NATSPEC// Construction Information

INTERNATIONAL CONSTRUCTION INFORMATION SOCIETY

BIM EDUCATION - GLOBAL – 2020 UPDATE REPORT

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EXECUTIVE SUMMARY

In January 2014 NATSPEC issued the first version of a report summarising the status of BIM education in several countries and regions across the globe. The report has been updated and reissued each year since, with this report being version 7.0 of what is now an annual update to the original report.

Each year the countries and regions included in previous versions of the report are given the opportunity to update their section to reflect their current status of BIM education. In the updated versions since the original 2014 report, additional countries have provided input, expanding the scope of the original report. This seventh edition of the report includes information for 18 countries/regions.

As reported in previous years, most countries and regions are reporting BIM education being provided to Architecture Engineering Construction (AEC) students by their higher education and technical training institutions.

Also, as previously reported, in general, the number of courses being offered is not significantly increasing year on year, with countries such as Australia, Canada, Chile and Finland perhaps being the exception. This may indicate that the quantity of courses offering some form of BIM education may be reaching saturation in many countries.

However, many countries and 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, etc. as oppose to simple modelling and use of specific BIM software.

Most countries' higher education institutions are including structured BIM education within the syllabus of their AEC courses, at both an undergraduate and postgraduate level. Countries such as Australia, Chile, China, Finland, Norway, Sweden, UK and USA are reporting a significant volume of courses and subjects available. Many vocational education institutions are also providing BIM education to the industry's workforce.

Studies carried out by some of the countries 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 have also discussed in this year's report about the introduction of the buildingSMART International Professional Certification programme and how that is being implemented within their respective countries. It has also been noted that many training providers are now looking to the requirements of this programme to develop coursework specific to the BIM requirements of industry.

Other certification schemes to validate the BIM knowledge of professionals in industry also continue to be reported with countries such as Australia, Canada, South Africa, UK and USA having all reported the existence or development of such schemes in their respective countries.

INTRODUCTION

Question

In October 2013 Richard Choy (NATSPEC) sent an email to a global group of parties with an interest in BIM, asking for a brief paragraph outlining the current status of BIM education in each of their respective countries/regions.

This question was interpreted in two ways, with the respondents either describing the current level of BIM awareness/use or the current level of training/higher education available. Some respondents also provided a much more detailed response than a brief paragraph.

Original report

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

Updated report

The report has been updated and reissued each year since, with this report being version 7.0 of what is now an annual update to the original report.

In the updated versions since the original 2014 report, additional countries have provided input, expanding the scope of the original report. This seventh edition of the report includes information for 18 countries/regions.

Early in 2020 NATSPEC again contacted the respondents who had contributed to the previous versions of the report, offering them the opportunity to update their information.

Even with everyone having been impacted by the COVID-19 pandemic, NATSPEC are pleased to report that the response to this year's update has been the best to date, with 17 countries/regions providing an update.

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

AUSTRALIA

Education/Training

There are 43 universities in Australia. Of these, 23 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; and Department of Civil and Construction Engineering at Swinburne University of Technology, among others.

BIM education, however, transcends the higher education sector and has been extended to vocational education and training institutions. Chief among all is TAFE. Many TAFE (technical) colleges are providing courses where BIM is incorporated into the syllabus, as well as, short courses related to BIM. As an example, in Western Australia, the North Metropolitan TAFE runs a short 3-day course titled 'Introduction to BIM.' These programs mostly focus on the use of BIM software packages. The topic of BIM management or the procedures for working in a collaborative environment are not generally covered.

At present, most Australian universities with courses related to AEC have BIM within their courses, in the form of providing BIM-specific subjects or as a part of other subjects within their curricula. The rate of BIM integration shows an outstanding progress. At least 86% have BIM as the major content of standalone subjects. And 78% of AEC higher education institutions have integrated BIM into the content of subjects, which are not traditionally related to BIM. The ideal BIM integration into a course, namely, having standalone BIM units along with integration into other subjects is claimed by less than half of BIM educators.

In terms of experience in BIM education, BIM education is Australia resembles a young training experience. Around 40% of institutions had started BIM education 3-6 years ago; 40% started just 1-3 years ago; only 10% had more than 6 years of experience in BIM education; and 10% have initiated their programs less than 1 year ago. This resembles a field still evolving where established norms of training and education are scarce.

In most BIM subjects, currently offered at Australian universities, students are introduced to BIM authoring tools, mostly from the Autodesk Suite of BIM tools: 3D modelling tools, complemented with scheduling and cost estimation. The assessment tasks of these subjects entail students apply their BIM knowledge to adopt BIM to analyse a real-life case project, 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.

With the emergence of Digital Engineering (DE) in Australia, some institutions, as discussed next, have moved towards defining subjects allocated to DE. That said, such efforts are in infancy stages. BIM education at Australian universities must 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.

These topics are currently missing from most BIM-related subjects at Australian universities. Nevertheless, integration of these is occurring in a basic level. That is, some universities like Swinburne University refer to the use of VR and AR for communication purposes (Unit: Driving Collaboration in Projects), and Western Sydney University claims to include DE, Blockchain, Artificial Intelligence and modern construction enterprises (Unit: smart construction). UNSW similarly announces offering advanced topics like Human-Machine Interaction and advanced digital fabrication – in the Unit Design information management.

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.

Five universities – out of 23 –offer BIM-related Courses/programs at the undergraduate and postgraduate levels. For example, Bond University and the University of Western Australia offer Master/Graduate diploma/Graduate certificate in Building Information Modelling. The University of Canberra, University of Melbourne, and Swinburne University offer Major/specialisation courses in BIM at the undergraduate level. These, on some occasions, are offered as a part of other degrees. For example, Swinburne University has planned to offer a BIM specialisation core unit from 2021, which will be considered as one of the three core units of the 2-year Associate Degree of Applied Technologies.

Most Australian universities, however, offer BIM as a subject within their programs/courses. Universities can be classified into three categories in view of the way they offer BIM within their courses:

- Category 1: Standalone units allocated to BIM content. These account for 52% of universities - 12 universities out of 23. Examples are Deakin University that offers a BIM unit titled Principles of Building Information modelling; Bond University whose BIM unit is Design Communication: Building Information Modelling; and Curtin University with the standalone BIM unit in undergraduate level: Building Information Management, among others.
- Category 2: Universities offer BIM-related training with different identifiers. Around 34% - 8 out of 23 - have their standalone BIM units with various titles. Examples: The Digital Construction unit at UNSW; and Queensland University Technology with Advanced Building Documentation unit.
- Category 3: Allocated to the style of BIM training in which BIM content is integrated into the delivery of other subjects. Almost 78% of the universities - 18 out of 23 - have incorporated BIM in different subject areas such as cost estimation, scheduling, business management, etc. As an example, Deakin University plans to deliver planning and scheduling subjects with 4D BIM. Construction Engineering Unit, Construct Planning & Design 2 unit of RMIT University apply BIM for budgeting and scheduling.

