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A FRAMEWORK TO INTEGRATE BUILDING INFORMATION MODELLING TO THE CURRICULUM OF THE QUANTITY SURVEYING UNDERGRADUATE DEGREE PROGRAMME IN SRI LANKA

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ABSTRACT

One of the primary sectors that contributes to the national economy of the country is the construction industry. The Quantity Surveyors (QS), offer specific expertise in project management and cost estimation. A revolutionary change is occurring in Sri Lanka (SL)'s construction industry due to the increasing demand for innovative technologies such as Building Information Modeling (BIM). But the Sri Lankan construction industry has been remarkably lagging in adopting these cutting-edge techniques. According to past SL research findings, one of the main obstacles in BIM integration among QS professionals is a severe knowledge gap. By involving BIM approaches into QS education this research aims to develop a framework to implement BIM within the curriculum of quantity surveying undergraduates according to the industrial demand in SL. This paper focuses on the potential difficulties of integrating BIM into SL's QS curriculum, where graduates may fulfill industry expectations. This research used questionnaire survey, semi- structured interviews for both academic and industrial QS professionals separately, and conducted existing university QS curriculum review to gather data. Purposive sampling is used as the sampling technique and this study uses a mixed-method approach to research, combining qualitative and quantitative evaluations, and analyzes data using descriptive statistics and content analysis. According to data gathered from industrial professionals, it was proved that SL construction industry does not widely use BIM and have a huge demand on knowledgeable BIM of QS in the current industry. Most of the knowledgeable BIM personnel gain knowledge from self-learning and by following some extra courses. Professionals with an academic background proved, that the current QS curriculums are outdated. As a solution, this research develops the framework to integrate BIM to the QS curriculum of the undergraduate degree programmes in SL. A framework suggestion is to be incorporated into the curriculum was the outcome of the researcher's reflections on the interview results. These results contribute to the growth and development of the Sri Lankan construction industry by knowledgeable QS professionals, thereby fostering the advancement of the Sri Lankan construction industry.

KEYWORDS: *Building Information Modelling, Quantity Surveying (QS), Education System, Sri Lanka*.

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1. INTRODUCTION

Ttechnology is constantly developing and transforming every aspect of life, from the most basic to the most sophisticated activities. Building BIM is one of the most obvious factors of a deep and systemic transformation that is rapidly evolving the worldwide construction sector (Olorunfemi et al., 2021). BIM is a multifunctional model platform that delivers as a project resource center and database, and it is a popular trend in the construction sector. The use of BIM software arrange for several assistances such as digitization, communication, and engagement among project contributors (Ismail et al., 2021). It allows for real-life scenario simulations and discovers potential difficulties such as clashes and errors in a virtual environment before the actual building project is established and which could be mitigated (Ying, Kamal and Esa, 2022).

Quantity surveying is a profession that facilitate the smooth progress and achievement of construction projects. The traditional duties of a quantity surveyor includes creating bills of quantities (BOQ), cost estimates, measuring, and planning, as well as other procurement-related duties including payment and claim handling (Yan and Cheng, 2021). Quantity surveyors or cost engineers in Northern America are recognized as the major individuals conducting high standard QS procedures. Mensuration, accounting, financial side, contracts, law, and information management are all samples of QS techniques. From the feasibility study stage until the delivery stage, QS techniques place strong emphasis on the cost and contract management. QS may work more efficiently, reduce mistakes and provide better results by applying BIM (Nawari and Alsaffar, 2016; Olowa, Witt and Lill, 2019).

The demand for new services from the construction industry has forced quantity surveyors to expand their capabilities. Building information technology and business management are two important competencies that the quantity surveyor might need to have. Software like cost-X, Revit, cube-cost and others may make it easier to develop these skills. The quantity surveyor of today must possess a wide range of Iinformation Ttechnology (IT) skills (Yan and Cheng, 2021).

