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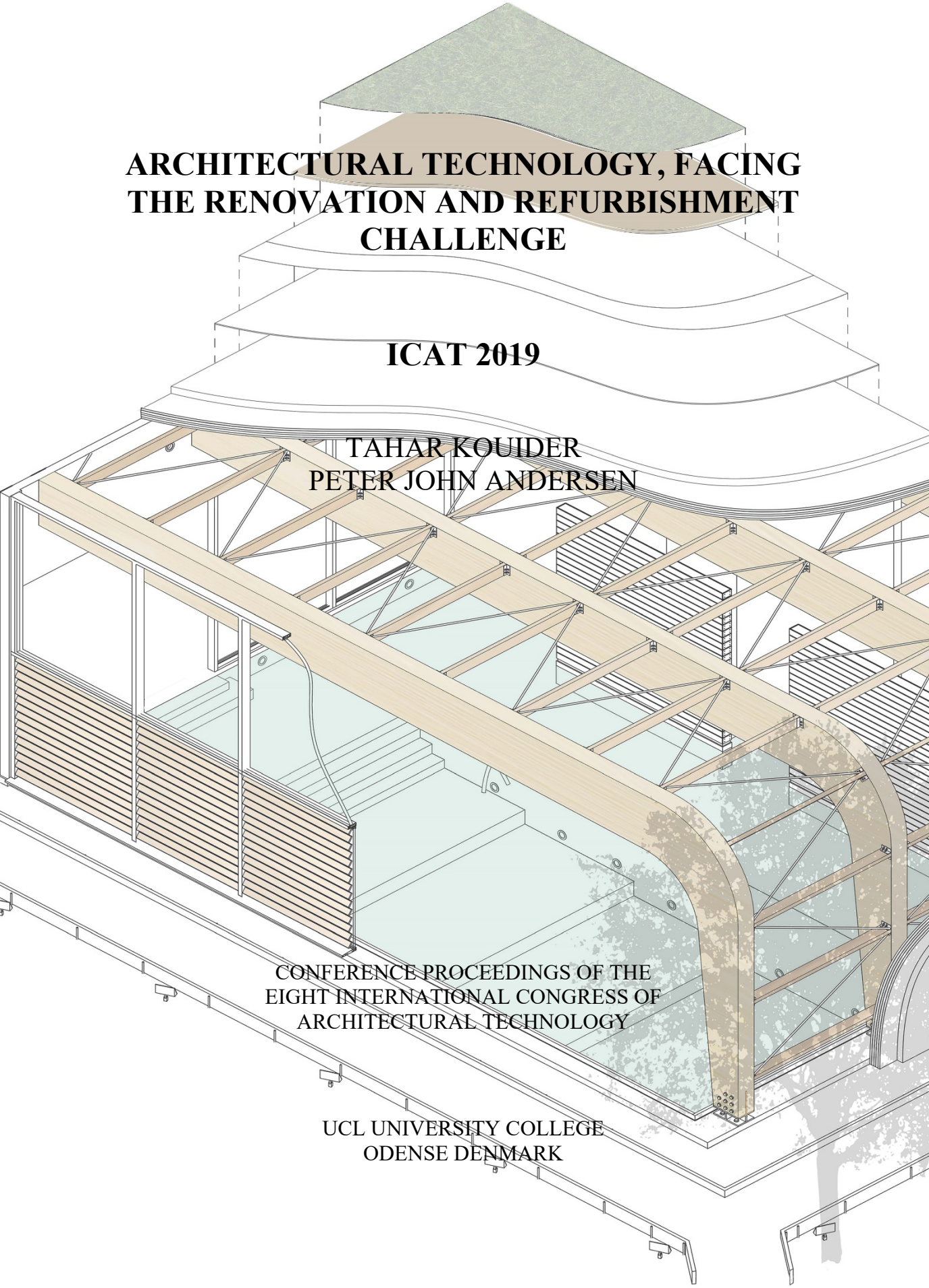
ARCHITECTURAL TECHNOLOGY, FACING THE RENOVATION AND REFURBISHMENT CHALLENGE

ICAT 2019

TAHAR KOUIDER
PETER JOHN ANDERSEN



CONFERENCE PROCEEDINGS OF THE
EIGHT INTERNATIONAL CONGRESS OF
ARCHITECTURAL TECHNOLOGY

UCL UNIVERSITY COLLEGE
ODENSE DENMARK

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FOREWORD

It is an honour for me to be able to welcome all delegates to ICAT 2019 in Hans Christian Andersen's birthplace, Odense, Denmark. It is the eighth time the conference is being held, and it is every time enlightening, thought provoking and filled with innovative experiences presented by selected authors.

The focus in our creative line of work is most often on new build, though about 50% of our work deals with renovation and transformation of the existing building stock. This does not only apply to Odense and Denmark, but is also true in most parts of the world, hence the theme of this conference and most of the papers being presented are focused on issues and developments within this vast and complex field.
Contemporary and often debated concepts such as BIM and sustainability etc. are not just reserved for new construction. They are as relevant to existing buildings and associated construction completed to the highest standard of best practice in order to fulfil the needs of society and environmental protection.

ICAT's core areas of interest which cover, amongst others, professional practice, education and development ae also covered by this conference through exciting and innovative paper presentations.
I am convinced that all the papers contain revelations and valuable knowledge that all professionals, academics and students will benefit from. Ig is hoped that this publication will allow for subsequent reflection and follow-up, as well as inspiration for launching new initiatives in all areas of Architectural Technology.

At a time when the construction industry is at its peak; where craftsmen, architects and engineers are in short supply; and where there is a shortage of materials; it is important that such a conference gives us the opportunity and time to ask, debate and think so that we can help ensure that the familiar mistakes of the past are not simply replaced by others, new and unknown.
Welcome to a set of ICAT's fairy tales.

Peter John Andersen, Conference Chair
University College Lillebaelt (UCL) - BUILDING

ARCHITECTURAL DESIGN STUDIO ENVIRONMENT AND STUDENT SATISFACTION: CASE STUDIES OF JORDANIAN UNIVERSITIES

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Abstract. The built environment plays a significant role in shaping users' behaviour and has an impact on their comfort and satisfaction. Of particular interest, the conditions of the built environment in educational places significantly affect the process of teaching and learning. In architectural education, design studios at the heart of any college of architecture. They are places where students spend most of their time nurturing their design skills, growing their imagination, interacting with their colleagues and tutors, producing, and exhibiting their projects. Therefore, special attention should be given to these places in terms of physical design characteristics and layout. Previous research on architectural design studios focused on the curriculum and methods of teaching, as well as the culture of the architectural studio. However, research on physical design and its impact on student satisfaction and performance is scarce. Psychological aspects of these spaces need further investigation. This study aims to evaluate the design studio environment in public and private universities in Jordan. A survey was distributed in six architectural departments to evaluate student satisfaction. Each department is analysed in terms of the spatial layout, accessibility and physical characteristics of the studios. The evaluation criteria adopted a modified version of Guerin's theoretical framework that addresses the built environment in terms of its physical, behavioural and natural criteria. The results showed a moderate satisfaction levels in general and significant differences regarding the level of satisfaction in public and private universities.

Keywords: Architecture, Design studio, Learning environment, User satisfaction, Guerin Framework.

1. Introduction

This study is concerned with the architectural design studio. The design of the built environment plays a significant role in the users' level of comfort and satisfaction (Obeidat et al., 2012). In learning environments, such as classes and studios, their design has a strong impact on the level of students' satisfaction and performance. According to Cardellino et al. (Cardellino et al., 2017), learning is an interactive process that is targeting the human and mediated by the built environment. Giving attention to the design of the learning environment

is vital in maintaining the quality of the educational process and achieving the learning outcomes. As stated by Tumusiime (2013), the quality of the learning environment depends on its capability to meet students' needs and maintain their knowledge.

The architectural design studio is an essential place where architecture education mostly takes place (Atakan, 2016). As an educational space, the studio should provide students with a good opportunity to express their ideas and communicate with tutors (Utaberta et al., 2011). According to Dixon, studio environment may affect the comfort and satisfaction of students, their productivity, motivation to work, behaviour, as well as the outputs of architectural education (Dixon, 2012). Obeidat et al. (2012) argued that the process of teaching and learning architecture requires a comfortable place which facilitates teaching of various forms including lectures, design projects, and tutorials. As students spend extended times in architectural studios, these need to be exciting and inspiring (Obeidat et al., 2012). Teaching architecture differs from teaching other disciplines in the built environment. Architectural education not only includes practical and theoretical aspects, but also requires an interactive learning environment that supports social interactions (Obeidat et al., 2012).

In Jordan, architectural education is popular and attracts many students. According to the latest research conducted by the Ministry of Higher Education and Scientific Research, there were 4538 architecture students at the end of the academic year of 2018. Jordan is relatively a small country but has nineteen architectural departments. These departments vary in their design, size, location, and environment. Typically, a design studio in these departments is rectangular in shape (Muniandy et al., 2015). Most of the studies that investigated architectural education focused on the curriculum and methods of teaching, in addition to the culture of the architectural studio. However, research on the physical design of the studio and its impact on student satisfaction and performance is quite limited. The aim of this research is to shed light on the architecture learning environment and its impact on student satisfaction. This study examines various public and private architectural departments in Jordanian universities and provides guidelines to improve these environments.

2. Theoretical Framework: Human Ecosystem Guerin Model

Guerin model is a dynamic model that helps researchers to examine various factors and their interactions in a single moment adjusted to variables, organism and time of the study. It is used as a structure to organize and specify variables that assess the interior environments in a simple way. The flexibility of the model helped the authors to choose any number and kind of variables according to their views (Guerin, 1992). This model describes the connection of humans with surrounding environments, containing the natural, built, and behavioural environments (Guerin, 1992).

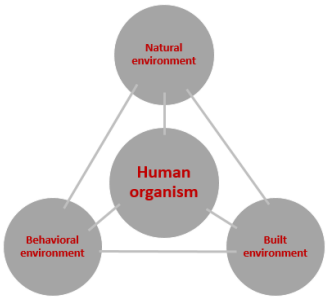

Figure 1. Human ecosystem model. Three environments surrounding the human organism and the mutual relations (Adapted from Guerin, 1992)

As shown in Figure 1, the human organism is at the centre of the model circumscribed by three types of environments; natural, social, and physical. The illustration emphasizes the mutual relations between the environments in addition to the interactions between the human being and these environments (Guerin, 1992). In this research, an adapted version of Guerin model is used to evaluate the level of student satisfaction in their design studios. The adapted model was used by Dixon (2012) to measure the studio environment, within four groups of the three environments (natural, built, and social) in addition to the human being.

2.1 HUMAN BEING

The human being is the centre of the model and the user of the surrounding environments. Each person has different characteristics that make him interact with the environment in a different way (Dixon, 2012). The following factors were selected as indicators of the diversity of students' characteristics: gender, Grade Point Average (GPA) and class level.

