NATSPEC// Construction Information

INTERNATIONAL CONSTRUCTION INFORMATION SOCIETY

BIM EDUCATION - GLOBAL – 2023 UPDATE REPORT

ISSUE VERSION: V10.0

ISSUE DATE: May 2023
COMPILER: Tom Banh (NATSPEC)
CONTRIBUTORS: See list at end of report

EXECUTIVE SUMMARY

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

Each year the countries/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/regions have provided input, expanding the scope of the original report. This tenth edition of the report includes information from 22 countries/regions.

As reported in previous years, most countries/regions are reporting BIM education being provided to Architecture, Engineering and Construction (AEC) students through their higher education and technical training institutions (vocational education). Some countries/regions have also reported the incorporation of BIM into the relevant course curricula at secondary education institutions. At the undergraduate and post graduate levels, most countries/regions are reporting a significant volume of courses and subjects available. However, there has generally been a slower uptake of BIM in education institutions across South Africa and Argentina.

In general, the number of courses being offered is increasing, as awareness of the application of BIM continues to rise. The content of such courses has now expanded to include more sophisticated applications of BIM. Course content such as BIM for costing, FM, openBIM information exchange, BIM management, digital twins etc. are being taught to complement the change in industry focus from simple design modelling to the application of BIM for the whole building or infrastructure life cycle. Alongside this, there has been an increased interest in the integration of virtual reality with BIM for risk and construction management.

Virtual/online courses continue to be offered as a teaching alternative, even as the effects of the global pandemic have tapered. This has given students the opportunity to access BIM education which otherwise may not have been possible. Face to face teaching methods continue to be offered, with BIM competitions being run to promote practical and collaborative use of BIM among higher education students.

Many countries/regions have implemented BIM requirements or are considering implementation of BIM requirements for the award of new public projects at the national or local levels. However, in some countries/regions, adoption remains slow due to a lack of BIM standards, information standardisation and structured BIM educational coursework consistent across educational institutions.

Some countries/regions have also emphasised the importance of sustainability in the built environment. This has been a key driver for continued development and implementation of BIM, and the application of data for improving productivity, efficiency, and health and safety.

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 the tenth edition of what is now an annual update to the original report. In the updated versions since the original 2014 report, additional countries/regions have provided input, expanding the scope of the original report. This tenth edition of the report includes information for 22 countries/regions.

Early in 2023 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.

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 levels in South Africa. BIM training is 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 were 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 is 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 have been affected by the pandemic during the last two years, 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-19.650 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 enrolees. 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. Of these, 24 institutions claim to have a noteworthy uptake of BIM in their programs. BIM education in these institutions is included across a wide range of courses and schools/faculties. This includes the Faculty of Science, Engineering and Built Environment at Deakin; School of Built Environment at QUT; School of Natural and Built Environments at UniSA; Department of Civil and Construction Engineering at Swinburne University of Technology; Bond University; and the Faculty of Engineering and IT and Faculty of Architecture, Building and Planning at the University of Melbourne, among others.

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. In total, 76 courses across the 24 institutions have incorporated BIM-related subjects in 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, 6 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 at 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.

Despite the promising outlook and these developments, such efforts are still in their infancy. BIM education at Australian universities should be evolved into one of incorporating various dimensions of DE with the elements below incorporated into the AEC-related curricula:

- BIM integration with other advanced methodologies like VR, AR, laser scanning and Internet of Things (IoT), digital twins.
- Procedures and tools for data extraction from BIM models and analyses of such data.
- Defining assessment tasks in the form of multidisciplinary projects with students participating from various schools, faculties fields of study beyond AEC.
- Management of data and information across the entire supply change of built assets.
- Contractual aspects associated with BIM and DE. This must entail linking smart contracts and Blockchain technology with BIM implementation efforts.

Apart from the above gaps to be filled, early findings of research studies indicate that BIM education in Australian universities needs to include recent standards for information management, such as the AS ISO 19650 series. 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, most of them offer no independent degree in BIM. However, 21% have independent degrees in BIM or offer BIM as a specialisation or major within the list of their programs.

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 – out of 24 – 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, the University of Melbourne offers standalone subjects in Building Information 'Modelling' and 'Management'; 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*; and the University of Western Sydney now have 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. The University of Melbourne now offers Micro certificates in BIM through the Faculty of Engineering and IT.

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. As an example, Deakin University delivers planning and scheduling subjects with 4D BIM among the syllabus. At the University of South Australia, BIM for building code checking (building surveying) has been taught since 2018, utilising Autodesk Navisworks in *Integrated Project* (4th year subject), with 4D and 5D BIM being taught too. At the University of Melbourne, BIM is incorporated in *Construction Measurement*. The *Digital Construction* unit at the University of New South Wales; and Queensland University Technology with the *Advanced Building Documentation* unit, all fall within this category. Subjects such as *Intellectual property rights (Data Exchange)* at Bond University are devoted to micro-credential courses adopting the buildingSMART Australasia BIM framework. So too, 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.

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. 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 also been providing an *Introduction to BIM* presentation to undergraduate students at universities across Australia for the past 10 years.
NATSPEC also provides industry seminars on the use of the *NATSPEC National BIM Guide*, *NATSPEC BIM Management Plan*, the *NATSPEC BIM 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*.

Transport for NSW (TfNSW) has, however, acted as the driving force behind promoting the adoption of DE in Australia, to maximise quality and efficiency in delivering transport projects. TfNSW has also led the National DE Working Group with senior membership from governments across Australia, as a federally sponsored group established to lead the way towards a consistent national approach to DE for transport infrastructure.

The DE journey in Australia, however, dates back to 2014, when TfNSW started a consultation schema with industry experts and major stakeholders. This was the outcome of establishing a BIM/DE working group in TfNSW, in 2012. In 2017, TfNSW released the *Data and Information Asset Management Policy* that formally recognised the value and critical importance of structured data. The DE Framework Program – a fully funded program – has been running since 2017, with the aim of bringing together experts from around Australia to develop practical, cost effective DE solutions based on global best practices. The outcomes have resulted in the evolution and release of consecutive versions of DE Framework: Release 1 (Sept 18), DE Framework Release 2 (Apr 19) and Release 3 (Nov 2019). The second stage of the DE Framework development commenced in October 2020.

In developing BIM training and education subjects, educators need to consider that currently, state governments in Australia, as well as the private sector, have recognised the great potential provided by DE in improving various facets of delivering and managing buildings, infrastructure assets and networks. This is reflected in the release of various versions of the *Digital Engineering Framework* by TfNSW; the *Victorian Digital Asset Strategy (VDAS)* and the combined set of *VDAS Guidance Parts A, B and C*; and *Principles for BIM Implementation* in Queensland, among other DE-related initiatives across other states and territories. The release of these documents and the ensuing efforts to ramp up DE education across Australia highlight the need for revisiting BIM training at Australian universities and the necessity of preparing students with the capability of using data and information as a crucial resource in construction projects. In light of the limited time and resources to educate students, there must be less focus on enhancing the technical skills of students in using various tools in future BIM training across various Australian universities.