The University of Canberra introduced BIM in the unit Interior Architecture Technology 3: Systems. BIM has been introduced in a wide range of subjects like building services, design team management and integrated technology too.

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. They also ran interviews 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 categories of 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.

NATSPEC has also been providing an *Introduction to BIM* presentation to undergraduate students at universities across Australia for the past 9 years.

NATSPEC also provides industry seminars on the use of the *NATSPEC BIM Project Inception Guide*, *NATSPEC National BIM Guide*, *NATSPEC BIM Management Plan*, the *NATSPEC BIM Object Properties Generator* and the *Open BIM Object Standard* (OBOS).

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, started in 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 recognises 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).

Currently, state governments in Australia, as well as the private sector, have recognised the great potential provided by DE for improving various facets of delivering and managing

buildings and infrastructure assets and networks. The ongoing development of the digital built environment in Australia is supported with 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 Part A, B and C*, the *Principles for BIM Implementation* in Queensland, and the *Australian BIM Strategic Framework* by the Board of Treasurers, among other initiatives across other states and territories. These documents highlight the need to revisit BIM training at 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 incorporated 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 treating BIM as a point solution and focus on effective management of data and information across wider generic 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.

buildingSMART's National BIM Initiative report to Federal Government (2012) identified 6 key areas needing attention to drive the construction industry forward. One of the key areas identified was multi-disciplinary BIM education. In recent years, BuildingSMART Australasia has joined the training and education movement in Australia. This has been through introducing the BIMcreds initiative, which provide BIM/DE practitioners a mechanism for demonstrating their competence. At the same time, it provides potential employers and project owners with confidence in the skills of the practitioners they hire.

A feedback summary at the completion of each assessment offers valuable pointers to areas of weakness, so that every applicant should emerge with a stronger sense of what it means to be an accomplished BIM/DE practitioner. BIMcreds data analytics reports are also informing training providers of common assessment errors so that courses can be modified or developed to address them, thereby creating a wider awareness of essential skills within the industry.

Since 2019, buildingSMART Australasia also formally accredits three postgraduate university programs in Building Information Modelling (BIM) and Integrated Project Delivery (IPD) offered by Bond University on the Gold Coast, which are made up of industry-friendly micro-credentialled subjects. Eligible candidates can complete the Masters degree in one year.

The Australasian Procurement and Construction Council (APCC) and the Australian Construction Industry Forum (ACIF) jointly published their *Framework for the Adoption of Project Team Integration (PTI) and BIM* at the end of 2014. Education and training in PTI and BIM 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*. The corresponding 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 two documents; *BIM Process Consistency: Towards a Common Framework for Digital design, Construction and Operation*; and *Asset Information Requirements Guide – Information required for the operation and maintenance of an asset.*

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. BIM is also trickling down to smaller consultants and smaller projects. BIM is becoming the norm. Some projects such as the Opera House and Pyrmont Bridge in Sydney are using BIM retrospectively to create a working model for FM.

The *NATSPEC National BIM Guide* and *BIM Management Plan* are being increasingly adopted across industry and government both as a framework for building projects as well as within education programs.

The NATSPEC BIM website, accessed by clicking on the BIM logo on the NATSPEC homepage, is a useful resource for general information on BIM, BIM R&D projects and the numerous BIM guidelines that are available.

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 AECOO 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 is poised to launch its Professional Certification program across the country in 2020, with several training providers.

Formerly known as Qualification Program, this program will attest to the knowledge of the

candidates through an online test provided by buildingSMART International (bSI).

The aim of the program is to provide standard essential knowledge of Open BIM and data management. It provides clear standards and promotes quality training by supporting and accrediting training content that meets a defined body of knowledge.

Most importantly, it provides the standards upon which training organisations can develop their course content. This structure ensures fundamental knowledge is acquired and it allows for a uniform online testing certification for individuals. It will therefore guarantee a benchmarked level of knowledge across the country and the world.

bSC also relays information about the new 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 AECOO 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 login 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

BIM education has continued to progress at all academic levels in Chile.

At a postgraduate level, during 2019 and the beginning of 2020, CORFO (Economic Development Agency of the Ministry of Economy) granted 647 scholarships for four different BIM training courses through its Human Capital Scholarships program. These courses are specifically focused on BIM for Reviewing, Modelling, Design and Construction of MEP systems. The course content is linked to the Roles Matrix published by Planbim in 2017. With this, the total number of scholarships related to BIM that CORFO has granted amounts to a total of 1,517.

Progress has also continued at the university level, with 90% of the universities that have AEC-related degrees currently teaching BIM. This means that 87% of the 108 programs existing in 2019 have BIM content included in their mandatory courses.

At the school level, in 2019, the first *e+bim* pilot was carried out. The initiative, led by Planbim and the Ministry of Education - with the support of 17 professional associations, private companies and academic institutions - consists of incorporating BIM into the curricula of technical secondary education.

In January 2019, 24 teachers and students from six technical schools were trained by professors from Duoc - a higher education institution - and Comgrap - a software vendor. These school teachers then included the BIM content they had learned in their curricula during the 2019 academic year. With this, BIM was taught to over 160 students.

The pilot project finished in December 2019, with the internship phase. Planbim managed to gather internships for 34 of these students in renowned architecture, engineering, and construction firms (such as C&D engineering and Badia y Soffia Architects, who were part of the original task force that supported the project).

Therefore, these students continued learning the practical application of BIM in real projects. More than 20% of the students received offers to continue working in those companies. This is a great success for the project since its ultimate goal is to increase the employability of technicians - who, many times, choose not to continue to higher education - and it also indicates that there is great interest from companies in hiring technicians with BIM knowledge.

Given the engagement generated by the first version of *e+bim,* in 2020 the initiative was expanded to 47 schools in four different regions of the country. This will allow BIM education to reach 1,250 students this year. The aim is that in the future all specialisations related to drawing or construction in technical secondary schools will incorporate BIM.

eLearning

Despite all the efforts from the State, the private sector and academia, there are still gaps in BIM training in Chile. These gaps are bigger in remote areas of the country, where sometimes there is a lack of infrastructure and/or educators to teach BIM.

To tackle this issue, Planbim is developing an introductory e-learning BIM program, funded by the Interamerican Development Bank (IADB). The course will be based on international standards and on the Chilean *BIM Standard for Public Projects*. It will focus on how to work collaboratively through BIM methodology. The course will last approximately 20 hours and will be provided free of cost.

Initiatives/Organisations

Planbim

Since 2016, Chile has been promoting BIM in public institutions through Planbim, an initiative of the Digital Transformation Committee of CORFO.

This initiative, using the procurement capacity of the State as a driving force, is articulating the process of implementing BIM in public institutions, being a requirement of most public tenders as of this year.

BIM Standard for Public Projects

In June 2019 Planbim published the *BIM Standard for Public Projects*. Developed through multisectoral work, the document defines and guides the information exchange process between public institutions and private companies as part of public tenders. This standard is aligned with the minimum requirements for the exchange of BIM information defined in several international standards such as ISO 19650, ISO 16739, ISO 29481, and others.