However, BIM is not widely used in the local construction industry yet. But in the near future, BIM will overtake the local construction industry expeditiously and some of the Sri Lankan projects are already used in BIM technology. Then in future, it may challenge the traditional quantity surveying practices. Lack of BIM experience, knowledge, expertise and resistant to change are the current challenges of BIM Implementation in Sri Lanka (Perera et al., 2021). The role of quantity surveyor is likely to change considerably in the future due to the constantly evolving demands of the modern construction industry and without updating the knowledge and experience, ? cannot overcome this challengers (Yan and Cheng, 2021).

The best solution to mitigate those problems is to improve the education system in Sri Lanka (SL) and it will be challenging for education to adapt to the complex demand of the construction sector. Further, the degree programs and related expertise offered by educational institutions must regularly recognize new opportunities and upgrade their curriculum to increasing abilities of quantity surveyor. This research is made to seek the way of upgrading undergraduate curriculum regarding the BIM to fulfil the industrial demand and mitigate challengers faced by future Quantity Surveyors, Sri Lanka.

2. LITERATURE SURVEY

BIM in construction industry

Project managers or BIM coordinators in the construction industry are responsible for introducing and putting BIM into practice inside their firms. They create BIM implementation strategies, set BIM standards and protocols, specify project-specific BIM needs, and manage the adoption of BIM tools and processes (Vigneault, Boton and Chong, 2019; Rachid, 2021). BIM is used by construction professionals to improve communication and coordination amongst different project stakeholders. They may discover and resolve clashes or conflicts before construction begins by actively engaging in

multidisciplinary coordination meetings and using BIM coordination tools, which reduces rework and delays (Keung, Yiu and Feng, 2022).

The BIM models are created and managed by construction experts throughout the course of the project. They aid in the creation of intricate building models by including details like phasing, sequencing, and construction techniques. As the project advances, they update the models to reflect alterations and as-built circumstances (Vigneault, Boton and Chong, 2019).

Building specialists can help BIM be used effectively for facility management and maintenance beyond the building phase. They can add asset and maintenance data to the BIM model to produce an extensive digital twin of the structure. Facilities management, space planning, preventative maintenance, and restorations can all benefit from this knowledge (Keung, Yiu and Feng,2022).

Application of BIM in Practice by Quantity Surveyors

A quantity surveyor is a specialist in monitoring and controlling building project costs. They work in the construction company operations (Vigneault, Boton and Chong, 2019). BIM has also had a considerable impact on quantity surveying techniques, resulting in more effective and accurate cost control. The following BIM procedures link to quantity surveying (Jin *et al.*, 2019; Calvin, Wing and Feng, 2022).

a) Quantity takeoff automation: Quantity Surveyors may automate the manual takeoff procedure by extracting quantities straight from the BIM model. (Olsen and Taylor, 2017).

b) Integration of cost estimation: BIM models may be connected to cost databases, giving quantity surveyors access to current cost information. Cost X, Sage Estimating are Software that can be used for cost estimation (Ekanayake *et al.*, 2022).

c) Early Cost Analysis: Quantity surveyors may do early cost analysis responses to BIM. Premavera P6 (Oracle) and e-builder are software that can be used for cost analysis (Sivarajah, 2022).

d) Change Management: The BIM model is updated to reflect design changes, and quantity surveyors may swiftly determine the impact on costs, reporting back to the project team right away. (Tomek and Matějka, 2014).

e) 4D and 5D BIM: The integration of time (4D) and cost (5D) data into the BIM model by quantity surveyors enables a more thorough knowledge of the project's schedule and budget. (Harrison and Thurnell, 2015; Vigneault, Boton and Chong, 2019)

f) Value Engineering: With BIM, value engineering procedures are made possible, allowing the QS to evaluate options and maximize project value without sacrificing quality. (Sivarajah, 2022).

Current Situation of BIM Application in SL's Building Sector

It is a prominent fact that the construction industry in Sri Lanka is turning out to be a blooming industry and QS contribution is a significant factor in project completion successfully, but still, BIM isn't extensively used in Sri Lankan quantity surveying (Epasinghe et al., 2018; Perera et al., 2021).

