

Virtual Design and Construction for construction project management education

Guide of practice for course level development



Enter

Introduction

This guide has been created as part of an educational research project “Virtual Construction Project Management Environment” at the Department of Construction, Unitec Institute of Technology, New Zealand. The research project is part of a curriculum development process currently in progress at the Department of Construction.

The objectives of this project were to:

- Enhance educational outcomes for learners by creating a Virtual Construction Project Management Environment that utilises Virtual Design and Construction technologies and processes
- Create a concept that can be transferable to a variety of courses in the construction discipline, including Architectural Technology, Construction Economics, Facilities Management etc.
- Contribute to the development of a more coherent knowledge base of effective teaching and learning in the construction discipline

We hope that this guide will assist you in your journey in developing Virtual Design and Construction education in construction project management context.

The project team wants to thank the sponsors [Ako Aotearoa Regional Hub Funding Scheme](#) and Unitec Institute of Technology Strategic Research Fund.

Acronyms and definitions

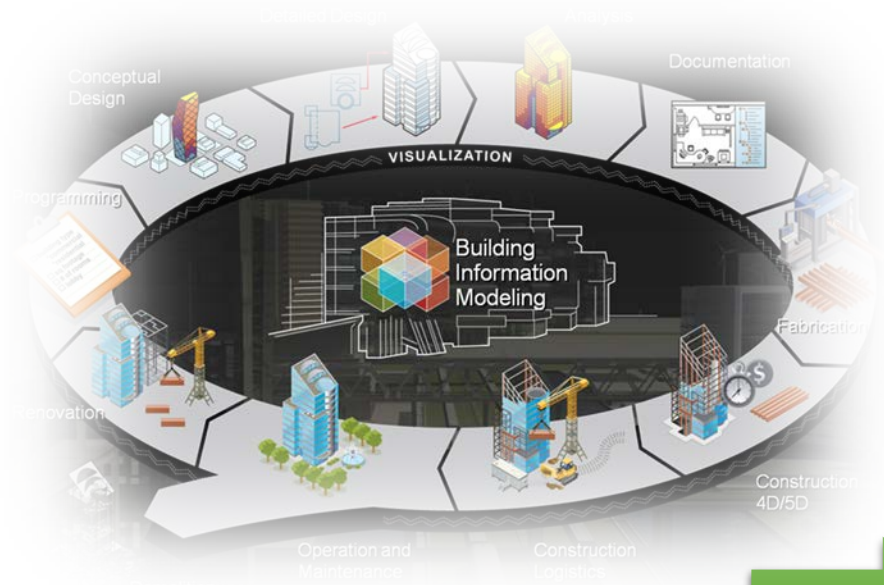
Definitions

Building Information Modelling (BIM) is a digital representation of the physical and functional characteristics of a building. As such, it serves as a shared knowledge resource for information about a building, forming a reliable basis for decisions during its lifecycle from inception onward.

Virtual Design and Construction (VDC) is the use of multi-disciplinary performance models of design-construction projects, including the product, work processes and organisation of the design-construction-operation team in order to support business objectives.

