650 terminology and processes to enhance information delivery efficiency.

The New Zealand Construction Industry Council *NZCIC Guidelines* have been digitised and made available to the New Zealand construction sector since November 2023. The updated content integrates BIM processes into the wider commercial project roles and tasks, facilitating seamless project execution from initiation to handover.

NORWAY

Education/Training

The high implementation of digital solutions in the AEC/FM industry is well represented in education. The use of digital solutions, including BIM-based tools, is implemented in the curriculum for architecture and engineering students at the university level in Norway. This covers dedicated courses at the bachelor, master, and PhD levels. We also observed increased use of digital tools in the “traditional” education at architectural and engineering universities. However, no university has integrated pervasive and holistic progress in using digital tools and processes in their study program, with one exception. The Norwegian University of Science and Technology (NTNU) offers a 2-year master’s specialisation in digital design and construction processes.

Students also generally have good access to software. Most universities have good facilities for working with digital tools and processes, BIM labs with large active screens for teamwork, VR glasses, and other equipment. Students also take the initiative for increased digitalisation of their education. At NTNU, students in collaboration with buildingSMART Norway, established a student community for digital-related activities like courses in software, industry presentations, and lending out digital equipment like VR glasses, drones, screens, 3-D cameras, and more for free for students and researchers.

Norwegian software developers play an active role in offering free software, courses, project examples from the industry, and feedback for further development. Another trend is the increased use of tools for visual programming like Dynamo and Grasshopper, in addition to Python for Machine Learning, for exploring content in BIM models. So far, this has only been used in a limited number of student projects. Still, this opportunity indicates a trend where students with construction backgrounds explore software solutions in a way that traditionally has been dominated by informatics students.

The increased priority of sustainability enforces the use of more data and can be seen as a driver for developing and using more integrated processes. The Virtual Design and Construction (VDC) framework is used actively at two universities (NTNU and Oslo Met) to utilise digital tools to support improved processes.

The next challenge is the increased integration of BIM-based processes in existing (traditional) courses in an integrated way. Dedicated tools for a defined task, like authoring tools for design, calculation for structural analysis, and the simulation of energy are used in many traditional courses. A newly developed textbook called *BIM! Program and Process* has been developed by professors at NTNU and OsloMet. It has been developed to increase the awareness of change in the way of working and collaboration, supported by digital solutions.

BIM-related standards are to an increasing degree included in the curriculum. In this respect, the ISO 19650 series of standards has an integrating role to include other standards, requirements and processes. Increased priority of sustainability has been supported by new standards within product data templates (PDT) and environmental product declarations (EPD). This type of integrated solution is mostly at the Master and PhD levels. The number of PhD students within the digitalisation of the AEC industry has increased significantly in the last few years. For these students are the combination of digitalisation and sustainability a clear profile in most studies.

Oslo Technical Vocational College (Fagskolen Oslo) has offered a one-year, full-time BIM education in a multidisciplinary environment since 2008. The curriculum focuses on both practical implementation of BIM software and digital enhanced collaborative processes. Through close cooperation and integration with the AEC industry, students get hands-on experience with ongoing real-life projects. Fagskolen Oslo integrates training in specialised BIM disciplines like MEP, structural, architectural and infrastructural categories. Fagskolen Oslo also provides BIM education for construction workers who seek training in on-site use of BIM applications for the construction site.

Initiatives/Organisations

The buildingSMART Professional Certification program is now available in several countries, in Norway we expect to implement this certification program in 2023. The program is an international education benchmark with focus on openBIM format and is based on ISO 19650. The goal is for Professional Certification to become a requirement in the

building and construction industry for BIM projects.

buildingSMART Norway has 140 plus member organisations, representing 25% of the total AEC industry turn-over. 10% of buildingSMART Norway members are from the educational sector. buildingSMART Norway coordinates several industry initiatives and BIM User Groups for all disciplines, in a series of arenas. buildingSMART Norway's network activities has strongly increased during 2020. Together with several Norwegian organisations and members, buildingSMART Norway is involved in the development and revision of National and International standards for digitalisation of business processes. In order to achieve a better understanding of BIM, open standards and digitisation processes and to promote best practices from the industry, buildingSMART Norway has started a webinar series in collaboration with our members organisations.

Awareness/Uptake

The Government and its legislative body the Norwegian Building Authority are fully aware of the need for digitalisation in the building and construction industry. The Building Authority runs and supports several initiatives in collaboration with industry.

Several projects that show a good use of openBIM are on-going in Norway. In 2020 three Norwegian's were nominated as finalists at the buildingSMART Awards Program with two of the three Norwegian finalist winning a prize under the categories Client Leadership and Technology Leadership.

Finally, the focus on the use of open BIM and data interoperability is moving from the project phase to include also the operational and maintenance phase of a building, with asset and facility management integration. Extensive work is also going on for potentiating an open data flow for construction product information.

SINGAPORE

Education/Training

In line with the refreshed Built Environment (BE) Industry Transformation Map (ITM), Singapore's BIM education continues to play a pivotal role in training a competent workforce to support the BE ecosystem. The infusion of BIM curriculum in all Institutes of Higher Learning (IHL) Built Environment courses is a key focus area under the new Key Transformation Areas (KTA). Currently, 11 IHLs offer full-time and part-time programs with BIM/VDC(Virtual Design & Construction)/IDD(Integrated Digital Delivery) curriculum. Third-party BIM software educational vendors have played a crucial complementary role in training professionals. To date, approximately 21,000 students and professionals have been trained in BIM/VDC/IDD.

The Institute of Technical Education (ITE) has integrated BIM into skill qualification programs for architectural space design, civil and structural engineering design, and facility systems design, primarily focusing on software capabilities.

All five polytechnics provide advance BIM modules across various disciplines, including sustainability, DfMA and Smart FM related programs. Customised programs for firms as part of workplace training are also offered to address skills gaps of staff performing IDD-related roles.

Five out of six autonomous universities offer BIM modules in their bachelor and master programs. Notably, Nanyang Technological University and the National University of Singapore have launched Centres of Excellence in BIM to focus on nurturing BIM R&D capabilities.

As the training and education arm of BCA, the BCA Academy (BCAA) leads the development of Integrated Planning and Design (IPD) and IDD competencies across the entire value chain of the built environment sector. It offers academic, career conversion, and Continuing Education & Training (CET) programs. To enable professionals to upgrade knowledge and skills as well as to apprise industry of best practices and latest application of BIM technologies, BCAA organises seminars, workshops and suite of IPD short courses such as in the areas of BIM Modelling,

Computational BIM, BIM for Building Lifecycle and Facility Management as well as Data Analytics.