2.2 THE BEHAVIOURAL ENVIRONMENT

Guerin (1992) outlined the behavioural environment by the socio-behavioural, psychological, socio-political, and biophysical aspects of the space. This includes human actions in the environment and the effects of human attitudes, behaviours, and relations in the environment (Guerin, 1992). In this study, the following social and psychological variables were chosen:

- Privacy: the desire to communicate or be isolated from others. In addition to physical accessibility, privacy includes visual and audible access (Dixon, 2012).
- Personal space: a mechanism utilized to support the organization of privacy. It is an active procedure to increase or decrease the distance between individuals and others (Namazian1, 2013).
- Territoriality: the integration of territorial cognition and behaviours of people according to their possession of the physical area (Huang et al., 2019)
- Crowding: a sense of restriction, and a feeling that others are violating their own personal space (Dixon, 2012).
- Safety of person: a significant feature which influence the perception of a person about an environment. The risk of safety means that individuals feel threatened in an environment (Dixon, 2012).

- Place identity and sense of place: this refers to how places are linked with the notion of oneself. It may enhance the individual recognition of self-esteem and offers a sense of belonging to the place (Dixon, 2012).
- Sense of community: the desire to preserve the mutual relationship with others by doing what they expect (Dixon, 2012).

2.3 THE PHYSICAL ENVIRONMENT

The built environment is the building envelope that contains building design, materials, surrounding as well as energy systems (Guerin, 1992). The physical environment can be evaluated according to the following:

- Anthropometrics and ergonomics: anthropometrics is "the study of the human body", including minimum dimensions and areas required for individual requirements when doing various activities (Dixon, 2012). Ergonomics is a domain of the space design regarding the requirements of the human body and the motion of muscles and joints (Dixon, 2012).
- Proxemics: these are included in this study as part of the physical environment. Proxemics assesses the perceptions of space and how the physical environment influences people's behaviours and the level of social communication. Furniture arrangements for example, may increase or decrease social interactions (Dixon, 2012).
- Safety and security of possessions: it may be for example essential to offer secure places to store the possessions of students such as laptops and other tools (Dixon, 2012).
- Flexibility in use: the flexibility of spaces including technologies and creative design that can be adapted to various activities (Dixon, 2012).
- Lighting: natural light and artificial light in learning environments can provide psychological satisfaction (Muniandy et al., 2015).
- Temperature: the ambient temperature of indoor spaces is one of the most important issues affecting the comfort of users (Dixon, 2012).
- Acoustics: this is a very significant feature which affects the users of indoor spaces as noise levels can cause stress in the workplace (Dixon, 2012).
- Personalization and control: the ability of people to control their environments enhance their performance and increase optimism between workers in workplaces (Dixon, 2012).
- Aesthetics: the indoor environment colours and design influences the visual comfort of human beings (Dixon, 2012).

2.4 THE NATURAL ENVIRONMENT

According to Guerin 1992, the natural environment includes climate, resources, plants and water". (Guerin, 1992). Access to landscape and natural light have a positive influence on human well-being (Dixon, 2012).

3 Standards and Recommendations

The architectural design studio environment should meet students' needs. Table 1 summarises some recommendations regarding the design of the architectural studio based on reviewing the literature.

TABLE 1. Recommendations regarding the design of architectural studio.

Issue	Recommendation
Lighting (Access to natural light, windows orientation, window floor area)	1- It is preferable to use both natural lighting (side or ceiling) and artificial lighting in educational spaces (Neufert et al., 1980), The lighting should be evenly distributed within the architectural studio (Zaza and Ziad, 2014). 2- North-facing windows are recommended to obtain equal daylight in the studio (Neufert et al., 2000). It is preferable to provide windows from both sides and use the appropriate shading (Demirbas and Demirkan, 2000) . 3- Studios need windows equal to at least 25-33% of floor area with North or East sides (Neufert et al., 1980).
Views and access to nature	4- The architectural design studio should provide visual comfort and a view of quiet green areas (Muniandy et al., 2015). 5- In order to achieve the quality of the design studio environment, the building should be integrated with the landscape (Aderonmu et al., 2016).
Furniture (flexibility, sense of community, personal space)	6- Furniture and tools in learning environments must be comfortable and designed with a high level of flexibility to be adjusted (Dixon, 2012). 7- The studio must be adaptable for several activities such as seminars, lectures, design work or presentation. This can be achieved by the flexibility of furniture and the existence of partitions to create different areas (Zaza and Ziad, 2014). 8- The architectural design studio should support the social interactions (Obeidat et al., 2012), by providing small group workspaces to encourage social activities (Muniandy et al., 2015), or by including side-to-side and face-to-face furniture arrangements (Dixon, 2012). 9- The architectural design studio should also provide students with different options that allow them to work with others or individually (Dixon, 2012).
Environmental conditions (temperature ventilation)	10- It is recommended to allow individuals to control environmental conditions such as ventilation, lighting, and temperature. (Ibem et al., 2017) 11- The ideal temperature for learning environments is 68- and 74-degrees Fahrenheit (Cheryan et al., 2014).
Layout, design, shape (territoriality, privacy)	12- In design studios, barriers like walls, doors, and partitions in workplaces create a sense of privacy and help individuals or groups to control their contact with others (Hua, 2010) 13- Open-plan studio spaces are noisy, and an increased need for visual and acoustical privacy (Dixon, 2012). While it reduces the sense of crowding (Ibem et al., 2017).
Colours	14- In learning spaces, it recommended combining bright colours with neutral colours to create an attractive environment (Dixon, 2012). 15- White colour is a neutral colour with vital advantages for space users. However, it may generate feelings of carelessness and tedium (Dixon, 2012).
Connectivity and building location	16- The studio should be located in a safe location with a welcoming area visible and easy to reach, providing natural lighting and ventilation, outdoor spaces, and green spaces, as well as linking the inside with the outside (Muniandy et al., 2015).

Issue	Recommendation
	17- It advised offering wayfinding techniques in the walkways like signs and numbering systems (Dixon, 2012).
Area and crowding	18- The number of students in the architectural design studio should not exceed (17-18) students in the studio with an appropriate area of 70 m² (Zaza, 2014 #7). 19- The square room gives a sense of less crowding than the rectangular one (Ibem et al., 2017).
Technology (flexibility)	20- Digital technologies and various modern means of technology should be integrated into design studios (Obeidat et al., 2012).
Student area	21- Space should provide for each student architectural design studio ranging from (3.5-4.5) m² (Neufert et al., 2000).
Spaces between (proxemics)	22- It recommended the drawing table provide comfort to students with size between (1.4-2.20m * 0.80-1.25m) (Neufert et al., 2000).
Safety and security	23- It recommended providing secure storage for students' personal belongings near the studio (Obeidat et al., 2012)

5. Methodology

This study aims to provide an evaluation of the design studio environment in various public and private architectural departments in Jordanian universities. It also aims to propose guidelines to improve these environments. Literature review was conducted to collect the optimum design requirements of learning environments. In addition, the study adopts a modified version of the theoretical framework of Guerin (1992) that addresses the built environment in terms of its physical, behavioural and natural criteria. Physical criteria include the building's envelope, site integration, energy systems, and design. Behavioural environment criteria include the socio-behavioural and psychological characteristics of the space. The natural environment criteria include access to nature, view and natural light.

Six architectural departments in three public and three private universities were randomly selected to conduct the survey and to analyse their environments. Each department was physically analysed in terms of its spatial layout, accessibility and physical features of the studios. A field survey using a structured questionnaire with a Likert Scale was distributed to the architecture students in each department to evaluate their level of satisfaction of these studios. The evaluation criteria were based on a modified version of Guerin theoretical framework.

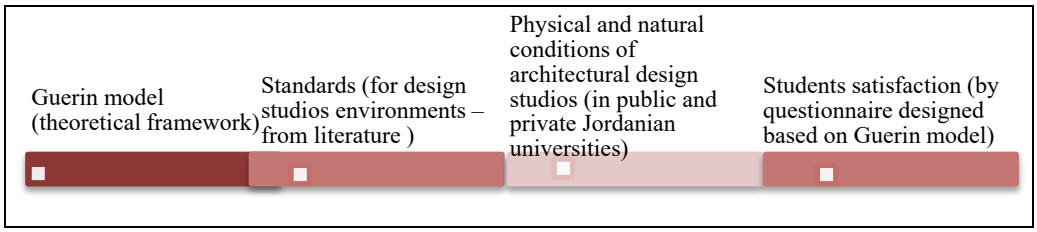

Figure 2. Methodological procedure.

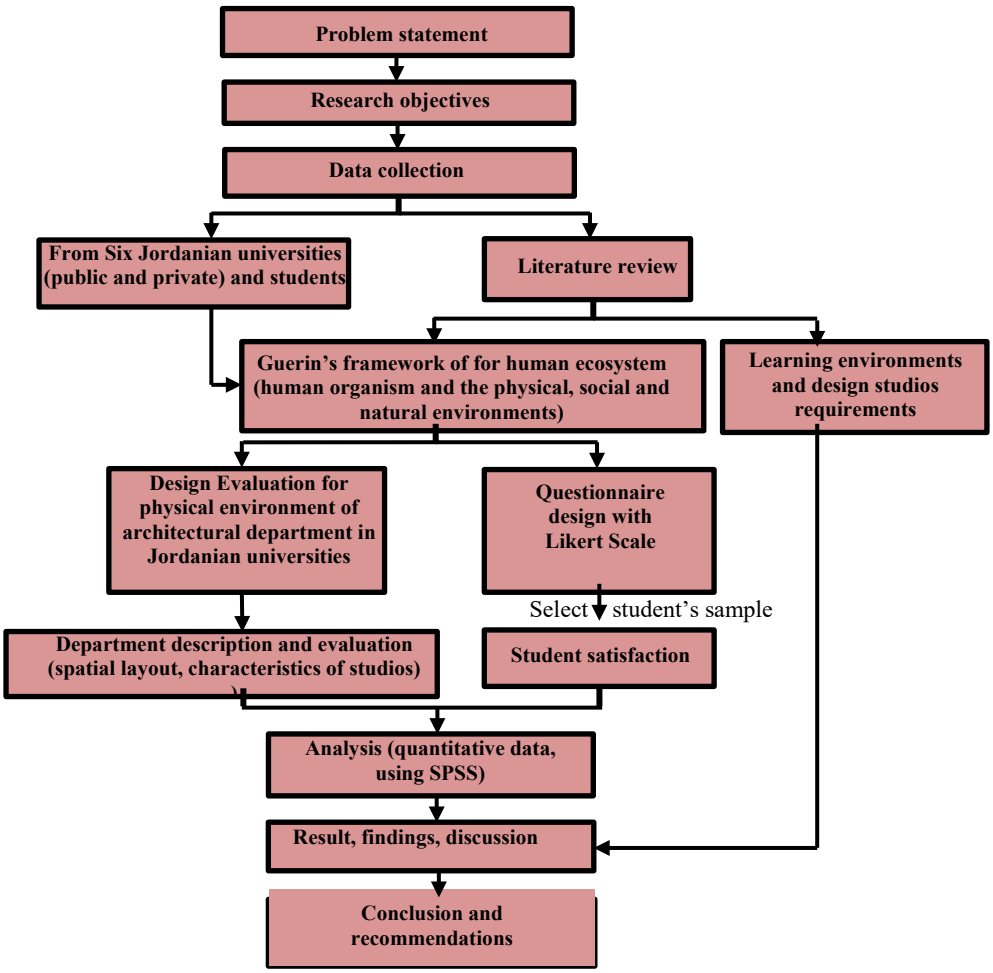

Figure 3. Methodology flow chart.