The implementation of BIM applications for the Quantity Surveying practice is a fear among Quantity Surveyors in Sri Lanka (Nagalingam et al., 2013). This is because the professional's existence is disturbed by the threatening and challenging nature of employing BIM in the practice and lack of knowledge of BIM and lack of professional expertise(Jayasena & Weddikkara, 2013; Perera et al., 2021).

Therefore, the current issues in the Sri Lankan Quantity Surveying are expected to be resolved through the evolvement of Quantity Surveying following the technology trend. For that, mainly forced undergraduate curriculums advance as the first step of the BIM concept. This also helps to implement BIM concept in Sri Lanka by solving lack of knowledge on BIM and lack of expertise (Epasinghe et al., 2018).

Existing curriculum review in Sri Lanka

Identifying technological gap between SL and global QS practices is crucial for industry expectations. Sri Lanka's construction sector is slow to adopt new technologies, and still quantity surveyors prefer paper documents and simple software like MS Word, AutoCAD. Modern software such as Primavera, Revit Architecture, and Cost X, are yet to be implemented (Ekanayake et al., 2022).

Consider about QS curricula of three universities named as "X", "Y" and "Z" in government, semi-government, and privets universities in Sri Lanka considering that the other factors were constant. Table 1 shows subjects related to BIM in existing curriculum in above selected universities.

Table 1: Subjects related to the existing BIM curriculums in three selected universities.

Year	"X" University	"Y" University	"Z" University
1st Year	Information and Communication Technology (ICT). (Credit – 3)	ICT 1 (Credit – 2) ICT 2 (Credit – 2)	IT application for QS. (Credit – 4)
2nd Year	BIM. (Credit -3) Advanced Building Measurement. (Credit – 3)	GIS and Remote Sensing. (Credit – 3) BIM (Credit – 3) Design appreciation. (AutoCAD). (Credit – 2)	Advanced measurement and contract administration. (Credit – 8)
3rd Year	-	Design appreciation. (AutoCAD - MEP). (Credit – 3)	Advanced quantity surveying. (Credit – 5)
4th Year	Automation of Construction. (Credit -3) BIM Management. (Credit -3)	Advanced ICT/ BIM & modeling. (Credit – 3)	-
Total BIM Mod: Credit	15	18	17
Total Credit value	148	157	186

"Total Credit Value" – These values obtained by observing the selected university QS curriculums

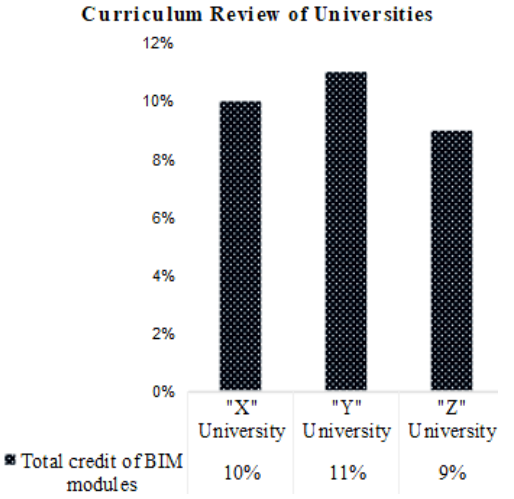


Figure 1: Curriculum review of selected three universities.

Based on the Subjects related on BIM in existing curriculum in three selected universities (Table 1), created *figure 1*. According to *figure 1*, The universities "X" and "Y" offered four-year degree programs, while "Z" offered a three-year degree program. The university "X" covers mainly BIM protocol and Construction Industry Council (CIC) BIM protocol. The "Y" university covers introduction to BIM and advanced BIM and some software like CAD and CostX as main parts around BIM knowledge. The University of "Z" mainly covered advanced measurements. Three universities allocate significant amounts of credits to theoretical BIM subjects, with most covering the theoretical part, while the practical part is less extensive. Considering the BIM modules credit, "Y" university gained the highest amount of credit on BIM modules (Refer Figure 1).