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 twining, 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 published four 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.*

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.

The *NATSPEC National BIM Guide* and *BIM Management Plan* have recently been updated to align with the AS ISO 19650 series and are being increasingly adopted across industry and government both as a framework for building projects as well as within education programs. BIM object creation tools such as the recently updated *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 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 openBIM 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.

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.

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/41WT4Ie).

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 will be implemented in 2023 and aims 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 (COREDUC 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 2022, they published a document that compiled the experience of 14 universities that introduced BIM in the undergraduate curricula of Architecture, Engineering and Construction careers (www.bit.ly/3ypNUa3). 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 16 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 will work to add 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/3yqkJUh). 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 plans 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

As the main battlefield for developing digital and composite talents, higher education institutions should actively adjust teaching strategies, which is closely focused on the development trend of Building Information Modelling (BIM) in China's construction industry and the requirements of talents. Based on the increasing demand for BIM talents in the construction industry, the development of general education is a significant initiative to enhance the personnel training of BIM. Setting up a perfect evaluation system of BIM training is the key to promoting the cultivation of BIM talents, and to foster high-quality people suitable for the development of BIM in the construction industry is an important measure to improve the in-depth application of BIM technology.

BIM courses offered in higher education institutions

As of 2022, 71 undergraduate colleges and universities in mainland China have already offered 72 intelligent construction engineering programs, and 69 higher vocational colleges have opened 72 intelligent construction technology programs. The BIM-related courses cover 16 out of 18 majors of civil engineering in secondary vocational colleges, and 33 out of 34 in higher vocational colleges, while all 18 majors of civil engineering in undergraduate institutions offer BIM-related courses, with 30% of schools having offered them for more than five years and 40% for three to five years.

BIM talent training mode

The talent training in vocational colleges mainly adopts the comprehensive education mode of "position, course, competition and certificate", which is based on school-enterprise cooperation.

Position: Guided by the industrial positions demand, cultivating the professional core qualities necessary for specific job tasks, BIM has been listed as a core professional competency of intelligent construction, architectural design, engineering management and other majors.

Course: Setting the specialised courses frame and curriculum model corresponding to the professional core quality. According to the requirements of different professional competencies, BIM-related courses have been offered BIM Building Modelling, BIM Municipal Administration, BIM Decoration, BIM Calculation and Costing, BIM General

Management, BIM Construction Organisation Design, BIM Formwork Scaffolding Scheme Design and Safety Calculation Scheme Design currently.

Competition: As a high-end demonstration and signpost for the course training, the competition refers to various vocational skills competitions at all levels. At present, the main industry BIM skills competitions are "PMS Cup" Intelligent Construction Innovation Application Competition, Glodon National BIM Graduation Design Innovation Competition, "THS Cup" BIM-CIM Innovation Competition for students in higher education institutions nationwide, and the National University Student Structural Design Information Technology Competition.

Certificate: The certificate is an evaluation of the course learning and an industry inspection, and mainly consists of a vocational qualification certificate and "X" certificate. Nowadays, BIM-related professional qualifications include BIM certificates issued by the China Graphics Institute, China Construction and Education Association, and China Association of Continuing Engineering Education, while "X" certificates include (BIM).

Currently, larger and more well-known construction enterprises have a greater demand for BIM talents, and some universities have introduced enterprises to participate in the teaching process through the form of school-enterprise cooperation, so that employers can select excellent graduates in the training process, so as to achieve the "seamless transition" between graduation and employment.

Typical mode of BIM talent training in vocational colleges

Colleges and universities that carry out BIM training use BIM to establish a project information platform. Led by the School of Construction Cost, organising the School of Construction Engineering, the School of Construction Equipment, the School of Architecture and Arts, the School of Management and Information, etc. to develop the construction of professional groups, and jointly create inter-professional teaching, training and graduation design, which is the innovation of practical courses, and also a comprehensive reformation from the organisation, teaching methods and assessment and evaluation for the courses in the teaching plan.

Current situation of BIM talent training

Research on the implementation of BIM courses in 100 colleges and universities nationwide indicate there are still major problems in the support of the teaching methods, teaching materials and teachers in the colleges and universities that offer BIM-related courses. The top three constraints are the lack of teaching resources for BIM software, such as courseware and instructional videos, the outdated hardware in the training room, and the fact that the professional teaching standards do not provide clear requirements for BIM software training, and higher education institutions are in the exploratory teaching stage. In the process of combining BIM technology with the curriculum, the biggest obstacle to professional reform is the matching degree of teachers. As teachers lack practical experience and project practice, they can only be satisfied with the requirements of software operation in the process of combining theory with practice and cannot reasonably and effectively combine the depth of professional courses with the breadth of vocational skills required by the industry.

Initiatives/Organisations

After the promotion and application of BIM in recent years, China has achieved certain results. In 2022, China and its provinces and municipalities released a number of policies and measures to promote BIM application and have continued to strengthen the implementation and promotion of BIM technology.

National level

In the *14th Five-Year Plan for the Development of Construction Industry*, *14th Five-Year Plan for the Development of Housing and Urban-rural Construction Science and Technology* and other policies issued by the Ministry of Housing and Urban-Rural Development and other departments, it is pointed out to varying degrees to accelerate the integrated application of BIM technology in the whole life cycle of the project, improve data interaction and safety standards, strengthen the digital collaboration among design, production and construction, and promote the delivery and application of digital results in the whole process of engineering construction. In addition, it also requires sustained investment in innovation, breakthroughs in key and core technologies, expansion of digital application scenarios, and consolidation of smart city bases.

In March 2022, the Ministry of Communication and Transportation and the Ministry of Science

and Technology released the *14th Five-Year Plan for Scientific and Technological Innovation in the Field of Transportation*, which specifies the requirement of "promoting the research and development of intelligent design technology for transportation infrastructure, promoting the application of Building Information Model (BIM) and Geographic Information System (GIS) technology, and improving the traceability and monitorability of infrastructure performance parameters" in the "key technology for digital upgrading of transportation infrastructure".

It can be seen from the above policies that the relevant national departments of China are vigorously promoting the in-depth application of BIM technology. At the same time, in order to activate the value of data assets, they have also strengthened the quality requirements for BIM digital results, and brought digital management services such as digital results delivery, BIM approbation application, project application and drawing review, and BIM data synchronisation into the planning.

Local level

In the context of national promotion of BIM application, with the development of BIM technology and the cultivation of market environment, BIM has become a hot spot in the field of construction in various provinces and cities.