Aligned with the strong emphasis on developing a skilled workforce to meet the growing demand for a competent talent pool in support of the BE ITM, Integrated Work-Study Programme (iWSD) was launched in April 2023 incorporating BIM/VDC/IDD/IPD content spanning various disciplines across the construction value chain

(<https://www.bcaa.edu.sg/what-we-offer/academic-programmes/diploma/iwsd>).

Students will undergo three semesters of schooling, complemented by 18 months of workplace learning in BE firms. The inaugural batch of students will commence their work attachments from October 2024. These work-study programs have fostered expanded collaboration with advanced BE firms and IHLs for career and internships, aiming to produce a stream of fresh graduates equipped with robust IPD skills and interdisciplinary knowledge, enabling them to thrive in a collaborative environment. The graduate and post-graduate degree programs offered jointly with universities, such as Singapore University of Social Sciences and the University of Newcastle (Australia), are also infused with IPD curriculum.

Initiatives/Organisations

In line with the BE ITM, the emergence of BIM and new technologies offers an opportunity to transform the current regulatory approval process in Singapore. Since 2019, the Singapore regulatory agencies had embarked on a co-creation journey with the industry to redesign the regulatory approval journey for building works. Under the new process in CORENET X, industry players will be required to collaborate and coordinate their designs upfront prior to submission. With the aid of technological enablers, the various regulatory agencies will then collectively review the submission, collaborate digitally and issue a coordinated response to the project team. This changes the current practice of Qualified Persons (QPs), who are Registered Architects or Professional Engineers, dealing separately with multiple regulatory agencies and having to reconcile the differences thereafter, which may result in project delays.

The BCAA has designed courses to train industry practitioners, with a specific focus on design consultants as they will be the primary individuals responsible for implementing

CORENET X initially. To date, 2055 professionals have undergone training in CORENET X, and additional training sessions are in the pipeline to extend this training to all BE professionals involved in the implementation of CORENET X from 2024 onwards.

A national Skills Framework (SFw) for the Built Environment is available for the BE sector on key information, career pathways, occupations and job roles, as well as existing and emerging skills required for the BE sector. It outlines possible career pathways across or within eight career tracks, one of which is Digital Delivery Management (DDM). buildingSMART Singapore is the accreditation body for the Digital Delivery Management (DDM) Accreditation Scheme, which offers recognition of the skills and experience of digital delivery personnel working in Singapore's BE. This accreditation scheme is based on the *Skills Framework for the Built Environment* published by national skills agency, SkillsFuture Singapore.

At present, there are over 500 personnel accredited in Singapore, accredited across the four accreditation tiers of DDM Accreditation Scheme. Since 2023, major Government Procuring Entities (GPES) have progressively adopted DDM as an alternative requirement in selected tenders. As part of the Continual Professional Development (CPD) framework, DDM accredited personnel are required to show documentary evidence that they have attended 20 hours of training per year. For more information on DDM track, please refer to the following link (<https://ddm.buildingsmartsingapore.org/ddm-accreditation-overview/>).

Awareness/Uptake

BCA continues to organise the annual International Built Environment Week (IBEW) to provide a platform for industry leaders and renowned professionals from the global built environment industry to exchange ideas and experiences on policies, business solutions and technologies, as well as explore business opportunities.

SOUTH AFRICA

Education/Training

The University of Johannesburg, through the Centre of Applied Research and Innovation in the Built Environment (CARINBE) has introduced the first ever digital infrastructure delivery in the continent. The Master of Philosophy (MPhil) in Digital Built Environment, is being offered by the University to accelerate and raise the BIM tide in South Africa and beyond. The program is accredited the national body SAQA and carries 120 credits. This program is suitable for professionals who hold a degree at NQF level 7 in any engineering or computer science program and would like to become experts in digital infrastructure delivery.

In addition, the University offers continuing education programs, such as *Building Information Modelling* and *Digital Infrastructure Delivery*. The goal is to raise the digital infrastructure delivery awareness in the built environment. The program covers, building information modelling, digital design and management, digital asset management, building performance analytics, sustainable design and reality capture as well as principles of digital infrastructure delivery. In addition, hands on training on authoring tools is offered within the program.

Initiatives/Organisations

Centre of Applied Research and Innovation in the Built Environment (CARINBE)

The CARINBE, set up within the University of Johannesburg, South Africa, is an established research centre to provide credible information to the built environment supported by robust scientific research. Comprehensive and industry-applied research in digitalisation, sustainability, and safety is the main focus. The Centre has partnered with the BIM Community to drive digital infrastructure delivery in South Africa. In 2022/2023, the centre conducted a comprehensive digital transition survey using BIM as a proxy, across the country. The survey explored the current state of BIM implementation in South Africa and associated challenges. The survey findings were used to develop a position paper on digitally transitioning the South African built environment.

The Centre recently launched its Virtual Reality lab in partnership with Cype to drive extended reality applications and integration in BIM, and train students and professionals on industry

use cases. To provide a socially sustainable digital transition in the built environment, the Centre, in partnership with the South African Local Government Authority, is piloting digital applications to provide security to infrastructure assets in municipalities, with the core focus of the program being training programs on the usage of digital technologies to secure government assets. The project covers waste management, power distribution, and water infrastructure, among others. Technologies such as drones, sensors and IOTs are being deployed on the project.

Awareness/Uptake

The South African-wide BIM survey revealed increased awareness, with responses spread across its nine provinces. About 65% of the respondents indicated a level of awareness ranging from average to very high. However, 53% indicated they had not participated in at least one project where BIM was adopted. The results are not surprising, as shown in follow-up questions, which revealed that 37% had no BIM training, including seminars, workshops and webinars. In comparison, 52% of the respondents also indicated they self-funded BIM training acquired with no support/incentives from the government or employers. Regarding BIM implementation stages within organisations, 44% of the respondents revealed they were at the non-usage stage.

Findings also revealed low use of collaboration platforms, issues on BIM standards acceptable to all stakeholders, and data exchange still primarily through PDFs with minimal use of Authoring & Analysis tools and CDE. Governments and industry stakeholders are currently being engaged on a roadmap to overcome the challenges of adoption and implementation.

SWEDEN

Education/Training

In 2023, changes within the education system and industry took place that may have impacted different education programs and levels. For example, the Swedish government changed the main subjects and learning objectives for upper secondary education. Today, before the changes, upper secondary schools offered CAD-related practical learning goals in their curriculum. However, no comprehensive mapping of BIM or CAD-related education within the built environment has been carried out since 2021. It will be necessary to initiate a more detailed study to map out the changes.