3. METHODOLOGY

Here explains the research methodology in detail, explaining how the study was conducted to meet its goals. This section includes the methodology for the research study and the techniques that analyze the data. This research study aims to develop framework to integrate BIM in undergraduate curriculum in Sri Lanka. The research was carried out using a questionnaire survey, semi-structured interviews and document review under the mixed method research approach.

Data Collection Methods

To carry out this research, two separate questionnaires were made for academic professionals and industrial professionals. The questionnaires survey and semi-structured interviews were conducted for the Data collection. The questionnaire survey was conducted through Google Forms with the quantity surveying professionals in the industry and academic. The questionnaire included two sections, and the questions were open- ended and closed-ended. Table 2 shows data collection methods, sample details and sample size. Sample was obtained through purposive sampling.

Table 2: Population and sample techniques

Data Collection Method	Population	Sample
Questionnaire Survey	QS Professionals in Construction Industry	20
	QS Professionals in Academic	20
Semi-Structured Interviews	QS Professionals in Construction Industry	05
	QS Professionals in Academic	05
Document Review	QS university Curriculums	03

The interviews were conducted with professionals from both physical meeting and online platforms as well. The questionnaire included two sections, and the questions were open- ended and closed-ended. In this study, background information from questionnaires, such as job history, current position, and other aspects were evaluated . The collection of secondary data included the of related materials of different university curriculums.

Data Analysis Methods

The qualitative data were analysed using content analysis and quantitative data were analysed using statistical tools in this study. This type of analysis may be used to examine the data that was acquired through open-ended interview questions. Here, it is important to compare the respondent's total feedback. To upgrade the identified lacking areas in the university curriculum on BIM and software applications, it is required to upgrade the existing BIM modules to suite undergraduate curriculum.

Therefore, this methodology contributes to achieving the objective of the research by providing an overview and analysis of the research findings. The survey was carried out via Google Forms among 40 industry and academic quantity surveying professionals who are working in Sri Lanka. Interviews were carried out among 10 quantity surveying professionals who are working in industry and academic fields in the Sri Lanka. Finally, it is required to collect further information to build the framework on BIM curriculum for QS undergraduates.

4. RESULTS AND DISCUSSION

The purpose of this research is to upgrade content on Building Information Modelling (BIM) in the undergraduate QS curriculum, to fulfill the industrial demand in Sri Lanka.

Analyzing Data on Industry Professional

i. Details of respondents

The questionnaire survey was carried out among twenty (20) industrial QS professionals and semi

structured interviews were conducted with five industrial QS (5) professionals (Table 2) in the construction industry (Figure 2). Throughout both surveys, most of the responses were senior quantity surveyors and second most resonance were quantity surveyors. When considering about the education qualifications, most of the responses in postgraduate level (Masters, MPhil, PhD) as the highest educational qualification and second most education qualification is the B.Sc. Degree. When analyzing the experience of the respondents, the majority has 0 - 5 years' experience and majority of the professionals work under the contractor. The second highest number of professionals has 10 - 15 years' experience and the second highest majority of the professionals work under the consultant.

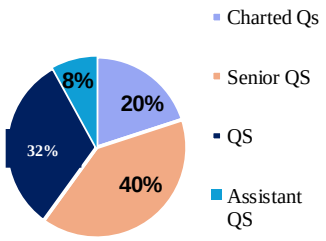


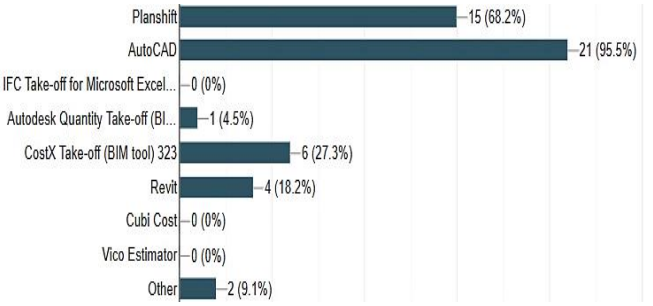
Figure 2: Sample population – Industrial Professionals

When considering the BIM adoption of the organization, only 12.6% already adopt BIM and 50.5% processing of adopting BIM and rest of other percentage of the organizations have not yet adopted this BIM and they will process to adopt BIM in near future.

ii. Current demanding competencies for the QS

When analysing the QS role in the construction industry, it shows QS integrates with all work from initial stage to final stage. In the software usage in the industry practice, quantity surveyors use a variety of specialized technologies to improve and expedite their work. These software programs help with project scheduling, budget management, cost estimate, and the analysis of intricate construction data.