5.1. EVALUATION TOOL

The study used a questionnaire to collect data from students about their architectural design studio environment and their satisfaction within these studios. An evaluation tool was developed based on previous studies and Guerin framework. The developed questionnaire was designed to measure the level of student satisfaction and contained five sections: general

biographical information, students' characteristics (screening ability, introvert vs. extrovert), 33 six-Likert scale items related to the physical environment of the studio, 15 six-Likert scale items related to the social environment of the studio, and 4 six-Likert scale items related to natural environment in the design studio. The six-point Likert scale indicated the degree of approval about their level of satisfaction in their design studio environments.

5.2. SAMPLE

Six Architectural departments in six public and private universities in different governorates of Jordan were randomly chosen based on their location, accessibility, and having various types of studios.

5.3. PROCEDURE

A total of 530-paper questionnaires distributed among the undergraduate students of architecture from first year to fifth year in all targeted universities, 495 of them were considered for analysis.

This questionnaire was designed according to the variables in the Guerin framework and divided into four sections about the human being, physical, social and natural environment. The questionnaire started with general questions about the university, age, year, and gender. After the introductory questions, there was 59 short closed questions followed by six points Likert Scales to indicate the degree of approval from strongly disagree to strongly agree.

6. Analysis and results

Each architectural design studio in each department of the selected universities was analysed in terms of the spatial layout of the college (or department), accessibility and physical characteristics of the studios. The total number of the evaluated studios was twelve. Table 2 summarises the general environmental characteristics of the selected studios.

TABLE 2. General environmental characteristics of the selected studios.

University	Studio	Students/ studios	studio shape	Student area	Windows – floor area	Artificial cooling-heating	Views	Drawing boards arrangement	Technology	Walls colours
1	1	15-22	rectangle - closed plan	9 m²	5-10 %	F, C	B	rows	data show, computer, Wi-Fi	pale apricot, white
	2	15-22	rectangle - closed plan	9 m²	5-10 %	F, C	B	rows	data show, computer, Wi-Fi	pale apricot, white
2	3	26-32 (2 groups	T shape - semi closed	7 m²	5-10 %	C	G	rows	data show, Wi-Fi	light grey, white
	4	26-32 (2 groups)	T shape - semi closed plan	7 m²	5-10 %	C	Mix	rows	data show, Wi-Fi	light grey, white

University	Studio	Students/ studios	studio shape	Student area	Windows – floor area	Artificial cooling-heating	Views	Drawing boards arrangement	Technology	Walls colours
3	5	25-30	rectangle, closed plan	2.5 m²	15-20 %	A	Mix	rows	data show,	light blue, white
	6	80-90 (4 groups)	rectangle - open plan	3 m²	15-20 %	A	N	rows	data show,	light blue, white
4	7	17-22	rectangle - closed plan	4 m²	15-20 %	F, C	B	rows	data show, computer, Wi-Fi	light blue
	8	17-22	rectangle - closed plan	4 m²	5-10 %	F, C	B	rows	data show, computer, Wi-Fi	light blue
5	9	15-18	rectangle - closed plan	5.5 m²	15-20 %	F, C	Mix	rows	-	White.
	10	15-18	rectangle - closed plan	5.5 m²	15-20 %	F, C	Mix	rows	-	White.
6	11	11-13	rectangle - closed plan	9.5 m²	5-10 %	F, C, A	Mix	U-shape	data show, computer, Wi-Fi	White.
	12	11-13	rectangle - closed plan	9.5 m²	5-10 %	F, C, A	Mix	U-shape	data show, computer, Wi-Fi	White.

*View, (B: Built environment, N: Natural environment, Mix: both built environment and natural environments)
*Artificial heating and cooling, (F: Fans, C: Central heating unit, A: Air conditioning)
1: Yermouk University, 2: Jordan University of Science and Technology, 3: Balqa Applied, 4: Amman Ahliyya, 5: Zarqa Private, 6: Applied Sciences.

The Statistical Package for Social Sciences software (SPSS, version 19, Chicago. Inc) was used for data processing and analysis. Characteristics of subjects' variables were described using frequency distribution for categorical variables in addition to mean and standard deviation for continuous variables. Group comparisons were conducted using the t-test. Frequencies were expressed in percentages. Statistical significance was set at $P<.05$. Table 3 gives a general statistical description about the sample in terms of gender, academic level and GPA. The total number of participants was 495 students; 35% are from private universities and 65% are from public universities.

TABLE 3. General statistical description of the sample (N=495).

Variable	No.	Per.
Gender		
Male	202	40.8
Female	293	59.2
Academic level		
1	98	19.8
2	109	22.0
3	129	26.1
4	95	19.2
5	64	12.9
GPA		
50-59	29	5.9
60-69	116	23.4
70-79	190	38.4
80-89	141	28.5
≥ 90	19	3.8

Regarding the general evaluation of students' satisfaction, students were rather satisfied regarding the three indicators of the physical environment. The mean of their general satisfaction on the three indicators was 3.603, see Table 4 and Figure 4.

TABLE 4. Mean and standard deviation of studio physical environment satisfaction.

Student satisfaction	Mean	Standard Deviation
Physical environment	3.419	0.764
Behavioural environment	3.846	0.826
Natural environment	3.571	1.152
Design studio environment general satisfaction	3.603	0.736

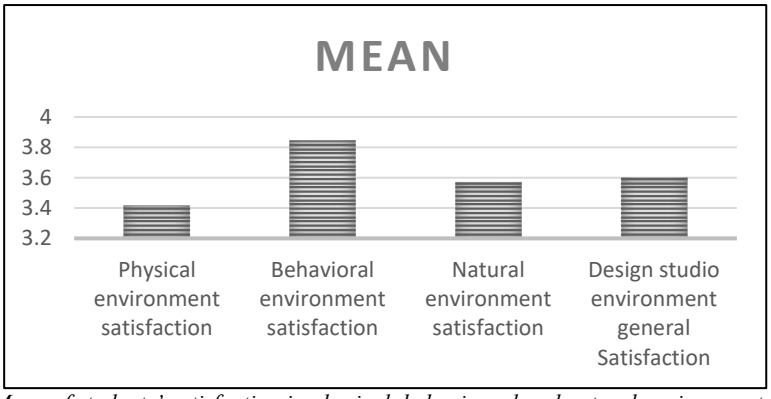

Figure 4. Mean of students' satisfaction in physical, behavioural and natural environments in addition to the general satisfaction in design studios environment.

Students in private universities showed higher level of satisfaction than those in public universities, see Table 6. Figure 5 shows the mean of student satisfaction in physical,

behavioural and natural environments in addition to the general satisfaction in design studios environment according to university type.

TABLE 6. The effect of university type on studio environment general satisfaction (mean ± Std. Deviation).

University type		Physical environment satisfaction	Behavioural environment satisfaction	Natural environment satisfaction	Design studio environment general Satisfaction
Public	Mean ± Std. Deviation	$3.322^{b} \pm 0.740$	$3.762^{b} \pm 0.805$	$3.393^{b} \pm 1.098$	$3.503^{b} \pm 0.723$
Private	Mean ± Std. Deviation	$3.599^{a} \pm 0.777$	$4.004^{a} \pm 0.843$	$3.903^{a} \pm 1.179$	$3.790^{a} \pm 0.725$
P-value		0.000	0.010	0.000	0.000

Notes: All values are $\bar{y} \pm$ SEM.

Different subscripts indicate statistical difference across categories of each variable

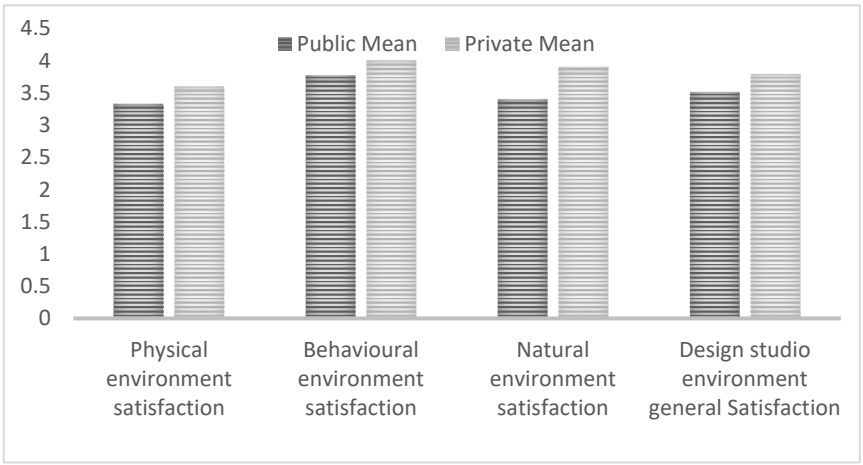

Figure 5. Mean of student satisfaction in physical, behavioural and natural environments in addition to the general satisfaction in design studios environment according to university type.

7. Discussion

As shown in the analysis above, the students are reasonably satisfied as the studios offer both natural and artificial lighting which provide psychological satisfaction (Muniandy et al., 2015). Furthermore, the furniture and its dimensions are appropriate and suit the students' needs. Most of the seating and drawing boards were arranged in rows. Such an arrangement satisfies proxemics' demands by giving each student his private space (Dixon, 2012). Because the furniture is not fixed, this flexibility allows easy furniture re-arrangement to perform various tasks and activities in the studio space (e.g. tutorials, lectures, presentations, and working on design projects). The availability of technological devices such as computers, projectors, and wireless connection makes the studio a convenient educational area for students. Providing a thermally-comfortable studio environment was achieved by installing central heating units and

electric fans for cooling. The ability to control heating and cooling systems enhances students' performance levels and satisfaction (Ibem et al., 2017).

In terms of the spatial layout, the majority of studios have a closed plan system which decreases levels of noise (Dixon, 2012). In addition, most departments provide personal safety including fire safety, location, noise levels, wayfinding, visibility of studios, and proximity of W.C.

Students are somewhat satisfied in terms of the natural environment of studios because most of the studios face the north and south which provide natural lighting. North-facing windows are best to obtain equal daylight in the design studio (Neufert et al., 2000). It is also recommended to provide windows from two sides to reduce glare (Demirbas and Demirkan, 2000).

Students are to some extent satisfied with the behavioural environment of studios because a large number of studios provide privacy, personal space in addition to safety. Studios designed in rectangle shape provide students with area between (5.0-9.5 m2) for each student which decrease the sense of crowding. Finally, studios provide a sense of community and facilitate social relations between students.

The results show that students were dissatisfied with the physical environment of design studio. Although these studios in general provide good amenities, they suffer from a number of shortcomings in relation to the fixed and non-fixed physical elements. For example, most universities have window-wall area ratio between 5-10%. This ratio should be between 25-30% (Neufert et al., 1980). The stools used in these studios are uncomfortable and non-adjustable seats (Dixon, 2012). Despite the fact that the furniture arrangement in rows provides students with personal space and privacy, this kind of arrangement is considered anti-social. Small group workspaces encourage social interaction (Muniandy et al., 2015). According to Dixon (2012), the studio should provide both types of arrangement and give students the choice to sit individually or in groups. Regarding colours, all studios visited in the study were painted using white or light colours. According to Dixon (2012), the colours in the design studios should include bright and neutral colours which provide visual comfort for users (Dixon, 2012). Additionally, most of the visited studios are facing buildings. Overlooking natural environment and green areas have a positive impact on human wellbeing (Muniandy et al., 2015).

The results show a significant difference between public and private universities. The studios of private universities are in better physical conditions than those in public universities. All the studios in private universities are rectangular in shape and the closed plan system decreases the level of noise and provides more privacy. The studios in the selected public universities have various shapes including open plan, semi-closed and closed systems.