From previous mapping (2021) we learnt that universities in Sweden offered:

- 8 Master programs (300 HP) with BIM education.
- 21 Bachelor programs (180 HP) with BIM education.
- 11 2-year university programs (120 HP) with BIM education.

Two new Masters programs (300 HP) are being developed at Jönköpings tekniska högskola and Linnéuniversitetet and will start autumn 2025.

Swedish higher vocational education schools (Yrkeshögskolor) offer 26 programs within the built environment. Most programs have courses focused on BIM applications and digital technology. The number of programs offered changes on a yearly basis due to industry demand.

A new mapping of BIM courses at Swedish universities and higher vocational education needs to be conducted for tracking changes compared to the last report. For example, AI and programming courses have been introduced in several programs and existing BIM courses are constantly being developed and updated.

Initiatives/Organisations

The BIM Alliance Sweden is a sector-driven non-profit organisation that works for development within the built environment with the help of BIM. The BIM Academy is a working group within the BIM Alliance that brings colleges, universities, and training

companies together on BIM related education and progress.

In 2023, the BIM Alliance established new working groups and initiatives were taken to coordinate workshops between the separate groups. The BIM Academy will be participating and contributing to several of them in 2024. The format will mostly be as digital breakfast meetings or workshops. Meetings and topics for the BIM Academy 2023 and 2024 will be common national guidelines within BIM (Nationella Riktlinjer), AI, and practical examples of BIM uses within education. The active members are Linköping University, Luleå University of Technology, Chalmers University of Technology, Royal Institute of Technology, Technical University of Jönköping, Dalarna University, Nackademin, City of Gothenburg YRGO, Yrkesakademien and STI.

InRoad, a collaboration between Aalborg University, Jönköping University, NTNU and the University of Oulu, and funded by EU Erasmus and the program for strategic partnerships for higher education has ended. The outcome of the project shows satisfactory results in choosing intensive workshops as a delivery method for teaching road design software. It enables the students to gain knowledge in the respective engineering topics, advanced digital tools, and concurrent engineering, all in the same workshop. According to Erasmus, “the project idea is very innovative and very relevant - based on a detailed needs analysis”. For more information, see: <https://www.en.build.aau.dk/web/inroad>.

Awareness/Uptake

One thing that may have a great impact on the development of BIM use in Sweden is the Swedish government commissioned Boverket (Swedish National Board of Housing, Building and Planning) to promote the digitisation of construction processes by developing support for public actors regarding BIM. Four proposals were made in the report from Boverket:

- That Boverket will be commissioned to produce proposed legislation on the regulation of BIM in collaboration with the Swedish Public Procurement Authority. These legislative proposals should be formulated in a way that enables a progressive introduction of the application.
- That the Swedish Public Procurement Authority, or another authority that the

government deems appropriate, be given a coordinating assignment to develop basic requirements for deliveries, based on ISO 19650, for use in public procurement for new construction or renovation of buildings.

- That Sweden should work to ensure that the European Commission mandates the European Committee for Standardization (CEN) to develop and manage a common classification system for the built environment.
- That the Board will be responsible for the task of investigating the set of requirements for the processing of building permits. Such an assignment should be organised with a possible coordination responsibility regarding requirements for IFC.

SWITZERLAND

Education/Training

Generally, training intuitions are growing constantly with courses offering more in-depth content. The fields include VDC, GeoBIM, Digital Construction, Coordination BIM, BIM2SIM, BIM for FM, Mixed Reality and Artificial Intelligence for BIM to name a few and finally BIM Certification. Several partners provide this part in Switzerland, focussing mainly on open BIM, technical universities and universities of advanced sciences offer a wide range of courses at an undergraduate and postgraduate level.

The universities in Zurich and Lausanne both push BIM forward by offering CAS, DAS and MAS programs:

- At the ETH Zurich (University of Science and Technology Zurich) CAS Digitisation, MAS Architecture and Digital Fabrication are part of the continuing education. The university also runs two research labs, the BRG (Block Research Group) and the National Centre of Competence in Research (NCCR) Digital Fabrication.
- As part of the digital degree programs, the EPFL (Ecole Polytechnique fédérale de Lausanne/Swiss Federal Institute of Technology) offers a complex introduction to BIM with 12 modules. The EPFL also conducts research on BIM based classification of building performance data for advanced analysis.

The universities of advanced sciences offer undergraduate programs as well as continuing education:

- The study program of the Institute for Digital Construction at the FHNW (University of Applied Sciences and Arts Northwestern Switzerland) focuses on changes triggered by digitalisation as well as changes concerning working techniques and mindsets in all areas of planning, construction, and real estate. The integration of VDC (Virtual Design and Construction) and IPD (Integrated Project Delivery) in all disciplines of construction is a clear priority. The continuing education modules (CAS, MAS) are carried out in cooperation with Stanford University.

- At ZHAW (Zurich University of Applied Sciences) continuing education concentrates on the field of Facility Management (“BIM for FM”) and Life Cycle Costs including BIM.
- The BFH (Berne University of Applied Sciences) in Biel focuses on wood construction. The CAS *Digital Planning, Building, and Using* is a general introduction to digital construction for the entire branch. The BFH also offers a two-day course on *BIM practice and basics*, including a buildingSMART certification. The CAS “Digital infrastructure” combines BIM and traffic infrastructure.
- The study course *Digital Construction* focuses on Building Technology and Structural Engineering at the HSLU (Lucerne University of Applied Sciences and Arts). This is the only program in the field of digital construction in Switzerland and is unique in Europe due to its interdisciplinary structure. The continuing education offers courses in Simulations with BIM as well as developing competencies for the ordering process.

In 2022, the CAS *Digital Construction* was established. This course provides in-depth knowledge of the digital value chain and data management over the lifecycle. A new six-day course on BIM-Basics and COBie (Construction Operations Building Information Exchange) Standards was also launched. To provide support for courses in *Digital Construction*, a digital Lab was established to give students access to advanced technologies, software, and tools as well as digital twins with different levels of detail to enhance the professional experience.

- The continuing education at the HEIA Fribourg (University of Applied Sciences and Arts — Western Switzerland) includes a CAS in BIM Coordination.
- The University Ost (East) at Rapperswil joins in with the module *BIM Basic Education* including the buildingSMART Certification Program. The program will expand to gardening and landscaping through the course *BIM to field – field to BIM* and will focus on the usage of machines and tools controlled by 3D data as well as

the data generated during this process.

Increasingly, private training institutions and large companies play a major role in the training field. Likewise, vocational schools in St Gallen, Sursee or Berne offer more and more courses in the field of BIM.