In recent years, Beijing has issued BIM-related policies, which all point to the integrated development of BIM, intelligent transportation, 5G and other new technologies to enhance the degree of intelligence. In 2022, it also launched the collection of BIM application demonstration projects to lead other projects to apply BIM through demonstration projects.

Shanghai is one of the first cities in China to promote the application of BIM technology. In order to accelerate the application of BIM technology in various fields, Shanghai issued the *Shanghai Construction Management Industry Digital Transformation Implementation Plan* in 2022, which requires strengthening the deep integration of information technology and the construction industry, focusing on the construction of digital twin cities, building an industrial/urban CIM base of "Internet of Things, Digital and Intelligence" in accordance with the principle of "overall planning, co-construction and sharing", and cultivating a number of construction industry digital demonstration enterprises to promote the development of industry digitalisation and digital industrialisation.

In May 2022, Shenzhen Housing and Construction Bureau officially released the Shenzhen *Building Information Model Data Storage Standard* SJG 114-2022, the first local BIM data standard based on the international IFC data format, giving a "Shenzhen solution" for the technical route of BIM reporting, archiving and application.

Other provinces and cities in China have also announced correlative policies to facilitate the application of BIM technology in 2022, and while stimulating the in-depth application of BIM technology, they are also gradually carrying out BIM approbation application and project application, intelligent design, model review, and independent research and development on software to integrate into the CIM-based smart city construction. At the same time, the relative policies also need to speed up the cultivation of a number of inter-disciplinary talents integrating BIM technology and business.

Standard status analysis

To standardise BIM implementation in various engineering fields, domestic industry organisations and construction industries have studied and prepared relevant BIM standards and specifications. Some BIM standards issued by national industries and local departments in 2022 are listed below:

1. National standards
   - *Technical Standards for City Information Modelling Infrastructure Platform* CJJ/T315-2022, released in January 2022.
   - *Engineering Information Model Data Storage Standard* T/CREA 018-2022, released in August 2022.
2. Local standards
   - Chongqing: *Standard for Professional Competence of Building Information Model Technician* DBJ50/T-409-2022, released in February 2022.
   - Beijing: *Fineness Standard for Construction Model of Urban Rail Transit Project* DB11/T 1973-2022, released in March 2022.
   - Shenzhen: *Building Information Model Data Storage Standard* SJG 114-2022, released in May 2022.
   - Shenzhen: *Urban Road Engineering Information Model Operation and Maintenance Application Standard* SJG 119-2022, released in June 2022.
   - Shenzhen: *Municipal Road Engineering Information Model Construction Application Standard* SJG 116-2022, released in June 2022.

- Jilin Province: *Building Information Model Design and Application Standard* DB22/T 5120-2022, released in August 2022.
- Beijing: *Building Information Model and Project Acceptance Data Interaction Standard* DB11/T 2031-2022, released in September 2022.

After investigation and analysis, China formulated corresponding BIM standards in the field of construction engineering in the early stage. With the implementation of BIM technology in different fields of engineering, BIM standards have been formulated successively for roads, bridges, railways, rail transit, etc. With the development of BIM technology, standards and specifications have been prepared gradually for BIM talent training, completion acceptance, data storage, and other aspects, enriching the requirements of all sectors of the BIM industry chain.

Awareness/Uptake

At present, the application of BIM in China's construction industry has transitioned from the promotion stage to the practical stage, covering the whole industrial chain of design, construction, and operation and maintenance. It has gradually formed a certain application law, which is reflected in four aspects: the universal implementation of BIM technology in the construction stage, the prominent value of BIM technology in enterprise project management of construction enterprises, and the trend of applying BIM technology in project management by the construction party. BIM technology has also been recognised and gradually promoted in the field of infrastructure.

With the extensive implementation and promotion of BIM technology in China, a good BIM implementation ecological environment has gradually formed, but there are still some challenges and deficiencies. Combined with the development of China's policies and standards, the SWOT method is used to summarise and analyse this.

S - Strengths

China has issued policies to promote BIM implementation and technical standards from different levels, promoting the effective development of China's BIM application, and establishing a good environment for China's BIM application. At the same time, the digital application market of China's engineering projects is emerging on a large scale. With the support of BIM policy, the demand for BIM technology at all stages is extremely strong. A number of innovative methods that integrate BIM technology and business scenarios have emerged to accelerate the development of China's BIM technology.

W - Weaknesses

China's supporting domestic BIM software system is still relatively lacking and cannot meet the needs of large-scale domestic BIM implementation. It is also difficult to ensure that all engineering projects are implemented in accordance with the requirements of BIM standards. For the rapidly changing smart building industry in the era of big data, it has affected the improvement of production efficiency and quality, as well as the guarantee of information security.

O - Opportunities

At present, the country is in the two strategic backgrounds of "digitalisation" and "dual carbon strategy". In the field of construction, it is intelligent construction aiming at green and emission reduction. The deepening of BIM implementation and technological breakthrough can not only promote the digitalisation of the whole life cycle of the project, improve the quality and efficiency of the whole process of the project, but also provide strong technical support for the digital transformation and upgrade of the industry and consolidate the digital foundation of smart cities.

T - Threats

There are also challenges behind the opportunities. In particular, as a new technology in domestic construction, municipal and other fields, BIM technology still has many key technologies to be solved. Further, in view of the traditional "experience + specification" semi-theoretical and semi-empirical application method, it is necessary to integrate the BIM theory and method, and move in the direction of data-driven, three-dimensional visualisation and virtual interaction to better achieve high-quality, sustainable development and empower the digital city.

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.bimkoncepce.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.bimkoncepce.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 electronical 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 openBIM 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 openBIM 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. Some examples of ongoing 2022 projects include the international BIM-ICE project hosted by LAB UAS, National Raksadigi-project hosted by Savonia UAS and international BENEDICT project in which the University of Tampere is a partner. The main goal has been the implementation of BIM based digital twins of houses on two projects: EKKIRA-project hosted by LAB UAS, and the Karelia UAS Digital Twin-project.

Some Vocational Education Institutes also provide BIM education as one part of studies and continuing education related to BIM. For graduate, postgraduate and further education students, there are several options offered at some UAS. For example, the Metropolia UAS offer courses such as:

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

- BIM Coordinator for infra production (8 ECTS).
- BIM Manager (5 ECTS).

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, including the following:

- buildingSMART Finland has about 120 company members and user groups for Education, Building, City planning and Infra are all up and running.
- 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.
- COBIM, the national common BIM requirements, was published by buildingSMART Finland in March 2012 and it is now in widespread use. English, German, Estonian and Spanish translations of the requirements have also been completed. In 2014, the Ministry of the Environment updated this 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. The need for updating the COBIM guidelines have been recognised and the update process has started as part of the national RYTV-development project. In the future, COBIM will become more connected to European BIM standards.
- National common BIM requirements have also been published to Infrastructure projects (Common InfraBIM Requirements). The last version was published in 2021 by buildingSMART Finland.
- The development of the Finnish LandXML based data format for neutral BIM data exchange for infrastructure (Inframodel) will continue.