Besides, the studios in the selected private universities have lower number of students which decreases levels of crowding and increases levels of satisfaction. In contrast to many public universities, all private universities also provide better thermal comfort conditions by installing Heating, Ventilation and Air Conditioning (HVAC) systems. In addition, the furniture arrangement in some architectural studios of private universities in Jordan is U-shape arrangement which increases the social interaction, sense of community, and sense of belonging. The majority of private universities' walls were painted in white which has provides visual comfort for users.

8. Recommendations and conclusions

The design studio is considered as a living-learning environment for architectural students. It is the space where architectural students spend extended times performing various socio-educational activities. Therefore, the studio should meet the needs of the students. Careful attention should be given to the design of the studio to increase the level of productivity, creativity and satisfaction of the students.

This study offers a few recommendations to enhance student satisfaction. Rectangular shape with a closed plan system is recommended with natural and artificial lighting. The arrangement of furniture should be flexible to allow students to work individually or in groups. Each student should be allocated more than (4 m2). Natural heating and cooling with HVAC systems should be provided. The maximum number of students in a studio shouldn't exceed 17. Seating should be flexible and comfortable and desks dimension around (1.2 * 0.80 m). Painting the walls in white or mixing white and bright colours is recommended in addition to providing views of natural environments.

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References

Aderonmu, P., Awoyera, P., Amole, S., Olofinnade, O. & Adekeye, A. 2016. Parametric measures for design workspace adequacy of selected institutions in Nigeria. ARPN Journal of Engineering and Applied Sciences, 11, 2105-2119.

Atakan, G. 2016. A comparative analysis of methods for triggering

"creative thinking" in design studios. Global Journal on

Humanities & Social Sciences, 344-350.

Cardellino, P., Araneda, C. & Alvarado, R. G. 2017. Classroom environments: an experiential analysis of the pupil–teacher visual interaction in Uruguay. Learning Environments Research, 20, 417-431.

Cheryan, S., Ziegler, S. A., Plaut, V. C. & Meltzoff, A. N. 2014. Designing classrooms to maximize student achievement. Policy Insights from the Behavioural and Brain Sciences, 1, 4-12.

Demirbas, O. O. & Demirkan, H. 2000. Privacy dimensions: A case study in the interior architecture design studio. Journal of Environmental Psychology, 20, 53-64.

Dixon, L. 2012. The interior design studio built environment: Exploring intersections of energy conservation, student satisfaction, and occupancy patterns, The Florida State University.

GUERIN, D. A. J. H. E. R. J. 1992. Interior design research: a human ecosystem model. 20, 254-263.

Hua, Y. 2010. A model of workplace environment satisfaction, collaboration experience, and perceived collaboration effectiveness: A survey instrument.

Huang, J., Mori, S. & Nomura, R. J. S. 2019. Territorial Cognition, Behaviour, and Space of Residents: A Comparative Study of Territoriality between Open and Gated Housing Blocks; a Case Study of Changchun, China. 11, 2332.

Ibem, E. O., Owoseni, A. O. & Alagbe, O. 2017. A Study Of Students' perception Of The Learning Environment: Case Study Of Department Of Architecture, Covenant University, Ota Ogun State, Proceedings of INTED 2017 Conference , 6th-8th March 2017, Valencia, Spain .

Muniandy, S., Khan, T. H., Ahmad, A. S. J. I. J. O. B. E. & Sustainability 2015. Evaluating the Physical Environment of Design Studios: A Case study in Malaysian Private Architecture Schools. 2.

Neufert, E., Jones, V. & Thackara, J. 1980. Architects' data, Granada.

Neufert, E., Neufert, P., Baiche, B. & Walliman, N. S. 2000. Architects' data/Ernst and Peter Neufert. Oxford; Malden, MA: Blackwell Science.

OBEIDAT, A., AL-SHARE, R. J. A. C. & HISTORY 2012. Quality learning environments: Design-studio classroom. Asian Culture and History, 4(2), p.165.4, 165.

Namazian, A. and Mehdipour, A., 2013. Psychological demands of the built environment, privacy, personal space and territory in architecture. International Journal of Psychology and Behavioural Sciences, 3(4), pp.109-113.

Utaberta, N., Hassanpour, B., Ani, A.C. and Surat, M., 2011. RETRACTED: Reconstructing the Idea of Critique Session in Architecture Studio.

El Zaza, I.Z., 2014. Architecture Design Studio: Toward the Ideal Interior Design of Architecture Studio in the Gaza Strip. Architecture Design Studio: Toward the Ideal Interior Design of Architecture Studio in the Gaza Strip.

A SYSTEM FACADE INTEGRATING HEATING, VENTILATION AND ENERGY PRODUCTION BASED ON MASSIVE WOOD

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Abstract. New technologies and advanced building components for low-energy buildings have been on the market for several years and their efficiency is constantly improving. The increasing attention to the CO2 footprint of buildings and building components as well as cradle-to-cradle principles has fundamentally changed the construction industry. However, the focus of these cradle-to-cradle principles is limited to a singular product. What is missing is a holistic approach, where the integration of building skin, load bearing elements, ventilation, heat and electricity production and a focus on embodied energies is integrated into one wall system. This is a system, where the combination and interaction between several building components forms one product in itself.

The façade introduced in this paper provides an answer to how the latest developments within low-energy windows, solar shading, ventilation, insulation and solar cells can be combined into one facade concept, integrating not only the latest available technologies but also focusing on ecology and embodied energies. This new façade concept is a building envelope with integrated solar cells, an ultra-light concrete cooling and heating device, a built-in decentral ventilation, and a highly insulated window with solar screens. The load-bearing element in the façade is made of massive wood. The facade can also be used for energy renovation projects.

Keywords: Façade, Integration, Ventilation, Energy Production, Massive Wood.

1. Introduction

The goal of this research was to develop a façade based on massive wood elements, where several technical functions, e.g. energy production, heating/cooling and ventilation, are integrated into one concept transforming a passive element into an active building component. Such an approach does not exist on the market and this research will fill this gap. The different analytical steps of this research project are presented first, followed by an overview of how this research has been influenced by national and international trends and is followed by own reflections and considerations, describing how the research influenced the educational environment, and outline opportunities for further research. The focus will be on the overall process rather than on the detailed steps. As an example of this detailing process, the analysis of the choice of a window and how the chosen window interacts with the load-bearing wood element and the insulation will be described.

The involved project partners are Danish and German firms, which are highly specialized in their field: The German window manufacturer Enersign windows delivered the window, the

glass rail and the solar screen. They have been pioneers in highly insulated window systems since 1995. Danish Inventilate delivered the ventilation unit. Hicon specializes in concrete elements and helped to develop the technical aspects of the concrete radiator for heating and cooling. Gaja Solar was involved in finding the best technical solutions for the coloured solar cells. Bauwerk-Energie helped with the calculations of the U-values and the thermal bridges. ÖHS built the mock-up model and helped to adjust the window position in collaboration with Enersign, the engineering firm and the author.

2. State of the art of prefabricated façade systems

The EU countries adopted climate targets in 2008 to reduce greenhouse gas emissions by 20% by 2020 compared to 1990 (*BMU, 2007*). Buildings generate 40% of total CO2 emissions (*UN, 2017*) and can become an important step towards fulfilling their climate goals through systematic energy renovation efforts and new energy efficient buildings. However, outdated construction methods will not help us to achieve these climate goals. The increasing requirements concerning energy consumption of buildings have resulted in a demand for more efficient façade constructions.

A traditional façade is a composition of several elements including windows, cladding, load-bearing elements and insulation. The common understanding of a façade is that it protects interior spaces from the influences of the external environment. The performance of a façade is measured by how well it can protect interior spaces from external climatic influences. There are several companies in Europe producing façade elements combined with insulation, cladding and windows. However, these façade elements are made of studs and beams instead of massive wood. The integration of a ventilation unit into a façade element has already been successfully tested at an experimental level at the University Innsbruck, Austria (Ochs, et al., 2015).

New technical possibilities and effective building services (e.g. ventilation and cooling) as well as new building materials have dissolved conceptual barriers, because building services can now manufacture the interior climate independently of external climatic conditions. Curtain walls and double-skin façades can be seen as a development towards the integration of the interior climate control and the façade design. In the past few years this strategy has been extended to include adaptive building skins, which can respond actively to changing conditions and requirements. An example of a dynamic building skin is the Al Bahr tower in Abu Dhabi (Alotaibi, 2015), built in 2012 with umbrella-like glass elements that automatically open and close depending on the intensity of the sunlight. A similar approach are dynamic components that can be integrated into façades. The Swiss firm GlassX has developed a phase-changing façade with a saline solution between two layers of glass that crystallizes when cooled below 26 degrees C (Kräuch, et al., 2014). When the sun heats the façade, the salt solution melts and stores energy, which keeps the interior cool. When the sun is down, the heat is released into the interior. To avoid overheating during summertime, prisms on the outside of the glass prevent overheating.

The German window producer Wicona has developed a façade concept with integrated active and autonomous building technology (Wicona, 2018). This window system controls the integrated ventilation, air conditioning and heating technology. The façade is able to react to changes in external and internal conditions, such as light or temperature. The thermal activation of concrete building components is also an important factor for controlling indoor

climate (Handler, 2017). These features contribute significantly to the energetic optimization of the building envelope and to the reduction in operating costs.
Another recent development is a research project at the Fraunhofer Institute in Freiburg, Germany. They developed a façade concept with integrated ventilation, heating and external insulation for renovation projects (Fraunhofer, 2017). A similar approach was presented in 2017 at the Passive House Conference in Vienna by the window manufacturer Smartwin, which presented a wall system with a ventilation unit and ducts behind the cladding of the façade (Freundorfer,2017). These efforts suggest that the technology, building materials and singular products are available on the market (Schulz, et al, 2018), but a system combining all these different possibilities including massive wood into one product is not available on the market yet.

3. The purpose of this research

This project provides a solution to how the latest developments within low-energy windows, solar shading, ventilation, insulation and solar cells can be combined into one façade concept based on massive wood, integrating not only the latest available technologies but also focusing on how ecology and embodied energies can be combined into one system. This research will show how massive wood can be used in multifunctional façade systems by rethinking the use of massive wood in prefabricated facade elements, so that the facade evolves from a passive to an active element of the building envelope. Wood is a building material that is constantly growing in sufficient amounts. Wood is a natural carbon sink, binds CO2, contributes to climate protection, is a natural energy storage and can be 100% ecologically recycled.

The new façade concept is a building envelope with integrated solar cells, an ultra-light concrete cooling and heating device, a built-in decentral ventilation and a highly insulated window with solar screens. The façade can be used for renovations as well as new buildings. The goal is to disseminate the results to professionals in order to influence current practices with a view to implementing more holistic, sustainable solutions into façade elements based on massive wood.

4. The research design and research methodology

A sequential mixed-methods design was used (Creswell 2009), consisting of qualitative, unstructured interviews (Launsø et al. 2017), followed by a quantitative analysis of materials and material combinations. Data collected through interviews is typically qualitative in nature. However, in this particular case the collected data can be classified as quantitative, because they were used to gather information about the physical properties of building materials. The two types of data were not equal in weighting, as most emphasis was put on the analysis of material combinations. However, the interview study was important to make a more informed decision about suitable materials for the quantitative analysis. Further, the interviews ensured that the choice of materials was not based on pre-existing ideas of what materials would be suitable, but followed the guidance of material experts. This has contributed to an objective and transparent selection of materials. In Figure 1 the knowledge production process is outlined. This includes two knowledge types, namely factual knowledge from product

specifications as well as knowledge from practitioners' experiences. The figure also illustrates the methods of data collection and the sources, which will be described on the following pages.