- The Gewerbliches Berufs- und Weiterbildungszentrum St. Gallen (GBSG) offers the following courses: *BIM – Basics (Individual Qualification buildingSMART)*, *BIM – Introducing BIM in a construction enterprise*, *BIM-Manager*, and *BIM Breakfast Talks*.
- Also mentionable here is the program of Campus Sursee with a vast extent of courses dealing with digital construction. The range covers courses in BIM basics, application of machines and drones, as well as a CAS *Digital Construction*. On top of that, an outdoor lab allows for experiencing BIM2Field under real conditions.

Software providers push mainly and not surprisingly the closed BIM side. For non-academic professionals, who plan to grow into the BIM area, an increasing number of training is offered. However, training and education on a more basic level is still only gradually being offered.

Initiatives/Organisations

In January 2018, the Swiss chapter of buildingSMART started to act. It is closely connected to Bauen digital Schweiz, an initiative of SIA (Swiss Society of Engineers and Architects), CRB (Swiss Research Centre for Rationalisation in Building and Civil Engineering), KBOB (Coordination conference of the building and real estate bodies of public clients), and IPB (Association of private, professional builders), being the legal entity for the chapter. One year later, the Swiss chapter started the Qualification Platform, which is used by numerous providers all over Switzerland, including the German, French, and Italian speaking regions.

In contrast to the closedBIM promoters, the buildingSMART Certification Program offers courses strengthening the open approach. The Swiss chapter increasingly oversees the registration of new training providers thus becoming an important player in BIM-related

education. Documentation published by Bauen Digital Schweiz and buildingSMART allows for a consistent overview of all programs over all stages of education. By now, 27 training providers are registered, with 4200 individuals certified since July 2019.

Awareness/Uptake

Professionals are increasingly aware of the fact that continuing education becomes important especially as far as BIM is concerned. Over the years, an increasing number of events and courses on this topic popped up all over the country.

As a new platform, the openBIM Forum started at the beginning of 2019, a congress driven by the major BIM software providers with over-average content delivered by first movers in the BIM market (architects, planners, contractors, owners).

In fall 2018, the Federal Council adopted its strategy, *Digital Switzerland* for the next two years, demanding in its action plan that the federal government and all federally affiliated companies make the BIM method mandatory from 2021 for real estate, and from 2025 for infrastructure facilities. Under the direction of *Digital Switzerland*, the Swiss Digital Day aims to make digitisation a tangible experience and promotes dialogue on the subject. The events encourage collaboration, new ways of thinking and vibrant debates on varied topics. One of these, of course, is BIM.

In June 2021 the BIM Industry Days, initiated by the SBB (Swiss Federal Railways), came into life. Based on a six-point plan, partners were invited to contribute to reach common goals. As one outcome, an initiative of training providers was established to unify and strengthen a targeted education. Although continued in the following months and years, there has been no substantial outcome.

TAIWAN

Education/Training

Architecture, Civil Engineering, and Construction related university or college departments used to teach CAD and visualisation/animation tools, e.g. AutoCAD, Sketchup, 3Ds Max, Blender, etc. in their required curriculum. Since around 2010, BIM-related courses have been increasingly introduced into these departments. Taking the Civil Engineering Department at the National Taiwan University as an example, it starts by offering an elective course called *Technology and Application of BIM* (3 credits) and subsequently offers more advanced BIM-related courses in its curriculum. To facilitate access to BIM education for college students and professional engineers, the department also provides online courses, such as *BIM Fundamentals for Engineers* and *BIM Applications for Engineers*, on Coursera, a popular global massive open online courses (MOOCs) platform, and NTU's OpenCourseWare (OCW). These courses, including both physical and online ones, were originally taught in Chinese, but, in recent years, English-taught ones have been offered and the online ones have attracted more than 110 thousand learners. Besides, the BIM Summer Program has been offered at NTU since 2014 for students from abroad. The program aims to help students understand the fundamental concepts of BIM and acquire essential skills to use BIM tools such as Autodesk Revit for BIM-enabled digital and green transformation.

The WorkSkills Competition (established by WorldSkills International in 1950, in Spain) adopted BIM as one of its new competition subjects in 2020, and the first competition was eventually held in 2022 due to the COVID-19 pandemic. Taiwan held a national competition in 2021 to select contestants to join this global event. For the BIM subject, the contestants must be under 25 years old, and the content of the competition is to reflect the WorldSkills Occupational Standards (WSOS), which includes work organisation and management, software and hardware, interpretation of the client brief, modelling, coordination of models, corrective modelling, data extraction, and visualisation. In 2022, Taiwan's representative contestant won a Silver Medal of Skill # 58 "Digital Construction-BIM" in the 46th WorldSkills Competition.

Besides education programs provided by universities and colleges, architecture-related

programs in several occupational senior high schools have introduced BIM into their curriculum. Several senior high schools have provided elective BIM courses for their students with 2 to 3 credits each. Furthermore, several research institutes in Taiwan have offered a variety of education and training courses. For example, the Taiwan Architecture and Building Center (TABC) has been offering a series of courses on the Application of BIM in architecture design, MEP practice, interior design, facility component modelling, quantity take-off, design integration, construction supervision, etc., as well as integrated application of BIM and GIS.

The British Standard Institution Taiwan (BSI Taiwan) and Taiwan Construction Research Institute (TCRI) have collaborated to provide a 3-day BIM training course on ISO 19650 Project Management and Information Exchange. Also, BSI Taiwan provides a 6-day BIM training course on ISO 19650 Project/Asset Information management. From 2018 to 2023, around 600 students have completed the two courses.

Initiatives/Organisations

In 2009, the BIM Research Center at the National Taiwan University (NTU BIM Center) was established to provide a platform for industry-academia-government collaboration on BIM adoption and applications in Taiwan. This signified the beginning of active involvement from academia in helping the industry and government with BIM adoption. Since then, some universities and companies in Taiwan started to establish their own BIM centers.

In 2011, the Chinese Institute of Civil and Hydraulic Engineering initiated the biennial Taiwan BIM Awards competition among construction projects and the first awards were given to 5 BIM application projects. It was clear that the scope of BIM applications has been expanded from mainly the design and construction phases in the early days to the whole life cycle, including building permit application review and facility management.

In 2015, the Taiwan BIM Alliance was established by the NTU BIM Center with support from Taiwan's Ministry of Science and Technology to use BIM as a driver to upgrade Taiwan's construction industry. The Alliance accepts only group members and currently has 50 industrial members, 6 governmental members, and 21 academic members.