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 were published in the international BIMEET-project 2020 (*BIM-based EU-wide standardised 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 (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/.

Different levels of BIM courses/training will be planned and executed based on the learning outcomes. 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 standard paper will guide national level BIM competence development strategies and LO frameworks.

Also, other new practical uses of BIM have been found in many recent openBIM 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.

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 register in an open standard format.
- 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 2024.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 to define “to-be” BIM based permitting process with data needs and the steps towards ACCC (automated code compliance checking).

A current building permit development project is RAVA3Pro. It is 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 includes 23 Finnish municipalities.

EU research project ACCORD (Automated Compliance Checks for Construction, Renovation or Demolition Works) aims to digitalise permitting and compliance processes using BIM and other data sources, to improve the productivity and quality of design and construction processes. ACCORD will develop a semantic framework for European digital building permitting processes, regulations, data and tools. This framework will drive the formalisation or rules and integration of existing compliance tools as microservices. See https://accordproject.eu/.

This reform will cause plenty of new needs for BIM education. An extensive BIM training for building permit authorities is needed and it is currently ongoing. Metropolia UAS has organised BIM basics and BIM coordinator courses for building permit professionals where participants have the opportunity to receive 80 percent support from the Ministry of the Environment, Finland. This reform also needs to be taken into account when national common BIM requirements are updated.

In 2019 the Ministry of the Environment published a national strategy and roadmap for information management standardisation in the built environment (RASTI project). The roadmap described a national vision for 2030 and highlighted the local implementation of international standards coherently.

Today we know that the goal of green transformation and digitalisation requires significantly more standards and new collaboration in data exchange. Based on the RASTI project vision 2030, buildingSMART Finland and Building Information Model Ltd. have launched Information standardisation for the built environment working program (RYTV). The goal for this four-year working program is to standardise and unify information in the built environment in Finland. Information standardisation for the built environment creates more sustainable, dynamic, and systematic mode of operation. The main principle of the program is to generate a strong foundation for the sustainable growth and development at the organisational and societal level. The working program also 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 need to enhance research and learning. Therefore, the program supports more enhanced BIM-education on the university and industry levels and adoption of international BIM standards. One main focus of the working program is to publish new national common BIM requirements for the built environment. The basic principle is to integrate model-based information of built environment assets (city scape and technical networks, transport infrastructure and buildings). Also, many use cases are defined in property set levels. The RYTV program also includes topics of competence development and change management. The development of defining BIM skills and national level learning outcomes will be one large task for buildingSMART Finland competence development and change management education - working group. The work will be one part of the RYTV-program. See https://buildingsmart.fi/en_GB/rytv.

The national KIRA growth program covers 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.

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 is 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 www.buildingsmartfrance-mediaconstruct.fr.

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 labelisation training.

Since 2015, the French government has launched a national program, the *PTNB*, and then the *BIM Program*, to promote the use of BIM throughout the territory, targeting SME's of the building industry. This is how a standardisation strategy was developed and recognised by the *EU-BIM-task-group* as a lever for the adoption of BIM in public procurement.

Another action of the PTNB has been to set up a *Reference of BIM skills, for project management companies, and construction*

SME's. Of course, a professional must, above all, remain a technician, with a knowledge of collaborative processes, and of the appropriation of BIM as a tool (and not as a finality).

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.). For its 7th edition, EduBIM was held at EIVP (Ecole des Ingénieurs de la Ville de Paris) in December 2021, with the theme "New perspectives of BIM - The digital twin and smart building". More information is available at https://easychair.org/cfp/edubim2021.

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.

Numerous significant advances have been observed in different domains, led by actors looking for new values for building, infrastructure and public works. The generalisation of BIM, for all actors, on all types of projects, both public and private, has been continuous since 2014. Thus, in 2019, BIM reached a rate of 66% of overall adoption in France. More specifically, for example, 42% of architectural agencies are implementing BIM practices in 2020.

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, was 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 developing standards and other publications, training, certification and accreditation, R&D in pursuit of these objectives, with significant achievements in 2022.

The School of Professional Development in Construction (SPDC) is the professional education arm of the Hong Kong Institute of Construction (HKIC) 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 Digitisation, 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 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, around 540 BIM managers and 540 BIM coordinators have been successfully certified by the CIC. Moreover, 14 BIM manager courses and 19 BIM coordinator courses have been accredited by the CIC.

The CIC organised the Inaugural BIM Education Symposium to provide opportunities for local higher education institutions to share their achievements and good practices in BIM education. A total of 13 educators from 11 institutions shared at the Symposium, which was received by over 900 participants. A Memorandum of Understanding (MOU) on BIM education was also signed between the Hong Kong Metropolitan University (HKMU) and HKU School of Professional and Continuing Education (HKU SPACE) as part of the collaborative directives. In July 2022, the MOU on BIM education between the Chu Hai College of Higher Education, City University of Hong Kong (CityU), Hong Kong University of Science and Technology (HKUST), The Hong Kong Polytechnic University (PolyU), The University of Hong Kong (HKU), and Vocational Training Council (VTC) were also renewed to continue the efforts for providing the new generation with the latest technologies and skills in applying BIM.

For the fourth year, the CIC BIM Competition continued to promote the practical uses of BIM through a collaborative and competitive learning approach among higher education students in construction-related disciplines. The theme of the competition was "*Modularity & Adaptability in Transitional Housing (T-Housing) Design with Use of BIM*". This was the first time the use of Common Data Environment (CDE) was mandated as one of the submission requirements for students to experience digital project coordination and collaboration using CDE. The CIC organised 25 different webinars to build up student's knowledge and skills in BIM, including BIM authoring tools, Geographic Information System (GIS) platforms, CDE related solutions and building energy simulation software, and sustainability and collaboration concepts, enabling their outstanding performance at the finals.

To enhance the industry's capacity in adopting and implementing CDE and digital construction tools for projects in Hong Kong, the CIC launched the first signature course on CDE, namely the "*CIC Master Class on Common Data Environment (Project Managers)*" in 2022. The course was designed for experienced practitioners who wish to leverage construction digitalisation and adopt CDE in their business workflow. The course has been set to re-run quarterly.

To cope with the surging demand for BIM Viewers, the CIC developed a "*Teaching and Learning Kit*" for BIM Viewer training, available

in both self-learning and instructor-led training. After completing the post-course online BIM Viewer Quiz, those passing the quiz are awarded a CIC BIM Viewer Certificate. Since its launch in 2021, over 17,500 individuals have completed the online training and received the BIM Viewer certificates by the end of 2022.