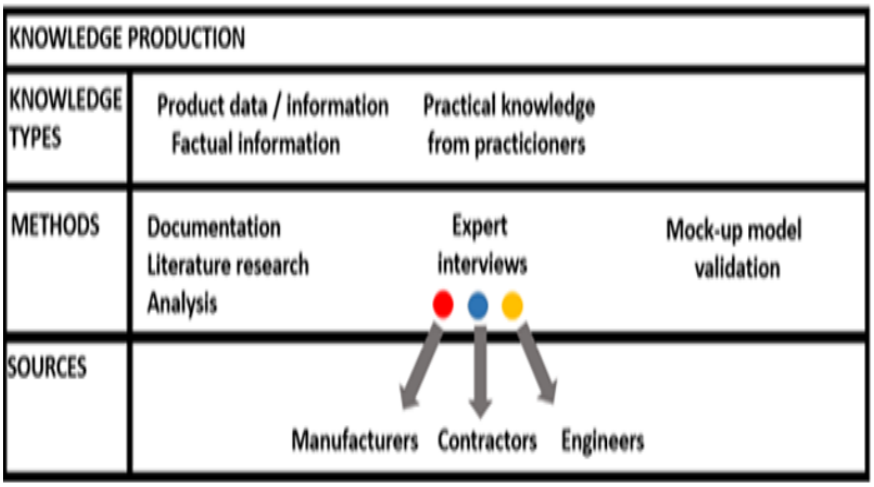

Figure.1. Knowledge production

5. Data collection phase 1 - Identification of the functions and the essential elements

The goal of Phase 1 of the data collection was to identify first the functions of the façade and then the essential parts of the façade that will fulfil these functions. This new façade is intended to integrate several technical functions, such as energy production, heating, cooling and ventilation into one product that is assembled offsite.

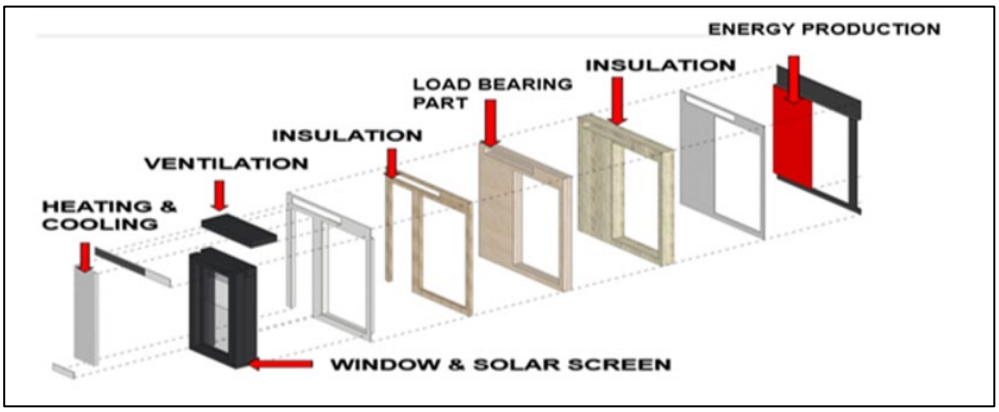

Figure 2. Exploded axonometric view of the different functions of the facade

The developed façade has to be as finished as possible when arriving at the construction site in order to reduce on-site construction work, requiring an absolute minimum of additional mounting and assembling on site. The goal was therefore to create a very thin building envelope, including insulation, exterior and interior finishes, electrical fittings, window and

solar screen. The façade also has to be stiff enough to ensure handling and lifting during the transportation and the onsite construction phase.

These functions of the façade define the essential elements necessary for the realization of the façade. In order to define the essential elements that will fulfil the described functions, several challenges had to be addressed. First, the load-bearing part has to give the façade element the required stiffness in order for it to be safely transported, lifted and mounted. Massive wood is used to fulfil these requirements. Between the massive wood and the cladding of the façade, insulation is needed to fulfil energy requirements. As the façade cladding is mounted off-site, the insulation as well as the fireproof layer between insulation and cladding have to be mounted. The mounted window together with the external cladding has to protect the insulation and the massive wood from weather influences during transportation and mounting. The ventilation system has to ensure a good indoor climate and the concrete radiator has to provide heating and cooling. Based on these requirements, the following essential elements were defined (in addition to massive wood): insulation with low lambda value, high performance windows and exterior solar screens, concrete radiators for cooling and heating, decentral ventilation systems, and solar cells.

6. Data collection phase 2 –material research

In Phase 2 of the data collection, it was necessary to undertake a systematic specification of each essential element defined in the first phase of the data collection. Since there are many types of massive wood elements, windows, insulations, ventilation systems and solar cells, it was necessary to create a specification for each of these essential elements in order to find the most suitable product for each category. A list of five producers for each of the essential elements of the facade was established and it was possible to compare the strengths and weaknesses of each of the five products for each category. For example, the specification of window manufacturers consisted of establishing a minimum u-value performance of the window, as well as finding producers from different countries (Denmark, Germany and Austria) and different materials, (wood, aluminium, fiberglass and PVC).

7. Data analysis and results

The approach to analyse the collected data was a comparison of combinations of different essential materials. After the essential elements for the façade had been identified and after producers for each element had been specified, it was necessary to identify the most suitable combination of elements for the façade.

For that purpose, an analytical model was developed for combining the different single elements with each other through a combination process that consisted of four phases, which resulted in the construction of a mock-up model of the façade.

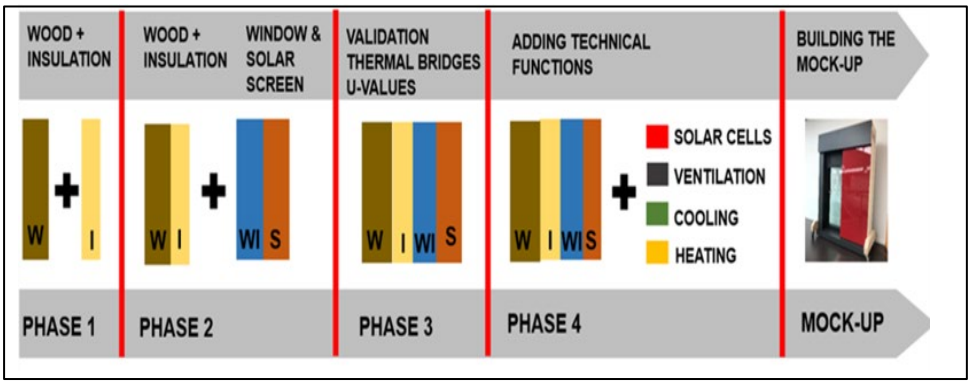

Figure 3. Analytical model for combining the different materials

8. Phase 1: Combination between the massive wood and the insulation

The first phase consisted of finding the most suitable combination between the massive wood and the insulation. As described above, massive wood was chosen as the core of the new element because of the ecological aspects and the needed stiffness. The different insulation types were analysed and then combined with different massive wood elements. In order to support loads of the façade and secure stability, the thickness of the massive wood was fixed at 120mm. The lambda values for the different massive wood elements were very close to each other so that the same U-value for all wood elements was used for the U-value calculations. The U-value calculation was undertaken for each combination. The massive wood wall consisting of cross-laminated timber was chosen for the load bearing element. Its stability and availability as well as the fact that it is produced in Denmark, which reduces transportation costs, were important considerations when choosing this cross-laminated timber wall instead of the other types. Due to the different lambda values of insulation types, the total thickness of the wall changed considerably. In fact, the total thickness of the wall was 150mm thicker with the wood fibre insulation compared to the PUR insulation. Rockwool and Isover insulation increased the wall thickness by 120mm compared to the PUR insulation. The U-value calculations were accompanied by moisture calculations to identify possible moisture problems. No combination indicated any moisture problems.

The PUR insulation due to its low lambda value resulted in the narrowest wall dimension of all combinations. PUR insulation is not as ecological as wood fibre, as it is a partially oil-based product. Isover and Rockwool consume more energy in their production process (Amtmann et al., 2014). The ecological aspects of the PUR insulation were taken into consideration as well. However, the possibility of realizing a very thin wall construction by having the same U-value made the difference. By a mechanical fixation with screws for the PUR insulation on the massive wood, it is possible to reuse the insulation at the end of the facades' life cycle. This makes it possible to dismantle the façade's components and to reuse its single components for other purposes.

9. Phase 2: Combination of the wood and the insulation with the window and the solar screen

The second phase consisted of analysing the combination of a window system and solar screens together with the wood element and the chosen insulation. During data collection phase 2, different windows were analysed. Five window manufacturers from Germany, Austria and Denmark were selected for the previously chosen massive wood and insulation combination.

The U-values of the different windows ranged from 0.60 W/m2K (German window) to an average of 0.78 W/m2K. (Danish window). The design of the frame differs from window to window. While Ideal combi operates with a skinny frame construction, Internorm uses a larger one. The largest window frame is from Krone vinduer. In order to compare the different window systems, I predefined the dimensions of the opening in the massive wood element. This predefined opening was used to test the different window types.

When combining the selected windows with the predefined opening of the wall, it was possible to measure the width from frame to frame in order to define how big the effective glass area will have to be for each window system. The effective glass area is reduced with a larger frame and will result in reduced solar gains generally and especially during the winter season.

The figure below shows the different window types combined with the wall of the façade.

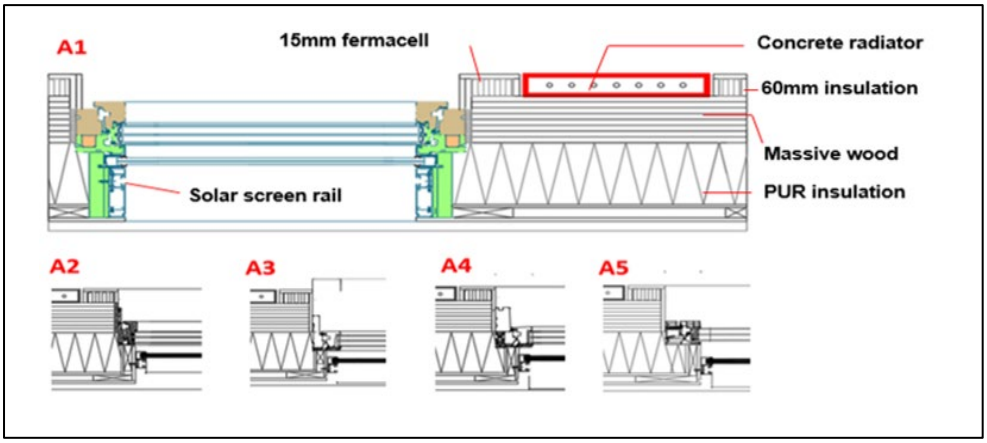

Figure 4. A1: Enersig, A2: Ideal combi, A3: Rationel, A: Krone, A5: Internorm

The German window producer Enersign is the only one offering an integrated solar screen rail built into the frame. For all the other manufacturers it was necessary to mount a guidance rail on top of the frame. This additional rail further reduces the sun impact on the glass. The difference between the smallest frame construction (Ideal Combi) and the largest (Internorm) was almost 100mm.