It includes more detail regarding how information should be delivered, through the definition of the Levels of Development, Types of Information, BIM Uses, etc. These definitions are based on international

standards and conventions, such as the BIM Project Execution Planning Guide from Penn State University, NATSPEC's BIM Object-Element Matrix, and the Level of Development from AIA and BIMForum USA.

It also includes conventions regarding geometric and non-geometric information that must be exchanged in a public project between the Appointing and the Appointed Parties. It establishes, as a minimum requirement, the incorporation in BIM models of the information established in the parameters of COBie and the *BIM Basic Information Delivery Manual* from BIM Locket (Netherlands).

Despite this standard being developed for public projects, it may also be used as a reference for private projects. The document is not a norm, but its use is mandatory in so far as public institutions include it in their bidding documents.

The document, originally published in Spanish, has been translated to English and Portuguese. As of March 2020, eight months after its publication, the different versions of the document and its associated guides had been downloaded more than 20,000 times.

ISO NCh publications

In 2018 Chile, through its National Institute for Standardization (INN), generated a mirror committee for BIM related ISO standards. Through the work of this committee, ISO 19650 parts 1 and 2, ISO 12006:3 and ISO 29481 parts 1 and 2 have already been published in Spanish as a Chilean norm (NCh).

In 2020, this committee will continue working on the translation and publication of ISO standards and participating in the international discussion of the ISO 19650 parts that are currently under development (parts 3, 4 and 5).

BIM Exchange Information Requirements

Regarding public organisations, standardised BIM Exchange Information Requirements (EIRs) have been generated for ten different types of projects: hospitals, health centres, bridges, airports, institutional buildings, educational centres, heritage buildings, courts of justice, social housing and public spaces.

These EIRs were created by Planbim together with the respective responsible institutions (Ministry of Public Works, Ministry of Housing and Urbanism, Judiciary Power) and are focused on requiring only prioritised BIM uses, which were selected to tackle specific problems and needs of the projects and institutions.

In 2020, new BIM EIRs will be developed for more types of projects, such as other social housing configurations, and the Chilean Antarctic Base. All these EIRs, which are aligned with the *BIM Standard for Public Projects,* will be used from this year onwards for the tender of public projects.

Mibim

In October 2019, the *BIM Implementation Matrix,* or *Mibim*, was launched. It was developed working with representatives of the public, private, and academic sectors. *Mibim* is a platform designed to help organisations objectively self-assess their current state of BIM implementation.

The matrix is organised as per the three phases of BIM use within the organisation: Planning, Implementing and Maintaining. The actions contained in these phases are sorted into four pillars: Strategy, People, Processes and Technology. By selecting a percentage of progress relative to the different actions that make up the matrix, the platform calculates the organisation's level of general maturity, and the level of maturity associated with each pillar and each phase. The resulting maturity level is accompanied by a report indicating the organisation's current actions and recommendations on the necessary implementation measures, should it require increasing its current maturity level.

As of March 2020, five months after launch, 177 companies have registered for evaluation in the platform, as well as 28 public institutions and 17 universities, from Chile and further afield.

Latin American Governments BIM Network

In 2019, the *Latin American Governments BIM Network* was formally launched. This network currently includes eight countries from the region: Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru and Uruguay.

The group aims to increase the productivity of the construction industry through digital transformation, accelerating national BIM implementation programs through collaborative work that promotes common guidelines and favours commercial and knowledge exchange in the region. In other words, one of its main goals is that the Latin American countries adopt common and aligned standards.

Additionally, one of the proposed actions for 2020 is to connect with governmental BIM associations from other countries and regions, in order to foster links between governments that are implementing BIM and thus promote

the exchange of lessons learned at a global level.

The *Latin American Governments BIM Network* is currently chaired by Chile and has three years funding from the IADB.

Awareness/Uptake

More and more private sector companies are either implementing or interested in implementing BIM. In 2019, the Faculty of Architecture and Urbanism of Universidad de Chile published the third version of the *National BIM Survey*. The survey showed that 34% of the respondents were regular BIM users. Among these respondents, architects have the highest percentage of adoption, with regular users at 41%, engineers at 25% and contractors at 17%.

On the other hand, 76% of respondents who are currently non-users, occasional users or indirect users, stated that they will increase their level of BIM use in the next 12 months.

CHINA

Education/Training

In August 2016, the Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD) published *2016-2020 Outline for the development of informatization in the construction industry*. It proposes to "focus on the introduction of BIM and other information technology professionals, cultivate interdisciplinary talents who are proficient in information technology and professional knowledge, strengthen training on information technology application and therefore enhance the informatisation application capability of all employees".

It is estimated that in the next five years, enterprises in China will have a total demand for 1.3 million BIM employees.

Universities, associations, industrial alliances, enterprises and training institutions in China are providing different types of education and training activities.

Currently, Tsinghua University, Shanghai Jiao Tong University, Tongji University, Zhejiang University, Huazhong University of Science and Technology, Chongqing University and other colleges and universities have offered BIM courses in the major of engineering management. These include the development history, technology application and design application. BIM has also been combined with some traditional courses, such as project evaluation, engineering drawing, computer-aided design, etc.

Furthermore, some activities from the School-Enterprise Combination and the Association of Production, Learning and Research are carried out to promote BIM technician training and technical application, such as:

- BIM-based application design competition, skills competition and case exhibition competition.
- BIM technology seminar, software training meeting, case analysis.
- Seminar on the integration of BIM with Internet of Things (IoT), GIS, Artificial Intelligence (AI) and other emerging technologies.
- BIM research project, standard/guidance, software development, etc.

So far, the training of BIM software covers Autodesk Revit, Bentley MicroStation, Tekla Structures, Graphisoft ArchiCAD, etc.

The China BIM Union (the third batch of pilot union of the Ministry of Science and Technology of China) has hosted the five-day workshop *Advanced Training on BIM Application & Industry Collaborative Innovation* biannually since 2015. Up to 2019 the workshop has been successfully held nine times, involving 740 participants (including designers, project managers, software engineers, university teachers, government officials, senior technicians and managers).

Since the 9th workshop, the new creative competition *BIM data of China* has been held simultaneously. The advanced training content contains:

- Overview of BIM application and research progress.
- BIM technology research and achievements display.
- BIM software development and project practice.
- Establishment of collaborative innovation platform in the BIM industry.
- Research and application of CDM (Component Datumize Model) technology and standards.

Initiatives/Organisations

The training organisation of BIM talents in China includes: China BIM Union, China Railway BIM Alliance, buildingSMART China, China Graphics Society and China Association of Construction Education. About twenty-three provinces or cities in China have established BIM Unions to implement BIM training.

China BIM Union, the earliest national-level institution in China, was established in January 2012. It is building the Chinese BIM standard system and has issued two national BIM standards and thirteen group P-BIM standards. At present, the union has taken the lead in organising domestic enterprises involving architectural design, construction, operation and maintenance, consulting, and software to train high-level BIM talents and jointly study BIM and the CDM series standards.