Initiatives/Organisations

The CIC BIM Space has been serving as a one-stop service platform for providing BIM-related services and support to the industry. We have started expanding our scope to not only encourage BIM, but also construction digitalisation technology adoption and proliferation through organising joint seminars and events in collaboration with different stakeholders to provide the industry with information sharing platform. Hands-on software workshops, advisory workshops, B2B speed matching days, awareness seminars and workshops, and showcases of advanced BIM and related technologies with their applications in real projects and exhibits in BIM Space have also been organised. A total of 52 webinars were organised throughout the year, covering various construction digitalisation-related events such as BIM Talks, BIM Solution Day, webinar series on the CDE Platform for Site Management, briefing of the Certification of BIM Personnel and Accreditation of BIM Training Courses, and launching of CIC Beginner's Guide on Construction Digitalisation, successfully attracting over 37,700 attendees to the CIC BIM Space.

The CIC has actively promoted the digital transformation of the construction industry. To help the industry, especially Small and Medium Enterprises (SMEs) in enhancing their capabilities, accelerating digitalisation, and embracing new technologies, the CIC has published the following three *CIC Beginner's Guides on Construction Digitalisation*:

- *CIC Beginner's Guide on Construction Digitalisation – Smart Site Digital Platform.*
- *CIC Beginner's Guide on Construction Digitalisation – Adoption of BIM in Small and Medium Enterprises.*
- *CIC Beginner's Guide on Construction Digitalisation – Adoption of Common Data Environment (CDE) for Information Management using BIM.*

These three publications provide information on the commonly required functionalities of a digital platform for managing construction projects, step-by-step guidance for SMEs to adopt BIM, and practical advice on the general considerations when selecting CDE as an information management platform and collaboration tool for BIM projects.

The CIC had conducted a review of the Hong Kong construction industry in 2020 to estimate the demand for BIM managers and BIM coordinators by 2025. In August 2022, the CIC commenced a survey on the current supply and demand of BIM personnel, to formulate a forecast on the future manpower requirement and availability. A total of 124 project-based surveys and 37 organisation-based surveys were collected. Additionally, the CIC interviewed 19 organisations, including different categories of stakeholders. The White Paper presented the supply and demand forecast of BIM personnel from 2022 to 2027 and identified the shortage in manpower. Key recommendations were made in the White Paper with an aim to facilitate the supply of BIM personnel.

The CIC Research and Technology Development Fund continues to provide financial support for research projects that improves the performance and competitiveness of the industry. Completed in 2021, one of the CIC funded research and development projects, namely "*BIM-Automation of Gross Floor Area (GFA) Calculation, Fire Safety and Prescribed Checking for General Building Plans (GBP) Preparation*" could automate most of the time-consuming calculation and checking issues mandatory for GBP submissions. Starting from 2021, CITF-eligible architectural firms were entitled to use this R&D product under a free license till the end of December 2022.

The Construction Innovation and Technology Fund (CITF) was established to encourage wider adoption of innovative constructive methods and new technologies in the construction industry with a view of promoting productivity, uplifting built quality, improving site safety, and enhancing environmental performance. By the end of 2022, CITF supported over 10,424 BIM training places.

In 2023, the CIC will continue to consolidate training needs from the industry and collaborate with SPDC and BIM training service providers to offer necessary training courses to meet the demands. In addition, the CIC is going to launch the *CIC Master Class on Artificial Intelligence (AI) for Construction*. This course aims to build the industry's capacity for the adoption and implementation

of advanced construction technologies using AI, machine learning and related technologies for improving productivity, health and safety measures, and supply chain and logistics management in Hong Kong.

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 to improve productivity, quality, green and safety of the construction industry 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 is 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.

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 was 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
As BIM has continued to move towards being business-as-usual, though only in commercial construction, the education sector has followed. This has seen most, if not all, training institutions include BIM specific content in their existing papers or added new BIM specific courses. Typical courses "enable students to explore current issues and advances in the use of Building Information Modelling (BIM) within the construction process".

BIMinNZ provide several training resources including *BIM101 - An Insight seminar booklet* and a guide on BIM *Productivity benefits* to assist industry with "a case for using BIM with real examples of the economic benefits it can deliver".

The NZ Institute of Quantity Surveyors have collaborated with their Australian sister organisation to produce a *BIM Best Practice Guideline* "a guide for quantity surveyors, cost managers or cost estimators looking to be involved with a project using BIM".

Initiatives/Organisations
BIMinNZ has continued to run quarterly BIM networking seminars in Auckland, Wellington, and Christchurch which are well attended with a wide representation across the construction landscape. They arrange a variety of presenters covering academic research initiatives, industry presented case studies, latest best practices from vendors and the like.

The Building Innovation Partnership, an industry, government, and university research collaboration, is getting underway on its seven year research program focused on improving infrastructure planning, design, construction and management processes, and the development of engineering solutions that improve the resilience and affordability of our built assets.
They have three themes:

- Theme 1: Better Investment Decisions with an initial focus 3-waters.
- Theme 2: Enabling Integrated design, Construction and Operation looking at BIM/Data Analytics/AI/Digital Manufacture/Digital Construction.
- Theme 3: Fit-for-Purpose Building Components with an initial focus into non-structural elements.

Construction Information Ltd (CIL) have continued to work with government and industry on developing and implementing the

NZ Asset Management Schema (NZAMS). CIL's intention is that the NZAMS will provide a framework for BIM innovation through the supply chain.

Research shows that around 50% of asset owner and managers are integrating digital asset or spatial information with asset management systems or looking to do so in the next twelve months while most others are aware of the concept and may look at it in the future. The research concluded that the inability to make the most of BIM models and data, post-construction, and the lack of a base model and existing conditions information can make adding BIM to major upgrades a costly exercise. A common schema is part of the solution for this.

Currently asset owners define their own metadata requirements and the deliverers of projects are required to collate the information for project handover. Invariably this results in each project defining a project unique metadata requirement in the BIM execution plan and manual processes to create and collect it.

If a common standard can be established that is widely adopted by asset owners, it will create an incentive for the supply chain to invest in creating content and tools to facilitate the automation of information management knowing that this can be reused across multiple projects and for different purposes. To support this industry adoption, CIL are developing a web-based toolset that enables users to navigate the schema and be able to define their organisation specific information requirements. The schema and tools are being piloted with the view to adoption by the Christchurch City Council, the University of Canterbury, and the Ministry of Education.

BIMinNZ released the third version of the *NZ BIM Handbook*. The aim of the *New Zealand BIM Handbook* is to promote the use of BIM and its benefits and to create, maintain and operate quality built assets in New Zealand. Developed in partnership with industry at every step, the Handbook is for New Zealand's building and construction sector but draws on best BIM practice from around the world. The handbook follows the normal progression of a project, from project establishment through to operation, and documents a consistent approach, using a common language, to BIM in New Zealand.