This reduction of the sun impact by 100mm for an entire window is considerable. The U-value of the entire window from the German window manufacturer Enersign is the lowest with 0.59 W/m2K and was therefore chosen.

Data for the enersign window

U-value frame: top, side,
Bottom: 0,59 W/m2K according to EN 10077
U-value window: 0,60 W/m2K according to EN 10077
U-value glass: 0,531 W/m2K, according to EN 673
G-value glass: 53 %, light transmission: TL 71 %
PSI value glass: 0,020 W/Mk, top, side, bottom Installation
PSI value: 0,022 W/Mk side

Figure 5. Data for enersign window

10. Phase 3: Validation through calculations of the wood, insulation and window combination

The third phase consisted of calculations of U-values and thermal bridges for the final composition. The U-value of the final façade composition is 0.12 W/m2K. The calculations were undertaken in collaboration with the German engineering firm Bauwerk Energie and Enersign. The window-wall connection at the top, the side and the bottom were analysed by means of a thermal bridge calculation and a visualization of the temperature flow with an outside temperature of -10 degrees Celsius and an inside temperature of +20 degrees Celsius. The first calculation showed that the maximum Danish thermal bridge value of 0.06W/mK according to Danish building regulation was not exceeded. The calculated values for the top were 0.033 W/mk, 0.027 W/mK for the side, and 0.051 W/mK for the bottom. In order to improve the thermal bridges, the entire window was moved 25mm to the outside.

The second and third calculation showed a reduction in heat losses. In cooperation with the Enersign window manufacturer, a 20 x 20mm aluminium profile was exchanged for a 20 x 20 mm “L” shaped aluminium angle with PUR insulation. This reduced the heat losses further and this modification was added to all new Enersign windows based on these results.

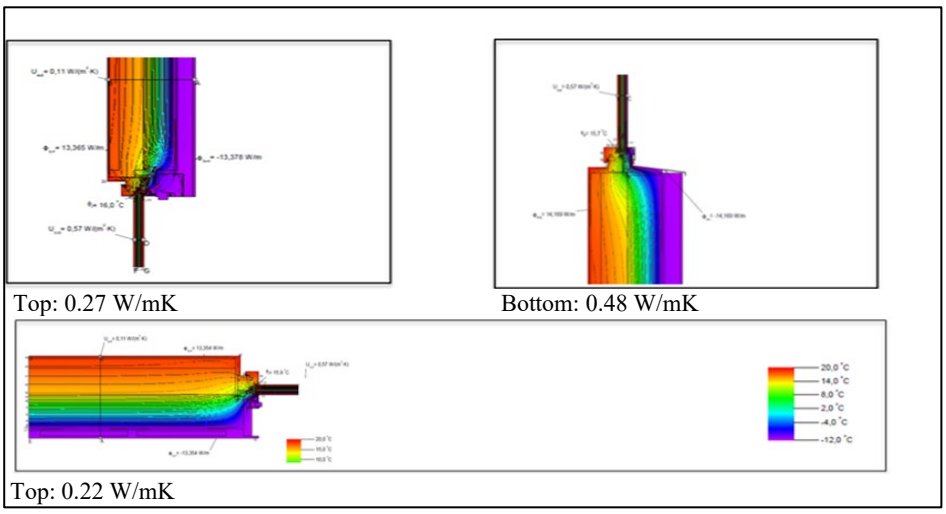

Figure 6. The thermal bridge calculation

11. Phase 4: Integration of cooling, heating, ventilation and energy production

The fourth phase consisted of the integration of the remaining functions of the façade, namely heating, cooling, ventilation and energy production, into the chosen combination. The producers for the technical functions of the façade had been identified in the data collection phase 2. The configuration of massive wood, insulation and window and solar screen from phase 2 were combined with the ventilation, the concrete radiator for heating and cooling, and the solar cells.

Data for ventilation system:

Manufacturer:	Inventilate.dk
Air flow range from:	20m3/h - 144 m3/h
Heat recovery rate:	85%
Specific electric power:	0.125 Wh/m3
Sound level unit:	30.0 dB(A)

Figure 7. Data for the ventilation system

An analysis of different solar cell types and ventilation units was undertaken. On the inner side of the wood-element, a 60mm insulation layer makes it possible to install all electrical cables and devices. These 60mm are covered with fermacell in order to fulfil fire regulations. These 60mm are used for electrical cables and the concrete radiator. Concrete was chosen due to the heat conductivity of the material. The concrete element comes together with the façade and has a hot water and a cold-water circuit. In the winter, hot water heats the mass and provides heating, while cold water provides cooling in the summer.

A mock-up model in scale 1:1 of the final combination was constructed, which was very useful to test the buildability of the concept. The mock-up model visualized what wasn't possible to show in the drawings and the calculations. The close collaboration between the carpenter, the window manufacturer, the engineering firm and the author helped to focus on assembling the different parts in an effective way.

Together with the carpenter, the window frame was moved in order to improve the thermal bridge results. These changes caused more problems rather than producing better thermal bridge values. Moving the frame by 50mm towards the outside would give a better thermal bridge calculation, but it would cause additional support for the frame, which would reduce the insulation layer and bring back the thermal bridge calculation to the starting point. Furthermore, the air tightening between the window frame and the massive wood is easier to handle when keeping the frame at the calculated position. Another issue that we solved with the 1:1 model was the shape of the hook that supports the concrete radiator. Here, a hook was formed and a wooden prototype of the concrete radiator in order to fix it onto the massive wood element and still have the possibility of dismantling the two components from each other without screws.

Figure 8. The mock up model in scale 1:1

12. Results, reflections and considerations on further research

This research has shown how different technical features can be integrated into one façade system based on massive wood. There are no technical limitations that hinder such a façade system, as the limitations for such a product are not a technical nature, but legal hurdles. When several components from different producers are combined into one product, the question of product warranties arises. Different products require special knowledge and production capacities, so that currently no company is able to integrate such a diversity of components into its portfolio. This calls for the development of alternative business models, where the product responsibility of the single as well as the entire product is in focus in order to offer a product warranty for the client.

References

Amtmann M., Höher M., Mair O., Strimitzer L., 2014, Dämmstoffe richtig eingesetzt. Eignung, Anwendung und Umweltverträglichkeit von Dämmstoffen. Austrian Energy Agency.

Alotaibi, F.,2015, The role of kinetic envelopes to improve Energy Performance in Buildings. J Archit Eng Tech 4: 149. doi:10.4172/2168-9717.1000149

BMU, 2017, Bundesministerium für Umwelt, Press release: bmu.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/climate_agenda2020.pdf

Creswell D., Creswell J., 2018, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Sage publications.

Fraunhofer, 2017, Flexible and functional, Prefabricated facade elements simplify building renovation, Press release Fraunhofer ISE.

Freundorfer, F. 2017, Tagungsband IPT 2017, Internationale Passivhaustagung, Paper:" Fenster und Lüftung als EnerPhit Innovation", (261-266)

Gimenez-Gavarelli P., Fereres, S., 2017, Glass encapsulated phase change materials for high temeperature thermal energy storage, Renewable Energy, Renewable Energy 107(2017)497-507.

Handler, S., 2017, Tagungsband IPT 2017, Internationale Passivhaustagung Paper: "Konditionierung und Energiespeicherung im PH mittels thermischer Aktivierung von Stahlbetondecken", Simon Handler. (533-566)

Kräuchi, P., Bionda, D., Plüss, I., Schröcker, M., Felsenstein, S., Zweifel, G., 2014. Thermisches Modell eines PCM-Fassadenelementes. Conference Paper: for the 18. Status-Seminar «Forschen für den Bau im Kontext von Energie und Umwelt», 4-5 September 2014, At ETH Zürich, Switzerland.

Launsø, L., Rieper, O., Olsen, L., 2017, Forskning om og med mennesker, 7. udgave, Munksgaard.

Ochs F., Siegel, D., Dermentziis, G., & Feist, W., 2015, Prefabricated timber frame facade with integrated active components for minimal invasive renovations, 6th international Building Physics Conference, IBPC 2015, Energy Procedia 78(2015)61-66.

Schulz, T., Kah, O., Bräunlich, K., 2018, New concepts for controlled ventilation: Conference proceedings, International Passive House Conference, Munich, 2018.

UN, 2017, United Nations, Report:
worldgbc.org/sites/default/files/UNEP%20188_GABC_en%20%28web%29.pdf

Wicona, 2018, Tilgængelig online hos:
wicona.com/en/int/Product/Facade/TEmotion-Intelligent-facade-concept.

AN INVESTIGATION INTO WAYFINDING DESIGN TECHNIQUES EMPLOYED IN NORTHERN IRELAND AND THE NEED FOR WAYFINDING STANDARDS

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Abstract. Wayfinding is the process of determining location and orientation and then planning and following a route to the desired destination. As one of the first to discuss wayfinding, Passini (1980) describes it as a problem-solving method which allows dynamic navigation to a chosen location. Consequently, the design of wayfinding schemes can impact on an individual's experience of space, either making it positive or negative. Mollerup (2013) indicates that anxiety and stress can result from inadequate wayfinding information. The aim of this paper is to critically appraise current wayfinding schemes implemented within healthcare facilities in Northern Ireland and determine how well these schemes perform. By doing this, the investigation aims to identify best current practices in wayfinding design and establish the importance of developing a regulatory framework for the design of wayfinding systems in the future. Primary data was collected through both observational site surveys and wayfinding system audits to assess the standards of the existing provision, highlight best current practices in wayfinding design and identify areas for potential enhancement. The findings of this investigation have exposed numerous inconsistencies and shortfalls in two local hospital environments. It also highlights the need for a robust standard framework that provides guidance to ensure consistent and successful wayfinding systems are designed in future healthcare provision.

Keywords: Wayfinding Design, Standards, Healthcare Facilities, Hospitals

1. Introduction

Disorientation and getting lost are very frustrating experiences for people who are trying to reach a specific destination (Passini, 1992). Wayfinding Design refers to systems or schemes created to facilitate navigation within a building or space. In healthcare environments those visiting hospitals may already be feeling anxious, therefore the usability of the wayfinding system becomes paramount. In 2013, data collected suggested that about 6.9 million outpatient hospital appointments are missed each year in the UK, each costing an average of £108. Doctors have associated a significant number of these with navigational problems (The Guardian, 2013). In Northern Ireland, there is no set framework for the design of wayfinding systems. The Disability Discrimination Act (1995) (DDA) and the Northern Ireland Building Control Technical Booklet R – Access to and Use of Buildings, provide very limited guidance in the area of wayfinding systems and standards, despite being focused on ensuring adequate access for all to both public and private buildings. While guidance is offered through the NHS Wayfinding, Effective Wayfinding and Signage Systems document, this information is at the discretion of the wayfinding system's author and open for interpretation. The best practice guidelines in this document are not enforced or assessed.

1.1. RATIONALE

The rationale for this research project stemmed from an interest in and the desire to extend knowledge in the subject. Good wayfinding design begins with the designer and the initial design of a project. Wayfinding is an important subject for architectural technologists.

1.2. AIM

To evaluate the current wayfinding schemes implemented within healthcare facilities in Northern Ireland and assess how well they perform.