Under the guidance of China BIM Union, many provinces and cities all over China have set up their local BIM unions, so far including: Fujian Province BIM Technology Union, Guangdong Province BIM Technology Union, Henan Province BIM Development Union, Shaanxi Province BIM Development Union, Yunnan Province BIM Union, Hainan Province BIM Application Union, Chongqing BIM Union, Guangxi Province BIM Technological Development Union, Shanghai City BIM Technological Innovation Union, Tianjin City BIM Technological Innovation Industry Union, Hunan Province BIM Union, Liaoning Province BIM Industry Development Union, Guizhou Province BIM Development Union, Beijing City BIM Technology Union, Shanxi Province Survey and Design Association BIM Technology Union, Gansu Province BIM Technological Development Union, Shandong Province BIM Technology Union, Hong Kong SAR BIM Alliance (buildingSMART Hong Kong), Taiwan Province BIM Alliance, Inner Mongolia BIM Union, the Yangtze River BIM Technology Union,, Shenzhen BIM Innovation Union, etc.

Awareness/Uptake

The China BIM Union issue questionnaires in each Advanced Training workshop. According to the survey in 2019, about 96% of respondents have participated in different kinds of BIM technology training (that proportion was 93.6% in 2018). 20% of respondents think their colleagues have a clear understanding on BIM technology, whereas 34% still think that their recognition on BIM technology is relatively limited. Respondents' confusion about BIM technology application mainly focused on the application (23.3%), software (13.2%), data interoperability (9.5%) and standards (8.5%).

Since 2019, China BIM Union, as the leader, has organised relevant enterprises of the whole industry chain of the domestic construction industry to conduct the research and publication of BIM-CDM technology standards. Among them, Building Datumize Model (BDM) integrates the data accumulated over the years in different fields in the construction industry into horizontal correlation and unification according to the business characteristics, and forms a vertical stratification according to the data use. Finally, it will have public data service capability. At the same time, to open up the vertical data chain in the construction industry, the unified standards are adopted for the construction, so as to bring up to scratch the internal and inter-enterprise collaborative work, technology cost reduction, efficiency promotion and business empowerment.

CDM is a building components database according to the demand of engineering construction and management. As a data

standard, the CDM standard aims to provide the construction industry with an intermediate data standard which is independent on any specific software/system, and to realise data-driven BIM rather than 3D model-driven BIM. At present, the CDM standard for precast concrete structural members and the CDM standard for the cast-in-place concrete structure have been completed and CDM-based data interaction and various applications have been realised through independent research and development software. It is planned to continue the investigation on data standards regarding building mechanical and electrical engineering, geotechnical and underground space.

CZECH REPUBLIC

Education/Training

In the Czech Republic there is a lot of BIM education and training taking place through BIM seminars, workshops and presentations led by CAS (Czech standardisation agency), CzBIM (Czech BIM Council), universities, software vendors, companies, technical chambers, etc.

In November 2019, CAS published the *BIM EDU* report, which describes the state of teaching at Czech public universities. The focus was on the main 5 Czech universities where AEC is taught.

The leading Czech Technical Universities have been implementing BIM into 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 would 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 software, or other special subjects.

However, this implementation of interconnections between subjects or fields (to collaborate) is also one of the biggest obstacles of BIM implementation into teaching.

There is no branch of study which would directly focus on BIM nowadays. Other obstacles are for example: lack of standardisation of BIM in Czech Republic (It is still going on), insufficient qualification of teachers, lack of study materials and models in sufficient quality, lack of money.

BIM is still part of research and development projects on a regular basis. 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 can adapt BIM to their school educational programs with effect from the school year 2021/2022.

Initiatives/Organisations

CzBIM – Czech BIM Council is a non-profit organisation which is focused on support of BIM implementation in the Czech Republic. It assembles professionals from both companies and individuals active in the BIM area. 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 standard bodies.

It resulted in success in 2017 when the Czech government approved a BIM implementation document which covered a strategic plan for the following 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*).

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*. 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 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 have been introduced during this BIM summit. Public projects, financed from public resources, above a specified value (note: the value set from 2020 is €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, BIM protocol. However, detailed information and documents are still in the ongoing process of preparation.

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 both for infrastructure and buildings. Some of the big contractors are running their own pilot projects.

Czech Ministry of Industry and Trade recommended IFC format for information transfer during the whole building lifecycle in April 2019.

There is a visible shift from "I would like to do BIM" to "do and try BIM", do projects in 3D CAD software 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 software and processes, the need to go through related education/training and lack of the best practice and Czech BIM standards.

In general, there are a few BIM projects currently running in the Czech Republic and the number is increasing, however 2D is still used for most 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 software. There is also increased interest around facility management and the usage of BIM, which caused development of new software tools and methodologies.

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. Therefore, the Czech government has launched a change of Czech building law and preparation for electronic communication between authorities and builders (builder's portal) in 2019. This should allow the whole building permit process to happen electronically from July 2023.

FINLAND

Education/Training

Universities, Universities of Applied Sciences (UAS) as well as Vocational Education Institutes provide BIM education for their students. All current construction and architecture students study BIM to some extent included in their professional courses.

Some UAS also provide whole bachelor's degree for Architectural education where the key areas are modeling (BIM) and model utilisation: visualisation, renovation, maintenance of buildings, lifecycle thinking and energy efficiency. Different courses are also integrated in various AEC programs e.g. BIM for Building Production; BIM for Structural Engineering; Simulation Tools for Building Services, BIM in Housebuilding Projects (integration of BIM holistically to building process).

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 EU, government and private sector. In these projects new BIM education and training methods have been developed for various groups such as designers, clients, contractors, house owners, public building permit and fire safety, and other officials.

Some Vocational Education Institutes provide continuing education related to BIM e.g. CAD-BIM utilisation for HVAC on construction sites. A new curriculum for a degree program for design assistants has been updated with inclusive BIM covered in every module of the study (implementation started in August 2018).

For graduate, postgraduate and further education students, there are several options and possibilities offered:

- Special Courses and Further Education is provided by some UAS:
  - 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.
- Software companies:
  - All vendors (Solibri, Autodesk, ArchiCAD, Trimble, Novatron, Symetri, Civil Point, Magicad, 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 over 140 company members and user groups for Education, Building, City planning, Dictionary and Infra are all up and running.
- KIRAHub continues as a new association in the footsteps of former KIRA-digi, a 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 in March 2012 and it is now in widespread use. English, German, Estonian and Spanish translations of the requirements have also been completed and four Annex for building owners were published. Updating the COBIM guidelines is currently ongoing.
- Guidelines similar to COBIM, but for Infrastructure (Common InfraBIM Requirements), have also been developed.
- The Finnish XML based data format for neutral BIM data exchange for infrastructure is now a buildingSMART project.
- The first Finnish textbook for BIM education: '*BIM on a construction site'* was published in 2016 by Building Information Ltd.
- ROTI 2019 is a report and an expert assessment (published every second year) on the condition of the built environment. It offers impartial information and viewpoints for experts, decision-makers and citizens alike. The ROTI report raises the issues of architecture, planning, design, and art in the built environment. The section 'Digital Solutions' is a part of the 2019 ROTI. ROTI gives recommendations like: improving the digital capacity and skills of both individuals and organisations, standardising the electronic system interfaces to be open and

machine-readable, determining common goals for RDI activities in the real estate and construction industry, significantly boosting construction companies' own research and development investments etc.