The Taiwan BIM Task Group was formed in 2018. Its initiated members are BSI Taiwan, NTU BIM Center, Taiwan BIM Alliance, TCRI, Taiwan Architecture & Building Center (TABC), and Taiwan Institute of Built Environment Lifecycle Management. The goal of the task group is to help Taiwan's construction industry apply BIM as a stepping stone for transformation into the digital era and eventually achieve the goal of sustainable and smart living.

Awareness/Uptake

In 2014, Taiwan's central government started to promote BIM Applications. After a few years of test runs on BIM applications in some public construction projects, almost all major national projects now require BIM applications. Several local governments, especially New Taipei City, Taoyuan City, and Taipei City, require BIM applications in their public construction projects, helping push the industry to be BIM-ready. One government effort to mention is the New Taipei City government's implementation of a BIM-based building permit application review platform that requires the submission of BIM models for automated review of design regulations for building permit applications. Also, design-build projects are mostly encouraged for BIM applications in Taiwan. However, Taiwan has not established national BIM standards yet. Only some local governments or national agencies have developed their own guidelines for BIM applications.

From the 2013 Taiwan BIM Awards, the increase of BIM adoption in the industry can be obviously seen in the early 2010s and there were more BIM applications by construction companies and owners. BIM applications by engineering consulting firms were more mature and extended to assisting the construction partners in the construction stage. One of the largest construction companies in Taiwan demonstrated how they applied BIM for construction management and made sure the BIM model was the only up-to-date source for consistent construction drawings. A new BIM service company spanned out from the construction company that built the National Kaohsiung Center for the Arts project. It started to provide BIM-based construction management tools as services to other construction companies.

Most major design firms in Taiwan have a high degree of BIM capability to handle BIM design

projects and continue to deepen BIM applications in their design process. Recently they have started to use BIM as a driver to transform their design process for achieving design automation and smart design. They also provide BIM services for the owners and construction firms. For example, one engineering consulting company has developed facility management tools for owners to manage the maintenance and operations of public infrastructure.

For a leading local consulting firm in Taiwan, BIM techniques are used not only in the design stages for collaboration but also in the construction stage, especially for health and safety issues. For example, one firm developed a photogrammetry-based procedure to build VR scenes integrated with BIM models. Site engineers can realistically experience different situations through VR helmets before construction starts. This helps a lot in personnel training to avoid dangerous actions and save lives.

For most major construction companies in Taiwan, although they have different focuses and degrees of BIM applications in their construction management, they are all aware of what BIM applications can help them in the pre-construction examination on design integration and constructability, construction management coordination, quantity take-off, quality assurance, risk elimination, construction safety, etc. Several companies have already integrated or started integrating BIM applications into their project management systems, including the development of APPs on handheld devices for construction quality inspection and issues management. One construction company has also developed a BIM-based facility management system for a public construction project.

After so many years of BIM promotion and applications in Taiwan, major designers and contractors in the construction industry have all been equipped with good BIM capabilities, and more and more owners, including governments, are currently requiring BIM applications for facility management.

With the availability of BIM-related ISO standards, several design firms and construction companies in Taiwan have completed ISO 19650 series certification. One of them even qualified for the ISO 19650 Parts 1, 2, and 5 BIM Level 2 Kitemark Certification,

the first construction company in the APEC area to complete this certification. Up until 2023, 10 companies have already completed the ISO 19650 series certification. In 2021, three experts from the same construction company were successfully awarded the international BIM Qualification - BSI BIM Project Information Certified Professional. As the first pilots globally, they were the first BIM managers in Taiwan to be awarded the recognised personal certificate for demonstrating BIM competency in a formal way. This indicates the determination and maturity of construction companies in BIM applications. It can also show that some construction companies in Taiwan have been well aware of the necessity of implementing BIM standards into their business process.

UNITED KINGDOM

Education/Training

The BIM Academic Forum (BAF – discussed later) published *Embedding building information modelling (BIM) within taught curriculum* in 2013 and *Current position and associated challenges of BIM education in UK higher education* in 2015. The latter report indicated that BIM is now becoming widespread across the various levels of higher education, albeit ad hoc and without consistency. In the main, this tends to be driven by individual academics or schools/departments that have a particular interest in the area of BIM and recognise its importance in the education of professionals.

Over the last few years, a number of BIM specific programs at master's level have emerged. A number of BIM specific BTEC level programs have also now begun to emerge. Apart from architecture and construction related disciplines, there are overall low levels of interest in BIM incorporation in teaching across built environment related disciplines. At the cutting edge where BIM is fully embedded into programs/modules, architecture maintains a significant edge over all other built environment disciplines.

BAF held its first international conference at Glasgow Caledonian University, 13th-15th September 2016. This brought together delegates from both industry and academia to discuss aspects around Education & Training, Process & Standards, Strategy & Implementation, Knowledge Management & Decision Support, BIM Maturity & Assessment, Asset Handover & Operational Management, Technology. The program also included a workshop to explore establishing a European BIM Academic Network to bring together the European national BIM academic forums. BAF are currently focusing on taking the first report of embedding BIM within the taught curriculum forward by drilling down to disciplinary perspectives at the undergraduate level. BAF are also aligning their activities in support of the UK BIM Alliance, and the Upskilling work stream, in particular.

Within the UK, Secondary, Further (FE) and Higher Education (HE) are devolved matters and in Scotland these fall within the Scottish Government's remit. According to sources published in 2018, Scotland has 26 FE and 18 HE Institutions. Although the Scottish

Government acts as the funding agency for HE built environment programs, accreditation is normally undertaken by professional bodies (PBs). During 2019, the focus for several built environment PBs was supporting the transition from the PAS 1192 to the ISO 19650 suite of BIM standards.

The Scottish Qualifications Authority (SQA) is the executive non-departmental public body of the Scottish Government responsible for accrediting educational awards at secondary and FE levels. The SQA acts as a single awarding body to devise, develop and validate qualifications and quality-assure education and training establishments which offer SQA awards. The SQA also publishes the Scottish Credit and Qualifications (SCQF) framework which offers a structured and incremental pathway (Levels 1-12) for education and training which spans between secondary and tertiary level qualifications and maps equivalences between FE/HE provision and workplace-based learning programs.

Within FE provision, the current suite of built environment awards is being refreshed. The SQA's Architectural Technology review team are in the process of constructing revised HNC and HND programs. On a very positive note, it appears that within named awards, interdisciplinary activities will have a raised profile. It is likely that the BIM Professional Development Award (PDA) will be offered as an optional 30 credit Unit. The BCTG Construct funded research project hosted by Glasgow College has now published a blended learning resource to help Scotland's construction sector close technical skills gaps by offering site supervisors access to online learning resources including an introductory module in BIM.