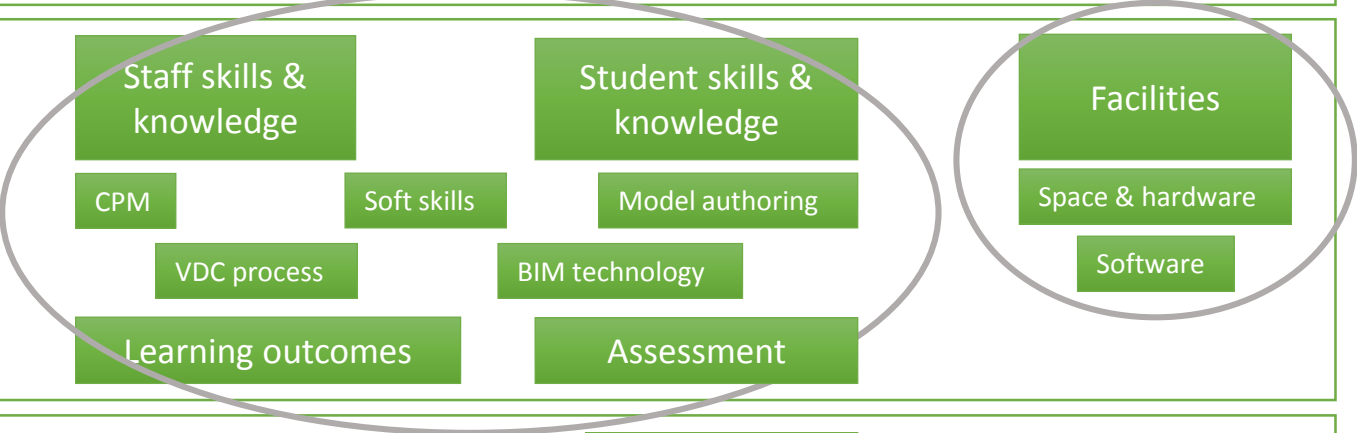
Acronyms

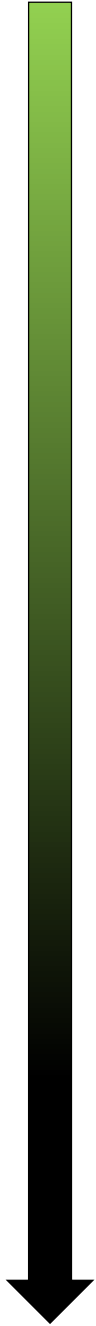
- BIM = Building Information Modelling
- CPM = construction project management
- LO = learning outcome
- NZ = New Zealand
- VDC = Virtual Design and Construction



Main menu

(you can navigate either through the main menu buttons topic by topic or go through the material page by page using the arrows on the pages)

What approach to take: integrate VDC/BIM as part of the content or have it as a separate one?	Integrated	As separate
Existing course or a new course?	Existing course	New course
How to avoid overloading the curriculum?	Core curriculum analysis	
What does your starting point look like?		
What do you want the end point to look like?	Learning outcomes	Assessment
What resources are needed for teaching?	Non-interactive	Interactive
How to source/develop a BIM model?	Sourcing a model	
What resources to look at to learn more?	References	



Integrated approach

In the integrated approach VDC processes and BIM technology are used throughout the course for the discipline specific tasks instead of the conventional processes and technology.

Application:

- You can integrate BIM and VDC as part of an individual course or as part of an entire programme
- Usually you integrate BIM and VDC as part of an existing course, but if integrated as part of an entire programme, then new courses can be developed in addition to the existing ones
- VDC can be used as a delivery vehicle for the course by using a BIM model as a central project, where all the theory and assessment links to, and VDC processes are applied to

Challenges:

- Space in the individual courses for additional content. A careful core curriculum analysis needs to be done for the course, and for the whole programme if wider adoption is chosen.
- Logical and coherent VDC/BIM pathway through the programme

Separated approach

VDC processes and BIM technology are taught as standalone subjects. Connections are created to the relevant discipline, but VDC/BIM is what drives the course, not the discipline context.

Application:

- Suitable for industry professionals, who already have proficient discipline specific knowledge and skills, but no understanding of VDC processes nor skills in BIM technology.
- Suitable for students at the senior level as an elective to deepen understanding of certain aspects of VDC/BIM
- Could be used as a temporary solution and introduced as an elective course for students at the senior level while developing the integrated approach for the whole curriculum.

Challenges:

- Disconnection from the discipline context
- Space in the curriculum for an elective

Existing course

Opportunities

- True integration to discipline context
- Review and update of the course as a whole

Challenges

- Space for new content
- VDC/BIM as an add on instead of integration



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New course

Opportunities

- “Fresh” thinking
- Flexibility in developing Learning Outcomes and through that assessment and delivery methods

Challenges

- Development requires time not just because of the development work, but also because the course needs to be approved by relevant committees



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Core curriculum analysis

Please see [Give me time to think](#), a practical guide for teachers and curriculum designers to determine appropriate student workloads and identify core curriculum. The focus of this book is on student workload and learning. Information overflow and excessive workload are seen as enemies of a deeper approach to learning. A time allocation and core curriculum process with study time calculation model are introduced to ensure that students will have enough time for high quality learning.

The guide is developed by Asko Karjalainen, Katariina Alha and Suvi Jutila at University of Oulu, Finland.