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. Furthermore, BIM sessions (training) relative to specific uses depending upon the profession and activities are organised on a regular manner.

Public sector clients are using BIM on some of their projects.

In Finland BIM always means using open standards: IFC for buildings and LandXML for infrastructure.

BIM education and training was carried out for Vocational Education Teachers and interested UAS teachers as a project to promote BIM education integration on all education levels through Ministry of Education funding.

The first draft for the skills and learning outcomes matrices related to BIM and energy-efficiency have been published in BIMEET, a project funded by the EU Horizon2020 research program. BIMEET project participants include LIST Luxembourg, Cardiff University UK, CSTB France, BRE UK, HOT Luxembourg, CRES Greece, VTT Finland and Metropolia UAS Finland.

Different levels of BIM courses/trainings 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 an ongoing effort to develop EU wide course content and delivery methods.

Extensive BIM training for building permit authorities has been launched in Finland's largest cities. BIM based building permit processing has been tried in some cities in Finland since 2011. In the initial phase, area calculations were checked on the building models and compliance inspections related to accessibility, housing design and fire and operational safety were carried out.

The first BIM model-assisted projects were under permit processing at the 2016 housing fair. A visual city model of the fair area's buildings and surroundings was created during the permit phase, where the user was able to explore the fair area and its buildings using game engine technology.

The Ministry of the Environment's guide (2015) on construction plans and studies, identifies the utilisation of BIM models in permit processing. According to the guide, the main drawings may also be presented as a BIM model, depending on the building authority's readiness. Based on the experience gained in construction supervision, BIM models can already be used well as supporting material for the permitting and supervision process. The models have been most clearly useful in assessing 3D city models, utilising the planned construction's compliance with the town plan, suitability for the environment and impacts on neighbours.

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

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.

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 2022 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).

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.

HONG KONG

Education/Training

The Construction Industry Council (CIC) continues to develop itself as a Centre of Excellence for BIM, formulating strategies for market transformation and promoting cross-discipline collaboration and wider adoption of BIM.

The CIC have expanded the spectrum of BIM training courses at the BIM Innovation and Development Centre. Apart from the BIM basic modelling, advanced modelling and data management, CIC offers additional day and night courses, covering BIM modelling for civil engineering, BIM object development and BIM Management in the areas of information management at different stages of construction projects. To cope with the strategic goals and development of CIC, The Hong Kong Institute of Construction (HKIC) was established and has been responsible for BIM related courses since January 2019.

The CIC revamped the free and open BIM Awareness Seminar and Workshop to version 2.0 and provided more comprehensive content to increase the knowledge and understanding of industry practitioners on BIM technologies and transformation process.
The CIC also organise BIM Talks by inviting local BIM experts to share their successful implementation of BIM in real life projects. Online versions of both events have been broadcast over the CIC's BIM Portal and YouTube channel.

To foster the collaboration with higher education institutions on the development of BIM teaching courses and to introduce BIM knowledge into higher education, the CIC signed a Memoranda of Understanding (MoU) with nine local higher education institutions including The University of Hong Kong, The Hong Kong University of Science and Technology, The Hong Kong Polytechnic University, City University of Hong Kong, Chu Hai College of Higher Education, The Chinese University of Hong Kong, The Hong Kong Design Institute (HKDI), Hong Kong Institute of Vocational Education (IVE) and Technological and Higher Education Institute of Hong Kong (THEi).

Initiatives/Organisations

The CIC revamped their BIM Portal to provide a convenient and user friendly platform to access and share more information about BIM, including CIC's BIM trainings, local events, BIM showcases, BIM objects, BIM Talks videos and local and overseas BIM standards and guidelines, etc.

The CIC opened a new venue called *CIC BIM Space* in April 2019 to showcase innovative BIM technologies and applications, collaborate with industry partners and stakeholders to promote adoption of BIM via seminars and workshops, such as BIM Solution Day and BIM Advanced Workshop, and provide advisory services to industry practitioners, especially Small and Medium Enterprises (SMEs).

In August 2019, the CIC published two new BIM Standards, namely, *BIM Standards for Mechanical Electrical and Plumbing* and *BIM Standards for Underground Utilities*, to elaborate and establish the BIM Standards for specific BIM usages and disciplines. In December 2019, we published *CIC BIM Standards for Preparation of Statutory Plan Submissions* to provide general guidelines for reference.

Also, in December 2019, the CIC organised the International Conference on BIM as one of the major events of Construction Innovation Expo (CIExpo) 2019. The conference gathered together world class speakers and BIM experts to cover the best practice and latest global development trends in BIM which attracted around 630 attendees. The CIC also organised the 2nd Asia Pacific Regional BIM Group Meeting and invited representatives from different economies to share their experience and polices on their development on BIM.

JAPAN

Initiatives/Organisations

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) established *BIM guidelines for government buildings* in 2014.

The focus is on the use of BIM, from the schematic programming phase to post-project maintenance.

As mentioned above, BIM utilisation was started in national government building procurement field, but CIM (Civil Information Modelling and Maintenance) which is BIM of the civil engineering field has begun 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:

- WG1. Establishment of standard BIM workflow.
- WG2. Development of object library.
- WG3. BIM support for building confirmation.
- WG4. Investigation of quantity survey and building classification code for BIM.
- WG5. Development of common data environment (CDE).

As a first fruit of the *BIM Promotion Roundtable*, the first edition of the standard BIM workflow was launched. In FY2020, MLIT Housing Bureau Building Guidance Division has plans to carry out a demonstration experiment with a budget of 2 billion yen for the purpose of demonstrating and improving the workflow.

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), and a budget of 2.3 billion yen is spent on R & D investment for FY2020. This includes, in architectural building-related matters, 90 million yen for building a BIM object library and 35 million yen for developing a BIM building verification examination. These were allocated under the supervision of Building Research Institute (BRI). In this R&D, a BIM object library providing an environment and a draft code of practice for BIM building confirmation has been developed.

PRISM plans to continue until 2021, and by that time the goal is to develop a common BIM usage environment for building production.

Awareness/Uptake

The *BIM Promotion Roundtable* is built from most of the private side parties representing building owner/promoter, architecture, engineering and construction and from government parties. In the roundtable very enthusiastic arguments about promoting BIM are made.