A number of HE centres including Napier, Heriot Watt, Strathclyde, Glasgow Caledonian, the University of Edinburgh and the University of West of Scotland continue to engage with BIM, either through the provision of named awards and/or by embedding BIM/digital in undergraduate/postgraduate teaching and research. Pockets of expertise have developed. These include Glasgow School of Art Simulation and Visualisation facility which explores interfaces between science, technology using advanced 3D digital visualisation and interaction technologies. The University of Edinburgh's *Scan-vs-BIM* concept has investigated the comparison of reality capture 3D point clouds with BIM models to

offer opportunities for enhancement of construction project delivery, for example with quality control across design and construction processes.

The Robert Gordon University's Scott Sutherland School of Architecture and Built Environment continues to participate in cross-discipline built environment projects through European ERASMUS links and the International Congress for Architectural Technology (ICAT) networks. Collaboration is developed through partnerships with centres in Spain, Netherlands, Germany and Denmark. Typically, undergraduate projects develop simulated BIM projects in team-working environments framed by real-world protocols such as ISO 19650. These projects use digital media to facilitate developing an analytical approach to deep learning in areas fundamental to built environment education; site appraisal, brief development and environmental analysis.

Construction Scotland Innovation Centre (CSIC) is one of eight industry led and demand driven Innovation Centres supported by Scottish Funding Council, Scottish Enterprise, Highlands & Islands Enterprise and 14 Scottish University partners. CSIC's remit is to support businesses in delivering transformational change in construction. CSIC's BIM in Practice program was developed to support businesses from their initial awareness of BIM practices to the continuous development of their BIM journey, offering support at all the following stages:

- Awareness: For businesses unfamiliar with BIM, introductory workshops offered an overview of the benefits of working with BIM can bring to an organisation and the practices and processes involved. These workshops were hosted at the CSIC Innovation Factory near Glasgow, by outreach at various sites across Scotland and as an e-Learning module.
- Understanding: Acknowledging that BIM requires significant investment and commitment of resources to any organisation considering adoption, the CSIC BIM For Business Leaders e-Learning Module was designed to enable greater understanding of BIM by CEOs, finance directors and other senior leaders involved in strategic decision making.
- Implementation: Covering the areas involved in implementing BIM such as

People, Processes, Systems and Practices, these workshops supported this stage in an organisation's BIM journey. Eight business focussed events were held throughout Scotland. In addition, four workshops focused on particular industry groups such as architecture and design. These workshops provided greater detail on the specifics of implementing BIM for businesses.

Since 2015, the *BIM Regions* have been actively seeking partnerships with local Higher Education Institutions. The London and SE BIM Region formed a partnership with the University of Westminster and ran a series of free BIM Events aligned to its master's program. *thinkBIM* is run by the Centre for Knowledge Exchange at Leeds Beckett University in partnership with the Yorkshire and Humber BIM Region. The South West BIM Region is run in partnership with University of West England. The *BIM Academy* is partnered with Northumbria University.

Design, Engineer and Construct (DEC), run by Class of Your Own, is an accredited learning program for secondary-school age students and has been expertly developed to create and inspire the next generation of Built Environment professionals. Class of Your Own are leading the *BIM4Education* initiative. This initiative has recently been awarded *CITB* funding to get teachers and students excited about BIM and construction. One published report has shown how the DEC program has worked well in Manchester as a partnership between the University of Salford and St Ambrose Barlow RC High School.

There are now many providers of BIM training within the UK. As identified above, the BIM Regions have partnered with local universities to provide free events. Other providers of paid for content include:

- Professional Institutions:
 - . Royal Institution of Chartered Surveyors (RICS).
 - . Chartered Institute of Architectural Technologists (CIAT).
 - . Chartered Institute of Building (CIOB).
 - . Institution of Civil Engineers (ICE).
 - . Building Services Research and Information Association (BSRIA).
 - . Building Research Establishment (BRE).

- . Construction Industry Training Board (CITB).
- . National Federation of Builders (NFB).
- . British Standards Institute (BSI).
- The *BIM Campus* provides a six-week intensive course.
- The B1M is an online video resource which includes a *BIM for Beginners* program.

Many of the AEC companies have run their own in-house training programs which are compulsory to attend and require a certain level of attainment.

There is significant body of research being undertaken into BIM. Each Higher Education Institution has its own research program and there are also numerous Knowledge Transfer Partnerships (KTPs) being undertaken. *KT4BIM* involves BIM4SME acting as a client to a virtual project with numerous KTPs; the objective is to achieve a Level 2 compliant project.

Initiatives/Organisations

The UK Government influenced a significant movement within the UK AEC industry by requiring the use of BIM on public sector projects in its *2011 Government Construction Strategy*. The primary objective of the strategy was to sustainably reduce the construction costs incurred by the public sector. BIM was identified as one of the principal initiatives to achieve the objective and was supported by the creation of the *BIM Task Group*. *Training and Education* was one of the Task Group's four work-streams and a key output was the *BIM Learning Outcomes Framework*. As a consequence, there has been a significant increase in the provision of formal academic qualifications, training, accreditation and research.

The subsequent *Government Construction Strategy 2016-2020* maintained the emphasis on developing digital and data capability in construction, although the BIM Task Group was no longer funded to support the wider adoption of BIM. The formation of the *UK BIM Alliance* has taken on the mantle from the BIM Task Group and there is a work-stream dedicated to upskilling the industry. The Alliance was formed in late-2016.

The BIM Task Group instigated a community of special interest groups with the aim of "raising awareness of BIM and promoting a

shared understanding of the value proposition and issues affecting the implementation of BIM", as stated in the *BIM4 Community Charter*. Each group determines their own approach and certain groups are seen to be significantly more active e.g. *BIM4SME* and the *BIM Regions*.

The BAF is the BIM4 Community special interest group representing Higher Education. Formed in 2011, BAF consists of a group of representatives from a large number of UK universities, with the aim of creating a dynamic collaborative group to enhance and promote teaching and learning together with the research aspects of BIM, therefore serving as a conduit between industry demands and BIM education in higher education institutions.

Scottish Government aspires to be at the forefront of the digital economy and is resolute that digital technologies will form an integral part of the country's transition to a low carbon economy. The use of BIM Level 2 was introduced by the Scottish Government in April 2017 with a view to encouraging its adoption across public sector contracts. The overall objectives were to increase efficiencies, reduce costs and promote collaboration within the Scottish construction industry. A wider ranging challenge facing built environment educators is how best to equip undergraduates with skills necessary to support industry across a range of digital-centric themes which research has identified as being key to forward travel for construction including:

- Higher definition surveying and geolocation, rapid digital mapping and estimating.
- Next generation 5D building information modelling.
- Digital collaboration and mobility, moving towards paperless projects from the office to the workforce.
- The Internet of Things and advanced analytics – intelligent management of built assets.
- Future-proof design and construction – designing with methods and materials of the future.