According to the gathered data, Figure 3 shows software usage in local construction practice.



According to the chart AutoCAD, Planshift, CostX and Revit are main software uses in QS field.

Figure 3: Software usage in QS.

iii. BIM education on quantity surveying practice

When considering BIM knowledge in QS professionals, **Figure 4** illustrates the survey results of how industrial QS professionals gather the BIM knowledge. Accordingly, 8% learn BIM at the universities, although the majority (72%) of the industrial professionals gather BIM knowledge through certificate or academic courses. The remaining respondents (20%) learn BIM on self-learning with industrial practice.

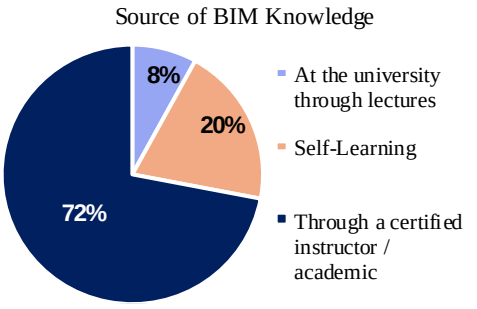


Figure 4: survey results of how industrial QS professionals gather the BIM knowledge

Analyzing Data on Academic Professionals

i. Details of questionnaire respondents

The questionnaire survey was carried out among twenty (20) academic QS professionals and semi structured interviews were conducted with five academic QS (5) professionals (Table 2) in the academic industry. Throughout both surveys, most of

the responses were senior lectures and the second most resonance were lectures. When considering about the education qualifications, most of the responses have Masters as the highest educational qualification and second most education qualification is the B.Sc. Degree. When analysing the experience of the respondents, the majority have 0 - 5 years' experience and the second highest number of professionals have 5 -10 years' experience.

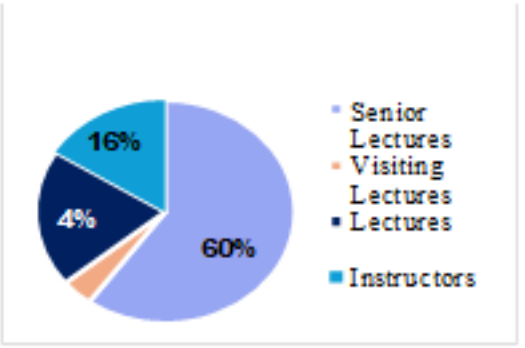


Figure 5: Sample population – Academic Professionals

Strategies for bridging the industry-academia gap

It is essential to implement solutions that effectively bridge the gap between industry and academia in BIM to ensure adequately prepare students for the specific requirements of the real-world construction situation. Teachers can use interactive teaching strategies, such virtual simulations and group projects, to help students grasp BIM better and become more interested in the subject.

To bridge the knowledge gap between academic learning and industry BIM practices, the critical role that a multidisciplinary approach plays should be highlighted. Understanding that hands-on experience is a powerful learning tool, they support incorporating real-world BIM projects and workshops within the academic program. Students may build a broad skill set by connecting theoretical knowledge with real-world applications through this practical method. In addition, the idea of planning site visits and inviting prominent figures from the business to provide guest lectures adds a significant dose of practical experience and gives students a direct understanding of how BIM is actively is used in regular quantity surveying procedures.