The role of the consortium is growing with respect to PRISM R&D investment. The BIM Library Consortium Japan (BLCJ) was established for the creation of the BIM object library before the PRISM investment began, 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 these 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 Digitization Council (BDR). The network aims to exchange and develop educational approaches, experiences, and teaching materials. In practice, the member universities tend to stick to their own approach.

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

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

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

Initiatives/Organisations

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

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

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

Awareness/Uptake

There is strong growth in the diversity of educational offerings. In particular the essential 'soft skills' and organisational change are increasingly being discussed.

There is also a strong undercurrent in the development of BIM-based quality assurance.

The development of knowledge leaflets by the BIR has helped create greater awareness in the industry about opportunities and possibilities created by using BIM.

At this moment 5 knowledge leaflets have been developed and translated into English.

NEW ZEALAND

Education/Training

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 programme 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 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 this sixth year running. 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 this year 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

All universities within building and civil engineering includes BIM in the studies. Universities such as NTNU and OsloMet have BIM courses where the buildingSMART standards are a formal part of the curriculum. They have developed a textbook combining software and process, where buildingSMART standards are included.

buildingSMART Norway (bSN) support yearly student BIM seminars with 250+ students. NTNU has established a 2-year master program in digital construction processes. Four university colleges in Norway offer one-year programs in BIM-specialisation.

The increasing market demand for BIM competences in the building and construction industry is driving the need for specialised education. bSN supports BIM education to raise awareness about the importance of digitalisation for the building and infrastructure industry.

There are approximately 50 bachelor and master thesis in BIM each year, where bSN members act as industry partners. All student's bachelor and master thesis are published on the bSN web site.

In 2014 bSN released an educational program with a focus on how to collaborate and work in a multi-discipline open BIM environment. The educational program is free to use for bSN member organisations and several private course providers have developed courses based on this program. This program was used as foundation for the buildingSMART International (bSI) Professional Certification Program.

Initiatives/Organisations

From 2020, bSN has started the implementation of bSI Professional Certification in Norway. This is an international education benchmark with focus on openBIM format and based on ISO 19650. The goal is for bSI Professional Certification to become a requirement in the Norwegian building and construction industry for BIM projects.

Several Norwegian organisations are involved in the development and revision of National and International standards for digitalisation of business processes.

bSN has 130+ member organisations, representing 25% of the total AEC industry turn-over. 10 % of bSN members are from the educational sector. bSN coordinates most industry initiatives and BIM User Groups for all disciplines, in a series of arenas.

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 openBIM projects are on-going in Norway.

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

There are 11 Institutes of Higher Learning (IHLs) providing full-time and part-time programmes with BIM / VDC (Virtual Design & Construction) / IDD (Integrated Digital Delivery) curriculum. Third-party BIM software educational vendors were also crucial in training, especially for professionals. To date, close to 15,500 students and professionals have been trained in BIM / VDC / IDD.

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

Four out of five polytechnics provide BIM modules in the three discipline streams and beyond, such as in sustainability-related programmes.

Five out of six universities offer BIM modules in their bachelor and master programmes. 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 education and research arm, the BCA Academy, takes the lead, going beyond BIM and Virtual Design and Construction methodologies into Integrated Digital Delivery concepts for its curriculum.

BIM / VDC / IDD content is incorporated into BCAA's full-time diploma programmes covering all disciplines across the construction value chain, joint degree programmes between BCAA and universities, such as Singapore University of Social Sciences and the University of Newcastle (Australia), as well as Master programme partnering with the University of Florida.

Currently, BCAA offers four specialist diplomas in BIM, VDC and Computational BIM (Building and Infrastructure), and six certification courses on BIM Modelling (for Architecture, Structural and MEP), Management, Planning for Owners and Facility Managers, and MEP Coordination.

BCAA also organises seminars, workshops and short courses on BIM / VDC / IDD such as

in the areas of BIM Quantity Take-Off, BIM Scheduling and Process Management, Computational BIM, BIM for Building Lifecycle and Facility Management as well as Data Analytics.

More than 13,100 students and professionals have been trained through the BCAA's BIM / VDC / IDD related programmes.

To support the development of leadership capability in Design for Manufacture and Assembly (DfMA) and IDD, BCAA partners with Imperial College, London to organise an Executive Development Programme on DfMA and IDD Leadership.

The BCAA also launched the Centre for Lean and Virtual Construction (CLVC) at the end of 2015 as a first-of-its-kind immersive and experiential facility for BIM, VDC and Lean Construction, to encourage IHLs and industry firms to utilise the Centre for training and experiential learning purposes.

The Singapore Contractors Association Limited (SCAL) Academy has also trained more than 200 students from its member firms in BIM software. The Singapore Institute of Architects also holds programmes engaging their members in BIM management and implementation.

Initiatives/Organisations

The Building and Construction Authority formulated the 1st BIM Roadmap in 2011 to drive the adoption of BIM under 5 areas:

- Public sector taking the lead.
- Promoting success stories.
- Removing impediments.
- Building BIM capability and capacity.
- Incentives for BIM adopters.

By 2015, the 1st BIM Roadmap achieved BIM adoption in most of the larger consultants and contractor firms in the industry. The 1st BIM Roadmap also saw the adoption of BIM in 102 public projects, 181 projects meeting mandatory BIM electronic submission requirements, SGD20 million committed to more than 700 firms who achieved an average of 21.5% efficiency gain, launch of the Singapore BIM Guide, Essential BIM Guides, BIM e-Submission guidelines and software-specific template guidelines.

The 2nd BIM Roadmap was launched in 2015, to advance the use of BIM in an integrated manner over the building life-cycle under 4 areas:

- Focus on VDC:
  - . Driving BIM collaboration throughout value chain.
  - . Building BIM capability of specialist contractors.
  - . New training programmes and facilities (such as the Centre for Lean and Virtual Construction) at all levels.
- BIM for Design for Manufacturing and Assembly (DfMA).
- BIM for Facilities Management and Smart Buildings.
- Research & Development.

As part of Singapore's Construction Industry Transformation Map (ITM) launched in October 2017, IDD is one key area identified to transform the built environment sector. Enabled by BIM, IDD aims to fully integrate processes and stakeholders along the value chain from design, fabrication, to assembly-on-site and operations and maintenance of buildings through advanced info-communication (ICT) and smart technologies.

The IDD Implementation Plan was launched in November 2018 to encourage more built environment sector firms to go digital.

The three focus areas under the Plan include:

- Raising awareness on the benefits of IDD through demonstration projects.
- Developing the IDD ecosystem, with enabling solutions, platforms and standards.
- Strengthening the industry's competency in IDD.

The Building and Construction Authority also engages industry leaders through the new IDD Steering Committee and subgroups, as well as practising BIM / VDC / IDD experts from various disciplines both upstream and downstream through the Trade Associations and Chambers (TACs).

To help the industry go digital with IDD, the BCA Academy is offering IDD related training programmes at various levels. These training programmes 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). These courses will help equip building professionals in Singapore with the necessary skills and expertise to execute IDD projects.