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What is the starting point = Pre-requisites

What is the end point = Learning outcomes

Planning the course content, delivery and the [assessment](#) is all about the journey from the starting point to the end point. For this you need to know what the real pre-requisites are, what the students know and can do already and what they need to be able to do or know at the end of the course. Don't assume things, instead investigate. Consider at least these areas:

- [Soft skills](#)
- [Computer skills](#)
- [Understanding of CPM](#)
- [Understanding of VDC process for CPM](#)
- [Technical BIM skills for CPM](#)
- [Model authoring skills](#)

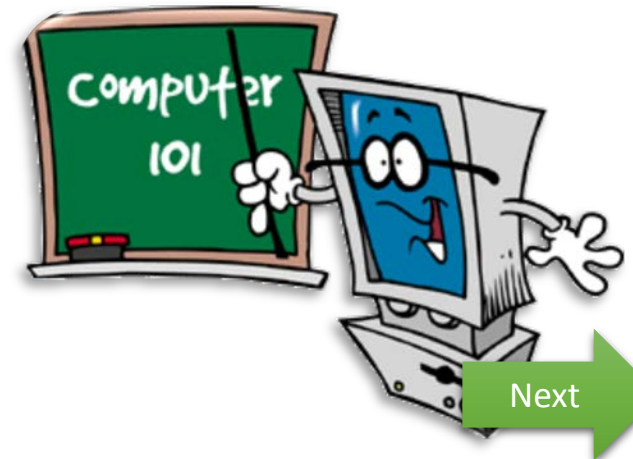
Don't forget that some of this might apply to staff as well, see [staff up-skilling](#)

Computer skills

Don't assume that your students are fully computer literate although they would be part of the digital generation. Quite probable is that you will get a wide range of capabilities, some fully capable computer operators and some just consumers of digital media. To find out what skills your students really have

1. Run a formative test at the start of the course
2. Investigate what computer literacy skills have been required in the assessments of the pre-requisite courses

If you choose the first one, you need to be able to quickly adjust your course accordingly. The second option you can do as part of the course development work.



Construction project management understanding

You need to answer these questions:

- Are your students required to have work experience? How much work experience they have?
 - You can ask your students how much work experience they have, but you need to be able to quickly adjust your course accordingly
- How much work experience your students have? What have they learned about CPM during pre-requisite courses?
 - Again don't assume things, see what and how CPM skills and knowledge has been assessed in pre-requisite courses

Remember the [core curriculum analysis](#), you cannot fit too much new information on one course. You need to find a balance between the CPM learning outcomes and VDC/BIM learning outcomes.

VDC process understanding

Possible topics in general might be

- Integration, interoperability, collaboration
- Communication
- Common language = terminology, guidelines, standards and protocols
- VDC for planning and programming

And specifically in construction project management

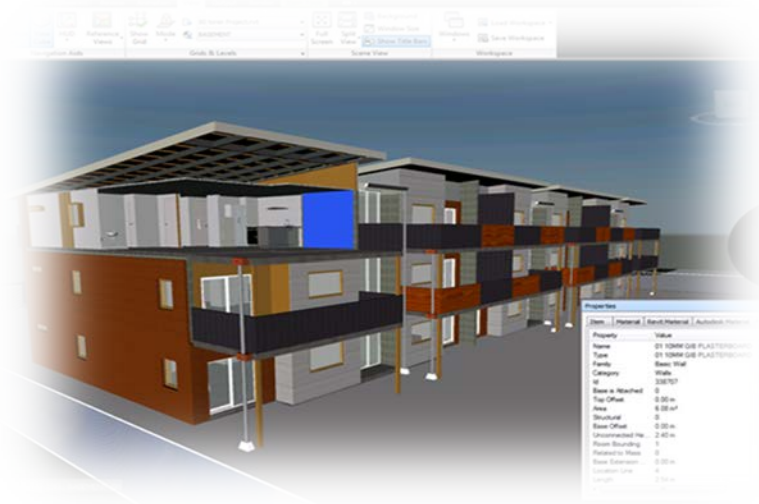
- Constructability
- Measuring and estimating
- Site utilisation planning
- Programming and sequence simulation
- Visualisation of H&S issues
- Coordination
- Production control
- Etc.

See also [Technical BIM skills](#)

Technical BIM skills

Possible topics might be:

- BIM for construction project management
 - Constructability
 - Measuring and estimating
 - Site utilisation planning
 - Programming and sequence simulation
 - Visualisation and communication of H&S issues
 - Coordination
 - Production control
 - Etc.
- What software is suitable for each?
- How to use the software for analysis and simulation?



Model authoring skills

Should a graduate of the programme be capable in model authoring?