On the strength of this foundation, there is an ongoing necessity for curricular growth in order to keep up with changing industry demands. They emphasize the need for flexibility and the need of keeping up with new developments in BIM technology, software, and industry trends. Education institutions may guarantee that their programs stay current and adaptable to the ever-changing construction industry by encouraging a flexible curriculum that changes in accordance with industry innovations. This flexible strategy is strengthened even further by creating a clear link between classroom instruction and real-world BIM needs. Guest lecturing business professionals and implementing industry best practices into the curriculum, guarantees that students will graduate with both the academic understanding and the practical know-how needed to function in the ever-changing BIM environment. These factors were conformed by Ojo & Pye, (2014).

ii. Upgrading content on BIM in QS undergraduate curriculum

When analyzing the results of academic professional on upgrading BIM content of undergraduate curriculum, firstly all were accepted that both software and theoretical knowledge need to integrate into the QS curriculum. In order to improve a Quantity Surveying program using BIM, theoretical understanding and software competency must be included. Most academic professionals accepted that introduction of BIM, BIM software with their usage and advantages, BIM Guidelines and standards and quantity surveyor's workflow with BIM, are included under the theoretical knowledge cover.

As the practical knowledge students want to acquire useful abilities like creating Bills of Quantities (BOQ), taking quantity takeoffs, identifying conflicts, and creating cost reports utilizing BIM tools. These areas must be included into the QS curriculum so that students graduate with the software skills needed for contemporary construction projects as well as a comprehensive grasp of the principles and real-world applications of BIM.

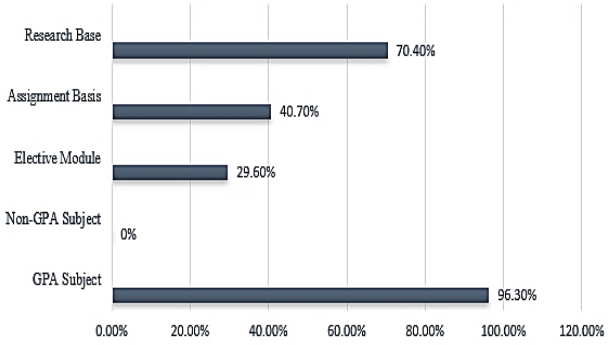


Figure 6: BIM Integration into Curriculum

According to the above figure 6, Many academic professionals (96.3%) have mentioned that more credit should be given to BIM subject. Similarly, it has been responded that this subject will be continued through research (70.4%) and assignment (40.7%) for further study.

5. CONCLUSION AND RECOMMENDATION

Quantity surveyors, also known as construction cost managers, play a crucial role in ensuring the economic feasibility and successful completion of building projects. Their expertise in Building Information Modeling (BIM) is increasingly important, as it allows for accurate data extraction and analysis from digital models. This skill also enhances the effectiveness of cost control procedures and facilitates collaboration among project stakeholders. As the construction industry continues to embrace digital transformation, quantity surveyors are at the forefront of innovation, ensuring smooth communication and effective project completion.

The local education system in Sri Lanka lacks sufficient technological knowledge, with most universities covering only theoretical BIM knowledge. Barriers include lack of expertise, high software costs, and limited resources. Future quantity surveyors can contribute to the modern construction sector by incorporating BIM models and software capabilities into university curricula.

6. RECOMMENDATIONS

For creating this framework (Refer figure 7), used "BIM maturity diagram; 2008/13 Bew – Richards" gave clear understanding of how BIM knowledge can be achieved step by step under QS curriculum. In other words, the intension was to demonstrate the progressive nature of the BIM learning process. This framework (Refer figure 7) provides a roadmap for the quantity surveying related academic professionals to implement BIM into the undergraduate QS curriculums by bridging the gap with construction industrial requirements. By adopting this farmwork, future challenges faced by quantity surveyors in Sri Lanka can be mitigated.

The following is the framework (Refer figure 7) which is prepared, and it clearly shows how BIM knowledge is shared year after year. The created framework, which fills in the gaps and arranges the implementation phases in an adaptable way, is the result of translating all the collected and evaluated data. The framework that was created was organized based on new learning objectives of BIM features and scales. The following is an overview of each section:

a) BIM aspects and scales involve step-by-step development from basic concepts to more complex ones.
b) The first component is the theoretical fundamentals, which will be introduced as a stand-alone module covering the ideas of BIM in the early years of the QS program.
c) Secondly, the practical fundamentals where applying BIM at levels requires applications like taking off quantities, detecting clashes, and preparing cost estimates, among other things.
d) The last component is represented integrated BIM system in the research and case studies and will be represented in the graduating year.