Awareness/Uptake

Continuing the success of Singapore Green Building Week (SGBW) and Singapore Construction Productivity Week (SCPW), BCA partnered with all the 12 TACs to organise a new flagship event, International Built Environment Week (IBEW) in September 2019.

The event will be held annually 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.

As part of the event, an international design competition targeted at full-time local and international students from tertiary institutions in the respective countries will also be held annually to raise awareness and build digital competencies in Green, Design for Manufacturing and Assembly (DfMA) and IDD concepts.

SOUTH AFRICA

Education/Training

The BIM Academy Africa has engaged with 16 tertiary universities and colleges including supplying a handful with different curricula BIM courses at university level.

Changing South African (RSA) university curricula is a fraught and time-consuming activity and thus the introduction into the mainstream coursework will still take many years to action. However, some universities have introduced BIM from a software perspective in the form of REVIT or ARCHICAD courses. The majority of these are stand-alone or short courses, completely divorced from the university's core curriculum.

RSA lecturers and university staff generally lack knowledge of and exposure to BIM, so to comprehend (much less lecture) the nuance and complexity of BIM processes is a challenge, and as such, the topic is therefore glossed over or ignored completely. This is further exacerbated by traditional educator's reluctance (or out and out refusal) to share information across departments within the AEC educational spaces and therefore stunt the development of collaborative courses.

Upskilling within the workplace is looking better though. The end of 2018 saw the BIM Academy Africa (in partnership with UK Whitefrog) establish the first African strategic implementation of BIM for the Ethiopian Government Ministries under the Ethiopian Construction Project Management Institute (ECPMI). The BIM Academy Africa also trained and internationally accredited 478 professionals in various BIM courses, while simultaneously providing hundreds of SA students (Wits, TUT, UCT and DUT) online learning access to NavBIM.com (Africa's largest learning portal for BIM education).

Initiatives/Organisations

Despite a lack of any private or public funding, the BIM Institute has been drafting the South African National BIM Guide for designers and operators in a bid to align itself with international standards. There is still a battle with certain technology vendors hell-bent on creating a monopoly in BIM software solutions.

A new local online book, *BIM - It's your move* by Vaughan Harris, has been published. The book gives the reader a no holds barred view of the current state of BIM in Africa. It encourages professionals to reinvent themselves, and the sector that they work in,

through an honest and insightful guiding hand (and sometimes a kick) in the right direction.

In 2018, and in collaboration with the South African Quantity Surveyor Association (ASAQS), the BIM Institute challenged Quantity Surveyors in the *5D BIM Estimating Competition 2018*. The results were announced at the 4th ASAQS Conference. The winners were selected from an impressive 48 entries. The competition sparked new concepts and communication solutions for estimating professionals. It focussed not just on quantifying the models provided, it tested the candidate's understanding of the principles of the Common Data Environment (CDE) and ability to identify and correct some errors within the architect's model geometry.

Entrants stated their chosen estimating software used to produce an elemental estimate (using the newly released estimating classification system developed by the BIM Institute). It showcased the innovators embracing the digital tools at hand – the future leaders of the RSA construction sector and the potential stars that will lead the country in its digitisation push.

Awareness/Uptake

The tipping point for BIM adoption in RSA requires a fundamental shift in building standards and education at the tertiary and institutional level.

Many traditional architects and engineers are caught up in the details (the fee structure changes that require clients to invest more to develop a digital twin), losing sight of the bigger picture related to the improved efficiencies the technology will bring to their daily operations.

This has created an inertia that spills over to the architect and engineering associations, leaving them unwilling to promote BIM within their ranks.

Construction professionals have not embraced the technology as a means to better deliver their projects, with government tenders in particular reinforcing manual processes as part of a wider policy on increasing jobs growth.

Design professionals within the RSA AEC industry still largely consider BIM solely as a software tool, failing to fully understand the often overlooked improvement in productivity a more holistic implementation would facilitate.

However, BIM adoption is gaining momentum within the African market. The BIM Institute and the BIM Academy Africa have led the charge in skills and resource development. African countries are increasingly using BIM (often to meet international investors requirements) and the demand for this skill set will keep increasing. Graduates and professionals that lack these skills are starting to feel their disadvantage already and will be marginalised more and more both locally and internationally.

RSA businesses continue to battle with slow economic growth, a diminishing pool of construction professionals leaving the African shores, a lack of foreign investment and pressure by the South African government to transform the sector faster and more drastically. With these pressures, we see the motivation of South African companies to keep pace with first world countries diminish directly proportionately to the stress that "business as usual" in this environment places on the sector.

The billions of Rands proposed for investment into the infrastructure development pipeline is great news, unless you factor in the aging RSA workforce. An inability to replenish this pool of professionals with young, skilled workers with digital skills is putting at risk the country's ability to ensure these projects are completed on time and within budget. This despite sporting one of the worst youth unemployment rates in the world and with Industry 4.0 having become a government focused initiative. This risk is also becoming clearer to foreign investors looking for opportunities in the country.

As a reaction to some of governments other policy decisions, we see RSA companies failing to invest the necessary time and resources to ensure their skills pools are future-proofed and skilled enough in current and future technologies designed specifically to ensure their own success. This short sightedness is lessening RSA's lead on competing African countries – some of whom have already started the digital standardisation process that RSA still fails to address.

This conservative thinking (and naivety) leaves many local companies with undelivered value. The greatest failure sits with central government (or influential agencies) that have yet to put their metaphorical foot down and prescribe digital adoption as a catalyst for growth. A case in point is the National Building Regulations which still require submitted drawings for council planning approval to be a 2D Paper submission only (under SANS10400 Part A).

SWEDEN

Education/Training

The education of BIM-related knowledge is now turning from a more technical focus on modelling, information transferring and visualisation, over to management-related assignments with collaboration, requirements management and organisational strategies with BIM.

At the universities practical BIM-knowledge in software and information generation is now more organised to self-learning exercises, 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:

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

Swedish universities offer 135 courses with BIM within a total of 840 HP, which is about 14 years' worth of study.

Initiatives/Organisations

The network of 18 Swedish universities have joined and meet regularly in the BIM Academy (BIM Akademin) group. The initiative has a purpose to share and contribute knowledge, educational assignments, lectures and software experiences through the network work with seminars, webinars and information distribution under the organisation of BIM Alliance, Sweden.

In the project of 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 under continual development, which gives input to national strategies for research and development in the field of Smart Built Environment. The governmental Smart Built Environment program started in 2015 and has several knowledge packages to develop education with digitalisation.

Several 3rd cycle education courses (for Ph.D students) have been developed in the field of BIM and digitalisation in Smart Built Environment. Examples include Parametrical Design, Design Automation, Generative Design, Information flow for Industrialised Construction. These courses are a part of the national strategy to change construction to a sustainable industry by digitalisation and industrialisation.

Awareness/Uptake

There is still 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.

BIM implementation in architecture, urban planning and real estate management, is currently more or less neglected in curricula at Swedish universities, with some exceptions.