These imperatives are likely to assume greater urgency in a post COVID-19 world as construction regroups, recalibrates and develops robust strategies to ensure survival as a viable industry.

As digitisation pushes the boundaries of BIM and what it means to a range of built environment stakeholders, there may be growing demand for built environment education to support wide ranging digital processes which underpin the development of environmentally sensitive and necessarily resilient solutions for future buildings/infrastructure. In that context, contemporary reference standards such as ISO 19650 will fit within a bigger picture framed primarily by construction's response to the climate emergency.

Scottish Futures Trust (SFT) is Scottish Government's agency tasked with improving publicly funded infrastructure investment. SFT liaises with the public and private sectors to deliver value-for-money on all public sector infrastructure investment across the country. The SFT's BIM Portal offers a range of online tools. These tools are designed to facilitate decision making to support BIM implementation involving the procurement of public sector building and infrastructure projects. These online resources include the SFT Grading Tool which predicts the level of BIM maturity which could be appropriately applied to a project, a return on investment calculator, whole life appraisal and BIM viewing tools.

Awareness/Uptake

The government's BIM requirements and the subsequent activity of the BIM Task Group and the wider BIM community has significantly influenced the awareness and take up on BIM within the UK. This is evidenced above by the broad range of support and resources available to via the UK BIM Task Group Website, the BIM Regions and BIM4 groups such as BIM4M2 and BIM4SME. This is supported by a frequent program of conferences run by amongst others the professional institutions.

In addition, institutions and industry related journals have sections on their websites specifically focused on BIM, which together with the plethora of BIM-specific resources such as *BIM Plus*, support the growing awareness of BIM within the UK.

The proposed program of the UK BIM Alliance includes a work-stream focused on Awareness and being the champion for BIM Level 2. The *Government Construction Strategy 2016-2020* indicated that progress had been made in

“developing digital capability in design and construction, with all departments on target to procure assets using Building Information Modelling (BIM) Level 2 by 2016”. The strategic objective within this strategy is “increasing BIM Level 2 maturity across government will enable departments to gradually move to BIM Level 3, which would support a fully integrated and collaborative process” (point 25).

The Government in conjunction with industry will develop the next generation of digital standards to enable BIM Level 3 adoption under the remit of the *Digital Built Britain Strategy*.

In common with the rest of the UK, construction in Scotland faces many well-rehearsed challenges. A relatively small core of major Tier 1 contractors is supported by long supply chains of sub-contractors and suppliers. COVID-19 has now interrupted many projects, causing significant delays not least because supply chains have been severally disrupted.

Some of the largest construction firms active in Scotland, are UK-based, others are controlled from abroad. Low levels of investment in training and cash flow challenges are among factors which mitigate against movement away from established business models. Construction has a complex and organic structure, is risk averse, slow to react to change and does not respond well to force feeding.

Feedback suggests that the Level 2 BIM methodologies promoted by the UK Government from 2011-2016 have not had significant impact on many construction firms. Despite Scottish Government's aspiration to develop a digitally enabled world-class construction industry, engagement with BIM is perceived to involve significant risk for many of the SME and micro-organisations which comprise 90% of Scotland's construction sector by numbers.

Feedback from one university actively involved in partnering with large contractors suggests three levels of contemporary activity. At the first (highest) level contracting organisations may regard BIM as a sub-set of initiatives to digitise all business processes with a view to eliminating waste, adding value and incorporating automation where possible. That

is a trajectory which moves towards the Industry 4.0 model which originated in Germany.

At the second level, contractors may be using BIM models, but often with gaps in workflows for many reasons including engagement and operational challenges within supply chains. The third level is *business-as-usual* which suggests little or no engagement with BIM processes. It is thought that many/most housebuilders in Scotland would fit the third category. Around 1,800 firms are directly engaged in house building activity in Scotland. 8 of the country's top 150 companies are residential house builders. That profile suggests a significant gap when a key player in the Scottish construction sector does not appear inclined to engage with BIM processes.

Although various strategies and interventions continue to support the development of BIM education across FE and HE, clearly Scottish Government's support for publicly funded projects to be BIM enabled has not transformed the construction sector. Post COVID-19, sustainable development goals are likely to feature more significantly in construction education/practice for the foreseeable future. Embedding strategies for resilience into business plans may be key to the survival of many construction related businesses.

In November 2017, the UK Government launched a centre of excellence in Cambridge to champion the "digital revolution" in the built environment. The Centre for Digital Built Britain's primary function is to assist with delivery of a smart digital economy for construction and infrastructure. Central to that initiative is the concept of digital twins. The aim is to develop digital protocols which will underpin transformation of the UK construction industry's approach to planning, constructing, use and maintenance of buildings/infrastructure. In that context, the UK Government set out a clear vision and powerful agenda for harnessing the power of digital technology, data capture, and analytics. The extent to which the initiative will harmonise with or overtake ISO 19650 BIM imperatives and impact on education/training for Scotland's construction sector remains to be seen.

UNITED STATES

Education/Training

There are 118 universities, both private and public, that are accredited by the National Architectural Accreditation Board (NCARB) to provide undergraduate, graduate and doctoral programs in Architecture. The coursework, focused on BIM in particular, range from direct *Autodesk Revit* coursework at the Georgia Institute of Technology to *BIM in Construction* at Montana State University, just to identify a few.

A number of universities also provide master's degrees in BIM Management as listed at the University of Miami, in Miami Florida, and Computer Graphics Technology at Purdue University. Stanford University and California State University also offer coursework in the Technology of Digital Graphics, among others. There are also community-based colleges too numerous to name that provide coursework in BIM with Revit. However, this coursework does not lead to an accredited degree in Architecture which is required in the US for licensure.

A good number of universities provide research programs for advanced degree candidates focusing on a range of topics including *Design Technology* at the Georgia Tech School of Architecture and the Texas A&M University *BIMSIM Lab* which focuses on Building Information Modelling and Simulation. The University of Hawaii at Manoa also offers a Doctor in Architecture. A good number of universities now offer online bachelor's degree programs.