The learning objectives in the curriculum should be reorganized to show that students understand BIM concepts and can apply them. This will be accomplished by upgrading QS curriculums including BIM.

Then incorporate the new BIM planned outputs, the educational approach to BIM necessitates updating the learning objectives. In the undergraduate years, a

module offers learning goals that span Level 0, Level 1, and Level 2. As the example it clearly shows (Refer figure 7) how second, and third year BIM modules overlap Level 1 and Level 2 BIM.

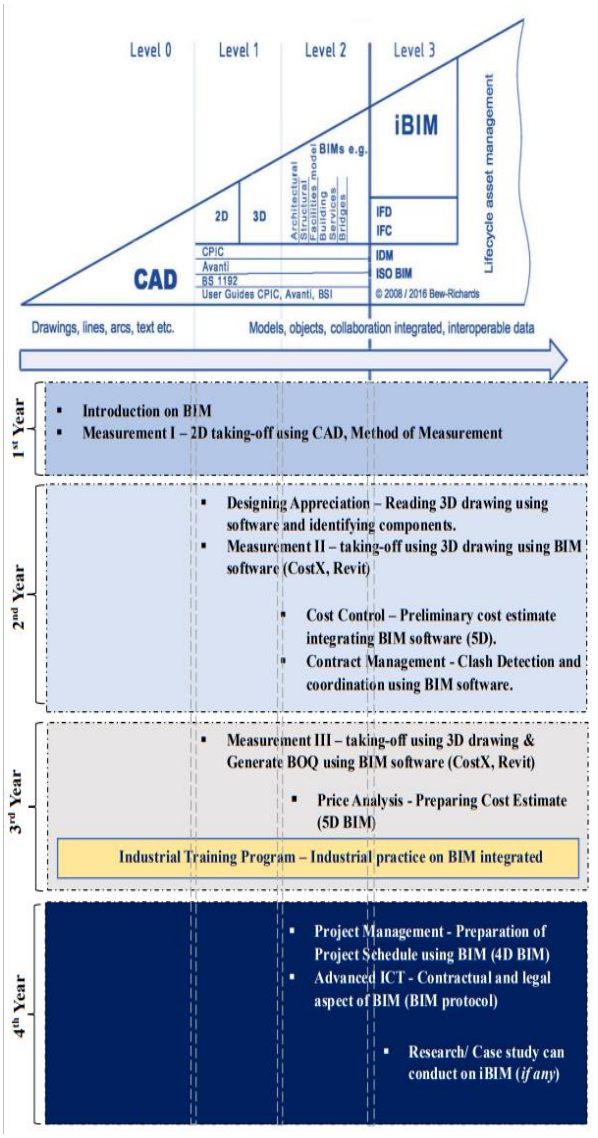


Figure 7: Developed Farmwork for QS undergraduate curriculum.

7. RESEARCH LIMITATIONS AND FUTURE DIRECTIONS

This study limited only for upgrading quantity surveying undergraduate curriculum including BIM and limited to conducted only of Sri Lankan practice. The role of quantity surveying is multidisciplinary, but this study focused on aspect of BIM challengers to the conventional QS practice.

The research on the topics that are studied can be expanded on a variety of ways. These topics are not included in the study as the scope has not been expanded and has been placed below for as suggestions for future research.

a) Focusing on upgrading postgraduate curriculums in construction related subjects by implementing BIM.
b) Focusing on identifying barriers to integrate BIM into the local undergraduate quantity surveying curriculum.
c) Focusing to identify practical challengers that involved technological based construction industry in Sri Lanka.

Abbreviations

4D – Four Dimensional
5D – Five Dimensional
BIM – Building Information Modeling
BOQ – Bills of Quantities
CIC – Construction Industry Council
ICT – Information and Communication Technology
IT - Information Technology
QS – Quantity Surveying
SL – Sri Lanka

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