Awareness/Uptake

The BIM Benchmark survey was run for the sixth year in 2019. It follows an industry control group of large and influential organisations in New Zealand's built environment. The number of projects using BIM has plateaued at 59% after only a slight increase in 2018.

"BIM is still not the status quo for undertaking construction projects. We have to weigh up the costs of BIM against the benefit of having the as-built data in model form. This is sometimes difficult to justify."

The expectation is that BIM use on projects will increase, but this has been the case for several years and the increases have not flowed through to actual uptake.

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.

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 openBIM 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
With the refreshed Built Environment (BE) Industry Transformation Map (ITM) launched in Nov 2022 that is built upon the earlier Construction ITM, BIM education in Singapore continues a pool of competent workforce under the new Key Transformation Areas (KTA) to support Integrated Planning and Design (IPD) ecosystem [see below for more details], through the infusion of BIM curriculum in all Institutes of Higher Learning (IHL) Built Environment (BE) courses.

There are 11 IHLs providing full-time and part-time programs with BIM/VDC (Virtual Design & Construction)/IDD (Integrated Digital Delivery) curriculum. Third-party BIM software educational vendors were also crucial in providing training, especially for professionals. To date, close to 19,000 students and professionals have been trained in BIM/VDC/IDD.

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

All five polytechnics provide advance BIM modules in the three discipline streams and beyond, such as in sustainability related programs. Customised programs for firms 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. Nanyang Technological University and the National University of Singapore have also launched Centres of Excellence in BIM to focus on nurturing BIM R&D capabilities.

The Building and Construction Authority's (BCA) education arm, the BCA Academy, takes the lead in developing the IPD/DD competency of the built environment sector across the entire value chain.

To help the industry go digital with IPD, the BCA Academy offers academic, career conversion and Continuing Education & Training (CET) programs that are aligned to the IPD skills and competencies requirements needed for various job roles.

BIM/VDC/IDD/IPD content has been incorporated into all the Integrated Work-Study

Diploma programs that the BCA Academy launched in April 2023, covering various disciplines across the construction value chain. These programs will provide a pipeline of fresh graduates with strong IPD skills and inter-disciplinary knowledge that enable them to work 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.

CET IPD programs include the application of data analytics (e.g. analysis of data to identify bottlenecks), and artificial intelligence in construction (e.g. multiple design options – optimised based on the developer's requirements – can be quickly generated based on machine learning of previous designs).

With the launch of Skills Framework (SFw) in 2019, individuals, companies and training institutions can make use of the SFw to know how to chart digital delivery management career pathways and mapping of IDD courses in the built environment sector.

To enable professionals to upgrade knowledge and skills, BCAA offers seminars, workshops and a 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.

In tandem with the introduction of the IDD Implementation Plan by BCA, *Principles of Integrated Digital Delivery* was launched to reach out to a wider group of built environment stakeholders and equip them with clear understanding and aligned knowledge on IDD.

Building on this fundamental course, a course on *IDD Project Implementation* was designed and will be offered as a customised value-chain based training approach to guide adoption of IDD and enhance collective learning for the project value-chain stakeholder to derive integrated outcomes.

Initiatives/Organisations

The refreshed Built Environment Industry Transformation Map (ITM) will help stakeholders within the sector collaborate more effectively across the value chain. The previous Construction ITM and Real Estate (Facilities Management) ITM, launched as two separate ITMs in 2017 and 2018 respectively, have been amalgamated into one Built Environment ITM to transform the Built Environment (BE) sector through the three key stages of a building's life cycle - from planning and design, construction, to operations and maintenance.

Building on the progress of the ongoing transformation, the Built Environment ITM is a timely refresh, as it recognises the need for greater collaboration amongst BE stakeholders as well as the shifts that have been made in technological advancements, sustainability efforts and longer-term structural trends.

One of the key transformation areas is on IPD, where stronger collaboration across the building life cycle can optimise resources. This will build on the existing efforts for IDD, which allows project stakeholders to collaborate with one another through digital platforms. Design considerations for the building's entire life cycle, including Facilities Management (FM), are factored in at the design stage, enabled by digitalisation, Common Data Environment (CDE) standards and progressive procurement.

Under the refreshed BE ITM, BCA expects to increase the IDD adoption rate by Gross Floor Area (GFA) for new developments from 34% today to 70% by 2025. The BE ITM also encourages the industry to move towards collaborative contracting where contracting parties, including the builder and facilities management firm, work together towards shared project goals at the start of the project.

BCA also engages industry leaders through the IDD Steering Committee and subgroups, as well as practising BIM/VDC/IDD/IPD experts from various disciplines both upstream and downstream through the Trade Associations and Chambers (TACs). BCA Academy also works closely with TACs to provide upstream support in IPD training and outreach contextualised to their specific fraternity and practice.

Transformation of the Built Environment sector will create new job opportunities but will also require some existing job roles to be redesigned to keep up with evolving trends. Hence, BCA, SkillsFuture Singapore (SSG) and Workforce Singapore (WSG) have worked closely with the industry, trade associations and TACs, unions and education institutions to co-develop the Skills Framework (SFw) for the Built Environment (BE) which was launched in September 2020. The framework provides key information on the sector, 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 DDM.

The DDM track involves the adoption and implementation of up-to-date emerging digital technologies to optimise operations and processes, improve collaboration and enhance work efficiency. This includes the provision of training to uplift digital capabilities, development of digital solutions and redesign of workflows supported by competencies such as 3D modelling, mixed reality, data analytics and process reengineering.

To provide validation for the relevant IDD skills and competencies identified in the SFw and to uplift the standing of the BE professions, BCA worked with buildingSMART Singapore (bSS) to roll out the DDM Accreditation Scheme. This scheme will also ensure firm or project level digital initiatives are managed by qualified professionals to deliver the intended project outcomes.

The DDM Accreditation Scheme offers recognition to prevalent digital delivery job roles available in Singapore's BE. It uses a structured framework (Skills Framework for the Built Environment) for assessing and recognising the digital skillsets of individuals, allowing employers and procurers to benchmark the digital competence of individuals in fulfilling digital job roles. This system enhances the employability of BE professionals in Singapore and ensures that they are appropriately remunerated for their skills. It also helps individuals plan their career advancement based on recognition of skills attained progressively, which helps attract and retain talent. At a broader level, it ensures that the digital aspects of Singapore's BE projects are staffed by competent professionals that can deliver good quality outcomes. There are four accreditation tiers in the DDM Accreditation Scheme that is valid for 2 years upon certification:

- Tier 1: Chief Digital Officer.
- Tier 2: Lead.
- Tier 3: Specialist.
- Tier 4: Assistant Specialist.

bSS is the official accrediting body for the DDM Accreditation Scheme. To encourage more fresh graduates to join the BE, bSS works with a network of lecturers in IHLs across Singapore to confer the Tier 4 (provisional) certification to students who have met the requirements of courses that are approved by the Accreditation Board of the DDM Accreditation Scheme.