1.3. OBJECTIVES

- To carry out observational site surveys and audits on various local healthcare facilities.
- To critically evaluate the wayfinding design techniques employed within these facilities in terms of practicality, consistency and level of success.
- To identify common problematic issues found at healthcare facilities.
- To investigate if a more rigid framework and wayfinding assessment system should be developed.

2. Literature Review

2.1. DEFINITION OF WAYFINDING

Passini (1980) defines wayfinding as a multi-disciplinary field that intertwines the roles of environmental psychology, geography, anthropology, architecture and environmental design. Kim (2016) describes wayfinding as a decisive aspect of the users' experience which can be enhanced or diminished by design.

2.2. SUCCESSFUL WAYFINDING SYSTEMS

Satisfactory wayfinding systems should enable the end user to establish the correct start and end location of their journey; confirm that they are moving in the right direction; and determine their position allowing them to orientate within a building (Gibson, 2009; Baskaya et al. 2004). Wayfinding depends on a sequence of precise communicational cues incorporating tactile, audio and visual aspects (Morag, 2016). Levine (2003) maintains that for a wayfinding system to be successful people need to receive a constant series of signals or suggestions.

The use of colours, textures and relevant indications at decision points are key techniques and contributing factors which can aid memory. Davis and Weisbeck (2016) provide further evidence that colour can help people in recalling and identifying environmental prompts and it has been shown to have a beneficial impact on wellbeing and autonomy (Dalke et al, 2006). One method to encourage wayfinding involves the use of coloured zones in hospitals (Greenroyd et al, 2017). However, Thompson and Hamilton (2012) believe that colours should be calming or neutral to diminish patient stress.

The provision of salient environmental cues presents a way for the environment to become more identifiable and memorable (Davis and Weisbeck, 2016). As these informational cues are noted, they can later be utilised when required for wayfinding. One significant cue is a map

of the facility. When designing wayfinding systems, a journey map is fundamental, indicating various decision points a user must make to reach their destination (Berger, 2009). By contrast, Farr et al. (2012) and Hölscher et al.'s (2007) argue that signage is more effective in comparison to the use of maps. Misinterpretation is common with maps causing disorientation. Specifically, 'You Are Here' (YAH) maps can cause the most difficultly, as users may incorrectly interpret their orientation. One in every three persons goes the wrong way after examining a YAH map, (Wright et al. 1993).

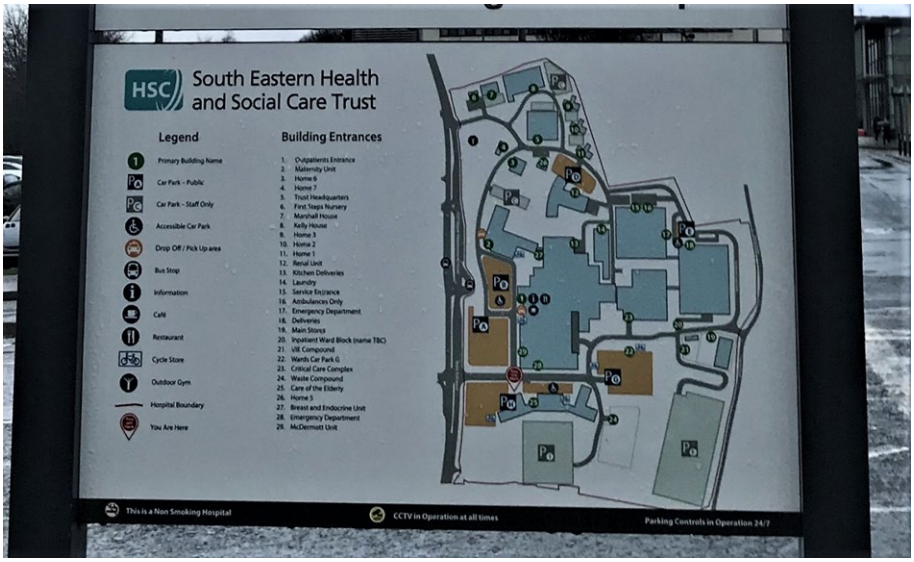


Figure 1. An example YAH map installed at the Ulster Hospital Car Park.

It is important to remember that more than one medium should be employed to support the entire wayfinding journey (Berger, 2009).

2.3. THE NEED FOR SUCCESSFUL WAYFINDING SYSTEMS

Wayfinding helps users and promotes feelings of comfort within an environment (Gibson, 2009). Short et al. (2017) suggest that wayfinding can affect experiences of a space either positively or negatively through the level of communication received. Arthur and Passini (1992) recognise that wayfinding within hospital environments is exceptionally important, as the same patients who navigate to numerous locations during one visit experience the most stress.

The design of a facility and the ease in which visitors can navigate by means of a wayfinding system can influence the reputation of a healthcare complex. Arneill & Devlin (2002) discovered that patients evaluate healthcare based upon their own knowledge, experience of the facility and the interactions they have with staff while there; all these unrelated to clinical procedures. Making a good first impression is imperative, and as wayfinding is the first engagement a user has with the space while navigating to the appointment location, it can be a contributing factor (Short et al, 2017).

Garling et al. (1986) discuss that the demand for efficient wayfinding systems becomes more critical as hospitals are constantly expanding. Additional facilities and extensions are

regularly added to help relieve pressure and demand. This complicates navigational routes and wayfinding systems.

2.4. THE DESIGN OF A SUCCESSFUL WAYFINDING SYSTEM

Inferior and ineffective signage can exaggerate navigational problems. Approaches to signage in terms of facility design tend to be constructed without considering how users typically navigate a space. Therefore, approaches that appear to 'work on paper' may not support visitor or patient wayfinding (Greenroyd et al, 2017).

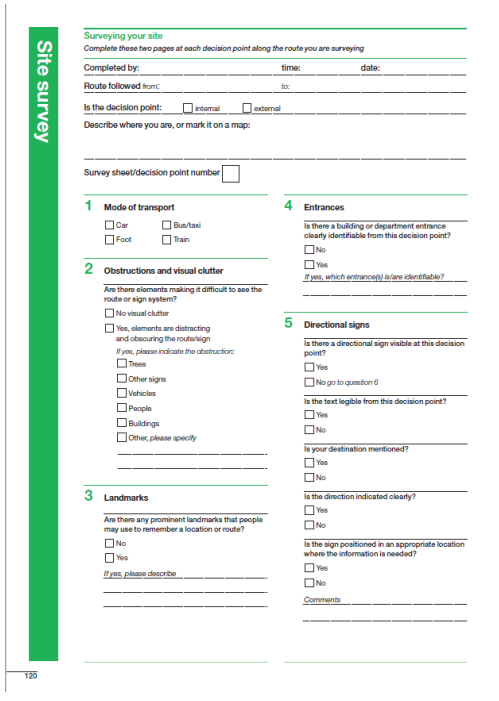
Greenroyd et al. (2017) refer to the best practice guidelines which have been developed from research and consultancy on various opinions about what makes successful signage. These guidelines are directed at advising designers on the placement and use of signage in healthcare facilities in NI with regards to the NHS (emf-standards, 2005). Although high-level recommendations are given, there is limited information in the way of design tools to aid designers and architects (Greenroyd et al, 2017).

In a contemporary study, Morag (2016) indicates that the theory, design principles and methods of wayfinding has evolved since they were introduced in 1960. However, Short et al. (2017) point out that with regards to healthcare and design a disciplinary gap exists. Health professionals do not have the pertinent skills to implement a meaningful design solution, and designers do not have the knowledge surrounding the complex and acute demands of the healthcare system.

3. Data Collection

Two local healthcare facilities were identified for auditing the current wayfinding systems. Professionally established site survey and audit tools were employed to assess the effectiveness of wayfinding systems in place and identify significant problems and inefficient wayfinding aids.

The site survey tool adopted is from Chapter 5 of the 'Wayfinding – Effective Wayfinding and Signing Systems' guidance document. This document is recognised as industry standard guidance for the provision of wayfinding systems in healthcare facilities. Chapter 5 of the document provides tools particularly designed for the evaluation of current wayfinding systems (figures 2 and 3). The 'site survey' tool and 'auditing your site checklist' were both utilised for this research. By employing these tools, it was anticipated that the research gathered would be in line with the best current professional healthcare standards.


Site survey

Surveying your site

Complete these two pages at each decision point along the route you are surveying

Completed by: time: date:

Route followed *from:* *to:*

Is the decision point: ☐ internal ☐ external

Describe where you are, or mark it on a map:

Survey sheet/decision point number ☐

1 Mode of transport

☐ Car ☐ Bus/taxi
☐ Foot ☐ Train

2 Obstructions and visual clutter

Are there elements making it difficult to see the route or sign system?

☐ No visual clutter
☐ Yes, elements are distracting and obscuring the route/sign

If yes, please indicate the obstruction:

☐ Trees
☐ Other signs
☐ Vehicles
☐ People
☐ Buildings
☐ Other, *please specify*

3 Landmarks

Are there any prominent landmarks that people may use to remember a location or route?

☐ No
☐ Yes

If yes, please describe

4 Entrances

Is there a building or department entrance clearly identifiable from this decision point?

☐ No
☐ Yes

If yes, which entrance(s) is/are identifiable?

5 Directional signs

Is there a directional sign visible at this decision point?

☐ Yes
☐ No *go to question 6*

Is the text legible from this decision point?

☐ Yes
☐ No

Is your destination mentioned?

☐ Yes
☐ No

Is the direction indicated clearly?

☐ Yes
☐ No

Is the sign positioned in an appropriate location where the information is needed?

☐ Yes
☐ No

Comments

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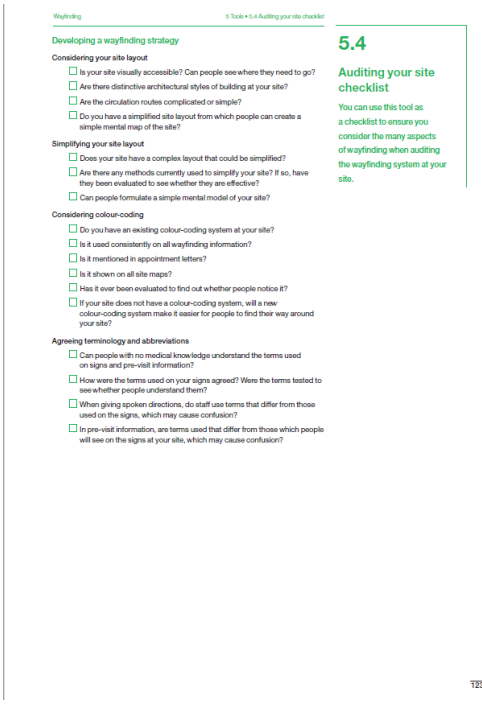
Wayfinding 5 Tools • 5.4 Auditing your site checklist

Developing a wayfinding strategy

Considering your site layout

- ☐ Is your site visually accessible? Can people see where they need to go?
- ☐ Are there distinctive architectural styles of building at your site?
- ☐ Are the circulation routes complicated or simple?
- ☐ Do you have a simplified site layout from which people can create a simple mental map of the site?

Simplifying your site layout

- ☐ Does your site have a complex layout that could be simplified?
- ☐ Are there any methods currently used to simplify your site? If so, have they been evaluated to see whether they are effective?
- ☐ Can people formulate a simple mental model of your site?