The following universities and colleges provide Specialised BIM coursework either as integral to the B Arch program or as an alternative course plan: University of Arkansas, Georgia Inst. of Tech., Stanford University, John Brown University, University of Washington, University of Southern California, Pennsylvania State University, Purdue University, Philadelphia University, Montana State University, California State University, Milwaukee School of Engineering, Clemson University, Wentworth Institute of Technology, Arizona State University, NYU School of Professional Studies.

Community Colleges also provide coursework, as at the Seminole State College of Florida, offering a 3-credit course for 3D modelling including Revit instruction as a standard

summer course, though there are many others providing similar education.

The American Institute of Architects (AIA) has for years supported the American Institute of Architecture Students organisation (AIAS) which is an independent, non-profit organisation and completely run by students from across the country. The organisation aims to promote the advancement of architectural education in the US. The AIAS Learning, Design, and Technology Task Force provide an online tool that provides an extensive listing of software packages that graduating students may encounter in the design field. These packages are grouped into the following categories: Drafting (CAD), Animation, Illustrative Drawing, Digital Modelling, Rendering, BIM, Diagramming and Video. Each category provides links to tutorials and instruction for the different platforms.

The Association of General Contractors (AGC) continues to sponsor and provide a structured program for those interested in a path in Construction Management obtaining certifications in the areas of Construction Management-BIM. The coursework aims to “enhance career development opportunities for individuals and improve the performance of construction companies and the industry”.

The first module titled *Building Information Modelling* includes 32 hours of intense study. According to their website, “two national credentials for Building Information Modelling and Lean Construction. Those that complete the entire BIM Education Program or Lean Construction Education Program are eligible to sit for an exam to earn a Certificate of Management-Building Information Modelling (CM-BIM) or Certificate of Management-Lean Construction (CM-Lean)”.

Initiatives/Organisations

The United States General Services Administration has produced, back in 2003, *The National 2D-3D BIM Program*, which has had a strong influence on the rate of adoption by the design/construction community by mandating its use on all GSA projects. The recently published *GSA BIM Guidelines for Revit* include guidelines for data submittals, roles and responsibilities, and technical standards and are now required as part of the BIM Execution Plan for all GSA projects.

Many states, including Wisconsin and Connecticut have adopted a similar mandate with other states like Massachusetts, Utah, Georgia, Virginia, Washington and Connecticut also looking to do so. This activity at the state level has put an onus on universities to apply more emphasis on BIM education and facility standards to include BIM technology. Indiana University and Penn State University have both issued BIM standards on all campus projects of 5 million or more in construction cost.

Other organisations like the National BIM Standard-United States® (NBIMS-US™) by the National Institute of Building Sciences, 2015 (NBIMS-US) provides consensus-based standards through referencing existing standards, documenting information exchanges and delivering best business practices for the entire built environment. The buildingSMART alliance is among the list of the technology programs. Other organisations leading the way towards national BIM adoption include:

- The CAD BIM Technology Center: According to the center’s website, the center sets standards, promotes system integrations and provide assistance for the installation, training, operation and maintenance of BIM based systems.
- The Naval Facilities Engineering Command Building Information Management and Modelling: The NAVY claims to be the first Federal Government Agency to leverage BIM with the goal of digital management of facilities. Their focus has been on standardised delivery of digitised facility data, 2D drawings and 3D parametric models.
- The Air Force Building Information Modelling for MILCon Transformation: The agency under the *USACE ECB 2018-7 Advanced Modelling Requirements on USACE Projects -- Category: Directive and Policy* sets the requirements for the advanced modelling requirements on all USACE projects. The policy states as one criterion: All Army and Air Force Civil Engineer Center (AFCEC) (ref d) design and/or construction projects, regardless of funding source or acquisition method, must utilise advanced modelling to generate design, construction, record,

and space utilisation drawings deliverables.

- Department of Veterans Affairs: The agency provides BIM standards covering all aspects of project submission including items like the Room data sheets and drawing deliverable requirements.

CONCLUSION

As reported in previous years it is clear from the responses received that BIM education and BIM awareness/uptake is still at different levels of implementation across the globe.

Most countries/regions are reporting BIM education being provided to Architecture Engineering and Construction (AEC) students by their higher education and technical training institutions. In general, the number of courses being offered is increasing, but the trend is not consistent across all countries/regions. This may be an indication that in countries/regions where BIM implementation is more well established, course offerings may be reaching its saturation point.

Furthermore, while the cumulative total number of BIM-trained students/professionals continue to grow year-on-year, in some countries/regions, the rate of growth is slowing. Generally, awareness of BIM continues to spread in all countries/regions, with a reach beyond just architecture and engineering, but also increasingly involving software and hardware providers, and regulators. However, this has not necessarily translated to an equivalent uptake.

As reported in previous years, many countries/regions are reporting that the content of courses being offered have expanded to include more sophisticated elements of BIM, such as BIM for FM, costing, openBIM information exchange and BIM management. This change in course content is consistent with increasing public and private demand as organisations realise the benefits of BIM beyond design modelling, but also for procurement, construction management, operation, and maintenance of assets. In particular, there has been an increased interest in integrating artificial intelligence with BIM, and on improving sustainability outcomes of building and infrastructure projects using BIM.

Some countries/regions have seen an increase in course offerings. However, the way content has been delivered remains varied across the institutions with new BIM-related courses being offered in some institutions, while others are integrating BIM-based processes into existing courses. There continues to be strong emphasis on the complementary nature of collaboration between education institutions

and industry organisations, with a focus placed on real-life experiences. This has acted as a catalyst for partnerships between the public and private sectors.

BIM competitions, promoting practical and collaborative use of BIM among higher education students continue to be run by education institutions. The level of interest in these competitions also appear to be increasing significantly.

Some countries/regions have developed or are developing BIM standards and guidelines. Notably, the importance of standardisation and alignment of terminology and processes across the industry for efficient information delivery has been recognised. Many countries/regions are adopting or incorporating the ISO 19650 series, *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)* in their guidelines.

The adoption of BIM on public projects at the national and local levels continues to be varied across countries/regions. The slow adoption may be due to a lack of BIM standards, information standardisation and structured BIM educational coursework consistent across educational institutions in those countries/regions. For countries/regions advanced in BIM implementation and where BIM implementation is a requirement for the award of projects, challenges in having the required hardware to support complex BIM applications have surfaced. This will likely become a more prevalent issue with the implementation of BIM in processes beyond construction.

Finally, as observed in previous years, liaison and partnership between education providers and industry is improving, which should ultimately lead to a coordinated solution of the training being provided, meeting the needs of the industry. This will bridge the gap between the theoretical knowledge of researchers and educators with the practical skills of practitioners, allowing graduates to be well equipped with BIM capabilities.

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