Awareness/Uptake

BCA continues to organise the bi-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

The upper secondary school (gymnasium 16-19) have today CAD-related practical learning goals in their curriculums for all the 303 school units in Sweden that includes a program of technology (teknikprogrammet). Of these 303 school units are 54 specialisations in civil engineering where the CAD activities focus on BIM related learning. An initiative is also taken, to develop applied BIM competences for teachers within the vocational education system including construction and installation, which was started up in the fall of 2020.

At universities, the education of BIM-related knowledge is now turning from a technical focus on modelling, information transferring and visualisation to be complemented with management-related assignments with collaboration, requirements management and organisational strategies with BIM. Practical BIM-knowledge in software and information generation is now more organised to self-learning exercises and learning is then applied with a focus on project-based use of BIM in the construction processes. Examples of BIM coordination, seamless flow of information in systems and simulation of multidisciplinary scenarios are now applied in the university educations. The updated mapping of BIM courses and courses with BIM related tasks is stable from the universities with following data.

Data from the university mapping shows that:

- 8 Master programs (300 HP) offer BIM education in Sweden.
- One new Master program starts in the fall of 2022 with focus on BIM and digitalisation of construction at Linköping University.
- 21 Bachler programs (180 HP) offer BIM education in Sweden.
- 11 2-year university programs (120 HP) offer BIM education in Sweden.

Swedish universities now offer almost 150 courses with BIM within a total of 875 HP which is about 14 years of study.

A number of 3rd cycle education courses (for PhD students) in industrialisation and design automation has been developed and conducted in the year of 2019 and 2020 in the field of BIM and digitalisation in Smart Built Environment. These courses are a part of the national strategy to change construction to a sustainable industry by digitalisation and industrialisation. Both courses have been further developed and executed in the year of 2021 with PhD students from universities all over Sweden.

Initiatives/Organisations

During the global pandemic, the eighteen Swedish universities met regularly in online meetings with virtual workshops and seminars, webinars and information distribution in 2021. The organiser was the BIM Academy (as a part of BIM Alliance Sweden) which facilitated these activities with the purpose to share and contribute knowledge, educational assignments, lectures and software experiences through the network. Further information on the BIM Alliance can be found at https://www.bimalliance.se/naetverk-och-moeten/intressentgrupper/bim-akademin/.

In the BIM Academy group in Sweden, an initiative of defining BIM Basics for Sweden was started in the fall of 2018. A structure for BIM basics is continuously under development, which gives input to national strategies for research, and development in the field of Smart Built Environment. The governmental program in Smart Built Environment started in 2015, which has a number of knowledge package to develop education within digitalisation.

The BIM Academy group, in addition to BIM basics, have during the year focused on new BIM tools and working methods, e.g. parametric tools and generative design linked to the different stages of the construction process and how to implement these in teaching different learning activities.

Awareness/Uptake

A study of how education in Sweden teaches how digital twins are practical for onsite production in construction was conducted in the later part of 2021. The purpose of the study was to describe what opportunities there were to develop teaching with digital twins with BIM knowledge for the construction site. The sub-purpose was to map current course content that focuses on the construction site and which of these elements in courses apply digital models for construction sites as an application with Building Information Modelling (BIM), Geographic Information Systems (GIS) or data models.

Results from the mapping of the current situation showed that application in courses with a focus on the construction site comes in the latter part of the education. That is, in either the second or third year of the university bachelor programs or in the fourth or fifth year of the master engineering programs. The

application of digital models for the construction site can be considered small overall and where the most common application is 4D/5D planning of the building's progression using BIM models. There is also no clear progression of knowledge regarding digitised construction for construction sites, but only different application areas. In general, few applications of either geometric models with associated digitisation or computer models handle the construction site as a focus area.

Still, there is a considerable discrepancy between the technically oriented BIM curricula at the universities and the more process and change oriented approach to BIM represented by the industry. The trend that we have seen since 2012 is that Swedish higher vocational education schools (Yrkeshögskolor) have started two-year programs that focus on BIM-applications for contractors, consultancy and clients. Now eight educational programs, as a complement to universities, have embraced the need for practical BIM knowledge for site construction and the relationship between design and construction site-related BIM is not as skewed towards design, but a more even distribution between different courses and assignments. Six of the eight educational programs have a number of practical BIM-assignments where students learn how to use models and related data for site based construction.

In the 2-year BIM-related vocational schools, about 15-40 HP (of 120 HP) was focusing on BIM related course assignment, while only 6-18 HP (of 180 to 300 HP) for the same application. The ongoing BIM-education that was started in 2020 by the Swedish government has introduced shorter courses with the higher vocational education system in an initiative to up-skill and re-skill competence within the workforce.

In addition, an initiative for practical education in the upper secondary school started in 2021. This initiative resulted in a number of new BIM courses for the employees within the construction industry. A number of workshops and the development of learning packages for these courses on practical BIM commenced in 2021.

The project InRoad was started to develop an all-new intensive course program for cross-disciplinary road infrastructure design in a digital age for higher education institutions in a global context. The project aims to develop a range of new didactic teaching tools with special focus on using a digitalised workflow and tools accordingly. These tools will be handled and described regarding their core engineering theory and methods and also communicative demands. The outcome of the project, both the developed curriculums but also the results from the assessment will be presented in other European countries and will be made available online for free to all who are interested. The project is a collaboration between Aalborg University, Jönköping University, NTNU and University of Oulu, and is funded by EU Erasmus and the program for strategic partnerships for higher education.

SWITZERLAND

Education/Training

Generally, the number of training intuitions is 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 openBIM, 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 research on a 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 North-western 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 has a clear priority. The modules (CAS, MAS) of the continuing education are carried out in cooperation with Stanford University.
- At ZHAW (Zurich University of Applied Sciences) the 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 competences 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 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 take over 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. Quite mentionable here is the new 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 trainings is offered. Yet training and education on a more basic level are still very rare.

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. A document published by Bauen Digital Schweiz and buildingSMART allows for a consistent overview of all programs over all stages of education. By now, 28 training providers are registered, with 2760 (in 2022: 1150) individuals certified.

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. Additionally, the Swiss BIM Congress came into life in 2016 and is implemented on a yearly basis. However, due to the pandemic, this event was postponed in 2020.

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.