The large consultancies and contractors in Sweden do now develop their organisations to follow digitalisation strategies with BIM to meet future innovations and challenges.

A trend, that we also see is that at Swedish practical education schools (YH-utbildningar) have started two-year programs that focus on BIM-applications for entrepreneurs, consultancy and clients. From 2017 to 2019 five educational programs were running and today there are ten educational programs on offer, focusing on BIM-knowledge as a complement to universities starting in the fall of 2020.

SWITZERLAND

Education/Training

Several partners provide this part in Switzerland: Focussing mainly on open BIM, technical universities and universities of advanced sciences offer a wide range of courses at an undergraduate and postgraduate level.

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

- The ETH Zurich (University of Science and Technology Zurich) additionally runs two research labs: The BRG (Block Research Group) and the National Centre of Competence in Research (NCCR) Digital Fabrication.
- Apart from the above-mentioned programs the EPFL (Ecole polytechnique fédérale de Lausanne / Swiss Federal Institute of Technology) researches on an interoperability platform between Building Information Modelling and Building Energy Modelling as well as a roadmap for the implementation of BIM in the State of Geneva.

Also, 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. The integration of VDC (Virtual Design and Construction) in all disciplines of construction has a clear priority.
- At ZHAW (Zurich University of Applied Sciences) the continuing education concentrates on the field of Facility Management and Life Cycle Costs including BIM.
- This year in fall the buildingSMART Certification Program will, for the first time, be part of an undergraduate course. The BFH (Berne University of Applied Sciences) also offers a CAS in digital planning, building and using.
- At the same time of the year a new study course Digital Construction will start focussing 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.
- The program of continuing education at the HES-SO Fribourg (University of Applied Sciences and Arts – Western Switzerland) includes a CAS in BIM Coordination.
- The HSR University of Applied Sciences Rapperswil joins in with the module BIM for Infrastructure and is also a provider of the buildingSMART Certification Program.

Increasingly private training institutions take over a major role in the training field. Software providers push mainly and not surprisingly the closed BIM side. In contrast the buildingSMART Certification Program offers courses strengthening openBIM.

For non-academic professionals that plan to grow into the BIM area an increasing number of trainings are offered. Yet trainings and educations on a more basic level are still very rare.

Initiatives/Organisations

Since January 2018, the Swiss chapter of buildingSMART has started to take action. It is closely connected to Bauen digital Schweiz, an initiative of SIA (Swiss Society of Engineers and Architects), CRB (Swiss Research Centre for Rationalization 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.

In 2019, the Swiss chapter went public all over Switzerland also taking into account the French speaking regions. Concurrently the committee in charge of the Professional Certification Program pushed forward to be able to release the Qualification Platform by the end of Q4. Subsequently, numerous providers established courses, not only in the German, but also in the French speaking part of Switzerland this year.

Another driver is Netzwerk digital, the coordination unit for the digital transformation of the planning, construction and real estate sectors.

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.

A new platform is the openBIM Forum that took part for the first time 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 *Digital Switzerland* strategy 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.

Together with the COVID-19 pandemic in spring, this will have a deep impact on virtualisation and digitalisation of the building industry. Being reluctant to, or unskilled, in using digital tools, many are now (more or less) forced to apply digital media due to working from home. This will lead to a change in the acceptance and understanding of digital processes, of which BIM is part.

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 programmes at Masters level have emerged. A number of BIM specific BTEC level programmes 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 programmes/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 programme 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 programmes, accreditation is

normally undertaken by professional bodies. (PBs) During the last year, the focus for several built environment PBs has been in 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 programmes.

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 programmes. 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 programme 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 Masters programme. *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 programme 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 recently 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* programme.

Many of the AEC companies have run their own in-house training programmes 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 programme 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. At this time, 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 programme 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 programme 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.

Recent 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 COVOD-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 135 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.

There are also community-based colleges too numerous to name that provide coursework in BIM with Revit but this coursework would not lead to an accredited degree in Architecture which is required in the US for licensure.

A good number of these 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 Modeling and Simulation.

Penn State University College of Engineering now offers a new Special Interest Course*, BIM and Execution Planning* (AE 576). The literature states, "The course is available to everyone: Penn State students enrolled at all campuses including World Campus, students enrolled at other universities, and individuals who are not currently seeking a graduate degree or certificate are all welcome to enroll".

The University of Washington is also providing new coursework in BIM. This spring the university is offering, through the Department of Construction Management, a BIM Certificate Course for three credit units.

Community Colleges also provide coursework, as at the Seminole State College of Florida, offering a 3-credit course for 3D modeling 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 Modeling, Rendering, BIM, Diagramming and Video. Each category provides links to tutorials and instruction for the different platforms.

The Association of General Contractors (AGC) has sponsored and provides 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 Modeling (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. It now claims that 72% of all construction firms have in a strong way adopted BIM strategy and realised significant cost savings in doing so.

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 of construction costs.

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 Modeling: 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 Modeling for MILCon Transformation: The agency under the *USACE ECB 2018-7 Advanced Modeling Requirements on USACE Projects -- Category: Directive and Policy* sets the requirements for the advanced modeling requirements on all USACE projects. The policy states as one criteria: 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 modeling 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 are reporting BIM education being provided to Architecture Engineering Construction (AEC) students by their higher education and technical training institutions.

As previously reported in general, the number of courses being offered is not significantly increasing year on year, with countries such as Australia, Canada, Chile and Finland perhaps being the exception. This may indicate that the quantity of courses offering some form of BIM education may be reaching saturation in many countries.

However, many countries and 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, etc. as oppose to simple modelling and use of specific BIM software.

Most countries' higher education institutions are including structured BIM education within the syllabus of their AEC courses, at both an undergraduate and postgraduate level. Countries such as Australia, Chile, China, Finland, Norway, Sweden, UK and USA are reporting a significant volume of courses and subjects available. Many vocational education institutions are also providing BIM education to the industry's workforce.

Studies carried out by some of the countries 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 have also discussed in this year's report about the introduction of the buildingSMART International Professional Certification programme and how that is being implemented within their respective countries. It has also been noted that many training providers are now looking to the requirements of this programme to develop coursework specific to the BIM requirements of industry.

Other certification schemes to validate the BIM knowledge of professionals in industry also continue to be reported with countries such as Australia, Canada, South Africa, UK and USA having all reported the existence or development of such schemes in their respective countries.

BIM awareness and BIM uptake generally appear to have hit a saturation point in many countries, with it being business as usual for many. However, this is not strictly a consistent global trend, with BIM reported as being widely adopted in countries such as Finland, Norway and Australia, and even required by government, in some countries, such as Singapore and UK, whilst still only being considered in others, such as Czech republic and South Africa.

In general, the provision of BIM education in each country and region is being sufficiently covered in terms of the basics and the hands-on technical skills of using particular BIM software packages. The challenge in many countries appears to be in taking this further, to fully prepare students for the digital world in which they will operate and to provide them with the BIM skills that their industry will demand in the future.

However, 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.

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