This is the case with the design disciplines, but not necessarily with construction project management. Unlike most undergraduate construction degrees in Europe or in North America, New Zealand CPM degrees do not include engineering subjects. Still it might be worthwhile considering, because it is proven that model authoring improves understanding of construction technology and sequencing among CPM students. In this case the size and complexity of the model needs to be carefully considered, so that the model authoring work does not take too much time and compromise other learning outcomes.

Staff up-skilling

There is plenty of literature on VDC processes, the challenge is finding what you need among it. Practical knowledge might be more difficult to find, instead of looking academic literature, look into blogs and BIM forums online and attend industry conferences and events.

Technical skills develop only in practice. There are no practical industry training for VDC/BIM, which would focus on CPM, in NZ. International software companies and their training partners provide online resources, some for free and more with fees, but no courses are organised in NZ. Self-training requires perseverance; a professional development plan should be created and time allocated for it accordingly.

Assessment –Project-based learning (PjBL)

Time has passed isolated, static and individual assessments, which have limited relevance to project tasks in the industry and also affect student motivation. Instead students should be involved in tasks similar to real world ones, which rehearse their collaboration, communication, creative thinking and problem solving skills. Student-centred teaching methods such as PjBL are known to support learning of these skills by integrating the course delivery and the assessment by using one or multiple projects as the core of the course. Project tasks are close to professional reality, they require students to apply discipline specific knowledge, but also require time management skills and self-direction, and working in teams rehearses their communication and collaboration skills.


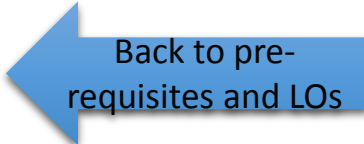
Integrating the assessment as part of the delivery, and running the course as a series of workshops will help to keep students focussed on the learning outcomes throughout the course, and the practical and the visual nature of VDC will keep the students engaged as well.

Read more about Project-based learning:

[What is project-based learning](#) by Buck Institute for Education

[What does successful project-based learning look like](#) by edutopia

[Project-based learning](#) by Great Schools Partnership

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Facilities –Space and Hardware

You need to answer these questions:

- Does the space that you have available support collaboration and the use of technology?
- Are on-site computers equipped with required memory, hard drive and processor capacity, graphic cards etc.?
- Is the hardware available able to run the software and cope with the files needed
 - [System requirements for Navisworks 2015](#)
 - [System requirements for Synchro](#)
 - [System requirements for Vico Office](#)
- Do students need the software on their own computers?

Facilities -Software

You need to answer these questions:

- Does your faculty have funds allocated for software licenses or do you use only freeware?
- Do students need licenses for their own computers?
- What is the required number of on-site licenses?
- How much time is require for the software installations?

Most CPM BIM related software are free for educational purposes, but not all software companies provide licenses yet for students' own computers. Software companies offer limited cloud-based licenses, but mainly for certain collaboration software such as [Trimble Connect](#) and [Autodesk 360 Glue](#).

Remember to keep up with the software updates, they renew yearly!

Non-interactive resources

Non-interactive resources include

- reports, guidelines and handbooks;
- books, journal and conference articles;
- websites, videos, webinars and blogs.

These resources can be used to demonstrate and investigate the different aspects of VDC and BIM depending on the course's LOs. The challenge with these resources is not the availability, but finding those most appropriate to the students' level of experience and intended LOs.

Interactive resources i.e. BIM models

BIM models are needed not only for CPM specific analysis and simulation tasks, but also to share and communicate project information. Without the models the learning environment is very artificial and theoretical.

There are two inter-linked challenges in obtaining BIM model resources

1. Defining what is a suitable model for the course considering students existing skills and knowledge and course's LOs
2. Sourcing a model

Due to the challenges in and cost of obtaining BIM model resources a programme portfolio wide approach for model sourcing is recommended. This to guarantee that the same model can be used in as many courses as possible, but on the other hand to coordinate the use of the model to prevent plagiarism in assessments and to prevent boredom within students if they are exposed to the same model too many times.

What type of model is suitable

Simple models are needed for demonstration purposes and for introductory exposure to 4D and 5D BIM tasks. The complexity and size of the models impact significantly on the ability of student to learn and achieve targeted learning outcomes. Models should only increase in size/complexity, once students have become familiar with BIM technology; with their understanding of construction technology; and with the core principles of CPM. If models are used consistently throughout the programme, students should be capable of working with an industry BIM model, or one with similar detail and complexity, during the last year of their studies.