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 90 thousand learners so far. Besides, BIM Summer Program has been offered at NTU since 2014 for students from abroad. The goal of the program is to help students understand the fundamental concepts of BIM and acquire essential skills to use BIM tools such as Autodesk Revit.

The WorkSkills Competition (which was 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. To join this global event, Taiwan held a national competition in 2021 to select contestants. For the BIM subject, the contestants must be under the age of 25, 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) is currently 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 2022, around 500 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 to see 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 55 industrial members, 6 governmental members, and 22 academic members.

The Taiwan BIM Task Group was formed in 2018, the 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 running 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 not only more mature but also 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 which 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 real 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 to integrate 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 2022, 7 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 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 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. Heriot Watt University'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 mantel 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.

However, many countries/regions are reporting that the content of such courses is now being expanded to include more sophisticated elements of BIM, such as BIM for FM, costing, openBIM information exchange, BIM management, digital twins etc. as opposed to simple modelling and use of specific BIM software. This change to course content is consistent with increasing public and private demand as organisations realise the benefits of BIM beyond the design stage, but also for procurement, construction management, operation, and maintenance stages of the assets. In particular, there has been an increased interest in the field of artificial intelligence and virtual reality and its integration with BIM for the whole asset lifecycle.

Most countries'/region's higher education institutions are including structured BIM education within the syllabus of their AEC courses, at both an undergraduate and postgraduate level. The approach 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 has also been a greater focus placed on the importance of real-life experiences which has led to increased collaboration between education institutions with government and private sectors.

As reported in previous years, studies carried out by some of the countries/regions indicate that there are many challenges being faced by educators in regards to incorporating BIM into the curricula, such as the knowledge base/skills of educators, resources available - both financial and physical - and a simple resistance to change by educational institutions and their educators. A lack of structured BIM educational coursework, consistent across educational institutions, has also been reported as a barrier to the progression of BIM education.

Many countries/regions continue to discuss the importance of the buildingSMART International Professional Certification program and how that is being implemented within their respective countries/regions. Other certification schemes that validate BIM knowledge continue to be provided and accreditation of the BIM training programs provided by higher education institutions is also gathering pace.

BIM has generally been widely adopted in many countries/regions. However, this is not strictly a global trend and in some countries/regions, uptake has been slow. The cost of BIM implementation and lack of standards are among the reasons for the slow adoption. However, sustainability in the built environment has been a key driver for continued development and implementation of BIM. Both the public and private sectors are seeing the value of data obtained through the application of BIM for asset and facility management, and the possibilities afforded by advanced construction technologies using machine learning for improving productivity, efficiency, and health and safety.

Progress on BIM education has gained momentum since the peak of the pandemic. While virtual/online courses continue to be offered as a teaching alternative, face to face teaching has been re-established. This has facilitated the successful organisation of numerous BIM competitions, promoting practical and collaborative use of BIM among higher education students.

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 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.

CONTRIBUTORS

NATSPEC and I.C.I.S. would like to thank contributors, past and present, who have provided input to this report for their respective countries/regions. Note: Where more than one individual from any particular organisation has provided input, the name of the organisation has simply been listed once.

Current contributors

- Mario Mauer – BIM Forum Argentina (Argentina)
- Carolina Soto Ogueta – Planbim (Chile)
- Huahui Lai/Rong Wang – China BIM Union (China)
- Li Sheng – Pinming Technology Co., Ltd (China)
- Mao Wang/Yuanxiang Yang – Zhejiang Huiyuan Engineering Data Technology Co., Ltd (China)
- Tianlun Yang/Xinkai Wang – NingboTech University (China)
- Daniel Cihelka – URS (Czech Republic)
- Annina Lehikoinen/Meeri Smolander – Building Smart Finland (Finland)
- Tarja Mäkeläinen – VTT Technical Research Centre of Finland (Finland)
- Timo Lehtoviita – LAB University of Applied Sciences (Finland)
- Shirley Lam – Construction Industry Council (Hong Kong)
- Masaki Muto – Building Research Institute (Japan)
- Eilif Hjelseth – Norwegian University of Science and Technology (Norway)
- BCA Academy – Building and Construction Authority – BCA (Singapore)
- buildingSMART Singapore (bSS) (Singapore)
- BIMcommUNITY.Africa (South Africa)
- Innocent Musonda – University of Johannesburg (South Africa)
- Johannes Herold – Schweizerische Zentralstelle für Baurationalisierung – CRB (Switzerland)
- Shang-Hsien (Patrick) Hsieh – National Taiwan University (Taiwan)
- Gilles Letourneau – Deltek (United States)

Past contributors

- Vaughan Harris – BIM Institute South Africa (Africa and South Africa)
- M. Reza Hosseini/Sarah Shuchi – Deakin University (Australia)
- Jennifer Macdonald – buildingSMART Australia (Australia)
- Ronald Webber – Central Queensland University (Australia)
- Saeed Banihashemi – University of Canberra (Australia)
- Canada BIM Council (Canada)
- David Watson – Digicon Information Inc. (Canada)
- Linda Newton/Simon Brodeur/Susan Keenliside – buildingSMART Canada (Canada)
- Shenzhen Municipal Design & Research Institute Co. Ltd. (China)
- University of Nottingham Ningbo (China)
- Petr Vokoun – BIM Project (Czech Republic)
- Päivi Jäväjä – Metropolia University of Applied Sciences (Finland)
- Rakennustieto (Finland)
- Sunil Suwal – Metropolia University of Applied Science (Finland)
- Tommi Arola – buildingSMART Finland (Finland)
- buildingSMART France (France)
- Emmanuel Natchitz – ESITC (France)
- Benjamin Mombree - Planen-Bauen 4.0 (Germany)
- Institute of International Harmonization for Building and Housing – iibh (Japan)

- Martijn Carlier – BIM Loket (Netherlands)
- Radboud Baayen – Stabu (Netherlands)
- Nick Clements/Rolf Huber – Masterspec (New Zealand)
- Alessia Bellini/ Steen Sunesen – buildingSMART Norway (Norway)
- Geir Johansen – Norconsult (Norway)
- Digitalisation, Built Environment Research and Innovation Institute – Building and Construction Authority - BCA (Singapore)
- Chris Allen – Nelson Mandela University (South Africa)
- Mark Grant – Construction Communication Network (Pty) Limited (South Africa)
- Gustav Jansson – Luleå University of Technology (Sweden)
- Niclas Andersson – Malmö University (Sweden)
- Nina Andersson – Jönköping University (Sweden)
- BIM Academic Forum (United Kingdom)
- Graham Paterson – Letsbuildigital (United Kingdom)
- Jason Underwood – University of Salford (United Kingdom)
- John Gelder – NBS (United Kingdom)
- Rob Garvey – University of Westminster (United Kingdom)
- Christopher Bushnell – Arcom (United States)
- James Robertson – Robertson Sherwood (United States)