1. Choose the building type based on the course requirements
2. Choose the model complexity based on how experienced the students are in VDC/BIM and in CPM -choose a year below to read more

[Year 1](#)[Year 2](#)[Year 3 >](#)[Previous](#)[Back to interactive
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What kind of model to choose –Year 1

Criteria:

- No previous exposure to BIM or construction technology
- Aim to learn construction technology. Focus on the construction technology not in BIM, BIM model as a visualisation tool

Model:

- Just a part of a building modelled or 3D details, LOd 300-400 (parts of an industry model might be suitable)

What kind of model to choose –Year 2

Criteria:

- No previous exposure to BIM, but some understanding on construction technology
- Aim to learn CPM. BIM as a visualisation tool to understand and plan better sequencing, H&S management, site utilisation etc.

OR

- No previous exposure to BIM, but some understanding on construction technology and CPM
- Aim to learn BIM. Focus on BIM as a quantity take-off and sequence simulation tool

Model:

- Structural model of a fairly simple building, focus on construction methodology, [LOd](#) 200-250 (industry model not suitable)

What kind of model to choose –Year 3>

Criteria:

- No previous exposure to BIM, but good understanding of construction technology and CPM
- Aim to learn BIM. Focus on BIM as a quantity take-off and sequence simulation tool

Model:

- Simplified structural model of a fairly simple building, [LOd](#) 200-250 (industry model not suitable)

Criteria:

- Previous exposure to BIM, good understanding of construction technology and CPM
- Aim to learn more advanced BIM

Model:

- Federated model of a moderately complex building, [LOd](#) 300-400 (industry model probably suitable)

How to source a model

There are different approaches to obtaining BIM models

1. [Obtain a model used in a real project in the industry](#)
2. Contract a model authoring company to author a model based on 2D documentation, and
3. [Author a model internally based on 2D documentation](#)

In addition some software companies like [Autodesk](#) provide sample models for educational purposes, but these are not generally suited to NZ circumstances as they use different construction methodology and imperial dimensions.

If model authoring skills are included in the graduate capabilities, a fifth option is to have the students to create their own models. This might be worth considering even if model authoring is not a graduate capability, because this is proven to improve understanding of construction technology and sequencing among CPM students. In the latter case the size and complexity of the model needs to be carefully considered, so that the model authoring work does not take too much time and compromise the other learning outcomes.

Model from the industry

Short term solution:

Ask a round from the industry who would be willing to give their model for educational purposes. You will probably encounter intellectual property issues with this, so reserve plenty of time for the process.

Long term solution:

Build relationships with owner-developers who require BIM in their projects and ask them to include the use of the BIM models for educational purposes into the contracts with each discipline. Tertiary institute's own facilities management department might be your best starting point. This relationship requires also plenty of time to develop to the point when you finally get a model.

Model development in-house

(you will see the steps by clicking the mouse)

1. For a very simple structural model you need only a sketch drawing to get started with. For a more complex one, you either need to design a building or secure a set of 2D drawings (possible IP issues), which can be used as a base for the model. If you are using the model for several different purposes, it is best to make sure that it is code compliant.
2. Create a [Project BIM Brief](#) (part of [NZ BIM Handbook](#)) to define what the BIM uses are. Think strategically: you are investing on the development, so you probably want to use the model in as many courses as possible. Consider also if you would need more than one development stage of the model.
3. '[BIM uses](#)' will guide you to define what information is needed in the model or what information it needs to be able to connect to in other systems. This will inform the model authoring process.
4. Choose the team/person for the modelling work. The model author needs to have a good understanding of the model authoring tools. The supervisor needs to have a good understanding of the different uses of the model and what it requires from the model. In some cases this might be one and the same person.
5. Treat the work as a proper project. Set tasks with milestones and a final deadline.
6. Run the model through [Solibri Model Checker](#) ([Navisworks](#) is suitable if no other check is done than clash detection) to see if there are any problems in the model.
7. Test the model with the tools that you want to use it with. Test also before the course delivery that the model is suitable for the activities/assessments and that the outcomes from the processes are what intended.
8. Redevelop if needed.

Check list

You should now have

- VDC/BIM related course learning outcomes (re-)developed
 - Core curriculum analysis done to prevent overloading the curriculum
 - Delivery and assessment methods planned
 - Staff trained
 - Non-interactive resources chosen
 - Suitable BIM model sourced and tested
 - Suitable space, hardware and software available
- You are ready to start the course delivery

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