Considering colour-coding

- ☐ Do you have an existing colour-coding system at your site?
- ☐ Is it used consistently on all wayfinding information?
- ☐ Is it mentioned in appointment letters?
- ☐ Is it shown on all site maps?
- ☐ Has it ever been evaluated to find out whether people notice it?
- ☐ If your site does not have a colour-coding system, will a new colour-coding system make it easier for people to find their way around your site?

Agreeing terminology and abbreviations

- ☐ Can people with no medical knowledge understand the terms used on signs and pre-visit information?
- ☐ How were the terms used on your signs agreed? Were the terms tested to see whether people understand them?
- ☐ When giving spoken directions, do staff use terms that differ from those used on the signs, which may cause confusion?
- ☐ In pre-visit information, are terms used that differ from those which people will see on the signs at your site, which may cause confusion?

5.4

Auditing your site checklist

You can use this tool as a checklist to ensure you consider the many aspects of wayfinding when auditing the wayfinding system at your site.

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Figure 2 & 3. Site survey and audit tool used to collect data.

Using the 'site survey' tool, the routes to different destinations within both facilities were surveyed and decision points noted. The routes began externally and the mode of transport was a car. A consistent approach was used for both locations to minimise variables within the researchers' influence. Once the site surveys were completed, additional aspects of wayfinding on the site were considered by adopting the 'auditing your site checklist'. This examined the external factors influencing the site user before they access the building and addressed the effectiveness of external signage. Certain aspects of the tools were deemed not applicable for this study and so these were not used. One such example is pre-visit information – which a pre-booked patient does not necessarily remember to bring and does not apply to many visitors or emergency cases.

4. Case Study Findings

The first healthcare facility, Omagh Hospital and Primary Care Complex, became operational in June 2017, making it relatively new. The second facility, the Ulster Hospital Dundonald, has been operational for over 50 years, initially opening in October 1962. A comprehensive insight of the wayfinding at both locations was obtained and is summarized below.

Both facilities are well signposted and prominent from their approach routes, with both the main and service entrances visible. This ensures that they can be distinguished from the existing surroundings.

At both facilities, navigational routes to the emergency department (A&E), the outpatient department and radiology (X-ray) were followed. Two routes to A&E were investigated: route

A following the external signage to the A&E entrance and route B navigating from the main entrance. Figure 4 shows that neither hospital is superior to the other in terms of the number of decision points, with both hospitals having the same number of decision points for two out of the four routes. This suggests that despite the Omagh Hospital being much newer, the layout and placement of departments in relation to the main building entrance is no better. However, it is notable that it took five decision points to reach A&E via route B in the Ulster Hospital. This reflects the hospitals age and the number of redevelopments and departmental changes that have occurred.

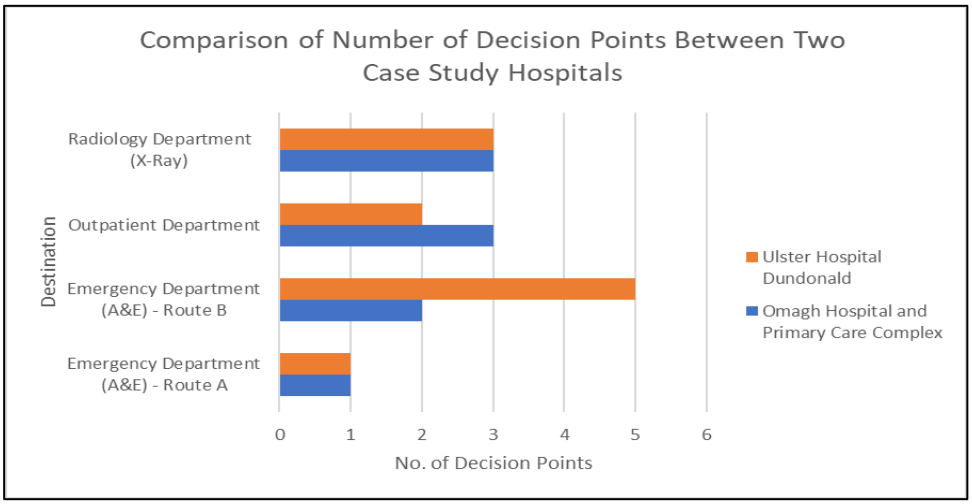


Figure 4. Bar chart showing the comparison of the number of decision points between the two case study hospitals.

Figure 5 shows the results of the observational site audit checklist, relating to site premises for both hospitals. Omagh Hospital, as a modern complex has a compact footprint with one main building allowing easier site navigation. The building façade was designed with the building user in mind, having a distinct glazed and clad entrance and protruding brick feature detail emphasising the approach route.

Site Audit Checklist – Site Premise	Case Study	
	Omagh Hospital and Primary Care Complex	Ulster Hospital Dundonald
Is your site visually accessible?	Yes	No
Are there distinct architectural styles of building at your site?	Yes	No
Do you have a simplified site layout from which people can make a simple mental map?	Yes	No
Does your site have a complex layout that could be simplified?	No	Yes
Are pathways at your site clearly identifiable and well lit?	Yes	Yes
Are pathways from public transport stops to site and building entrances clearly identifiable and well lit?	Yes	Yes
Does your site have taxi drop-off and pick-up points at each building entrance?	Yes	Yes
Is your site visible from approach roads?	Yes	Yes
Are site entrances visible and prominent from the main directions of approach?	Yes	Yes
Are the site entrances clearly differentiated?	Yes	Yes
Are the car parks and drop-off points at your site individually and clearly marked?	Yes	Yes
Can people find out which building their destination is in once they have arrived?	Yes	Yes
Are public entrances to the buildings clearly visible and identifiable as public entrances?	Yes	No

Figure 5. Results of the observational site audit checklist comparing site premises.

The Ulster Hospital differs greatly because the facilities are spread out through multiple buildings on the site. These buildings are similar in appearance, making it harder for individuals to differentiate between them and find their destination. Individuals approaching are heavily reliant on directional cues, emphasising the importance of clear and visible signage at key decision points. The multiple undesignated car parks on site could result in unfamiliar visitors parking remotely from their desired location.

Regarding signage the two facilities make use of several different methods as noted in the table contained in Figure 6. These methods are discussed in greater detail through the case studies.

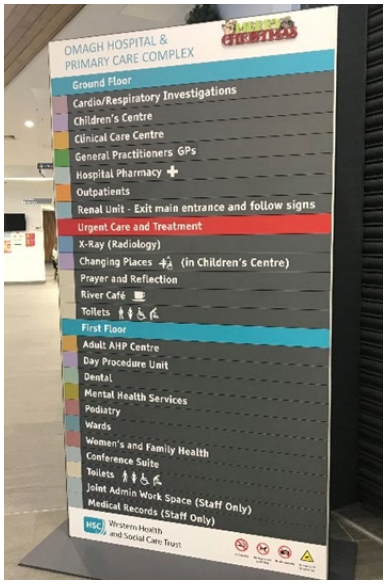
Site Audit Checklist – Signage	Case Study	
	Omagh Hospital and Primary Care Complex	Ulster Hospital Dundonald
Do you have an existing colour-coding system at your site?	Yes	No
Is it used consistently on all wayfinding information?	No	N/A
Is it shown on all site maps?	N/A	N/A
Can people with no medical knowledge understand the terms used on signs?	No	Yes
Are there prominent locational signs at site entrances?	Yes	Yes
Are both upper-case and lower-case letters used?	Yes	Yes
Is there a high colour contrast between the text and sign background colour used on your signs?	Yes	Yes
Are type sizes for each type of sign used consistently?	Yes	Yes
Do signs suspended from the ceiling have a larger type size than those positioned at eye-level?	No	N/A
Could the design of the signs be improved to make them more effective?	Yes	Yes
Is the layout of each sign type consistent?	Yes	Yes
Are the signs at your site consistently aligned?	Yes	Yes
Is it easy to scan through the lists on your signs?	Yes	Yes
Is it clear which direction the arrows on your signs are indicating?	Yes	Yes
Can visitors quickly see directions of services and facilities they may want to find in a hurry, such as toilets, lifts, information desks and telephones?	No	Yes
Are the signs visible and legible from where they will be viewed?	No	No
Are locational signs at your site prominent?	Yes	Yes
Are the directories at your site positioned at strategic points, such as key entrances, car parks, ad in areas where people will be changing levels?	Yes	Yes
Are the directories used at your site flexible enough to change as departments move or change names?	Yes	No
Are the directories positioned where people can stop and read the information without causing an obstruction?	Yes	Yes
Is your site map simple and easy to understand?	N/A	Yes
Are maps located at key decision points at your site, and are they well lit?	N/A	Yes

Figure 6. Results of the observational site audit checklist comparing signage.

4.1. CASE STUDY 1: OMAGH HOSPITAL AND PRIMARY CARE COMPLEX

The facility made use of a directory board (Fig. 7) placed both centrally in the entrance lobby and fixed to the wall beside lifts and stairs where users change levels (Fig. 8). These directories

employed both abbreviations and a colour coding system for each different department. The directories read in order from ‘Ground Floor’ to ‘First Floor’ with the departments listed alphabetically.



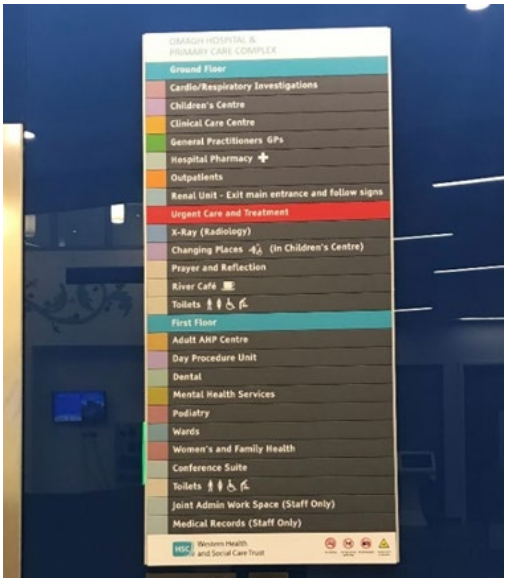


Figure 7 & 8. Main entrance directory board and directory board by the lifts.

Signage elsewhere was typically hung overhead along corridors and at key decision points (Fig. 9). The text size was consistent with that on the directory boards, but the colour coding system was essentially non-existent. Other rooms and facilities were indicated directly through fixed wall and door signage (Fig. 10 & 11) using words and recognisable symbols. The wall fixed signage was placed at a high level and protrudes out into the corridor (Fig. 12). In some cases, a colour coding scheme was present, however, it was inconsistent and differed from what was originally denoted on the directory boards.

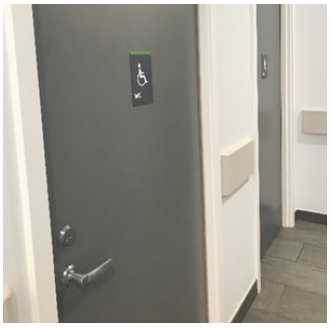


Figure 9 &10. Overhead signage and door fixed signage.

Figure 11 &12. Wall fixed and protruding wall fixed signage.

4.2. CASE STUDY 2: ULSTER HOSPITAL DUNDONALD

Methods of wayfinding currently in operation at the Ulster Hospital take the form of directory boards. These directory boards record the list of departments and what floor they are found on, with directional arrows. The directory boards are located on each level at the lifts (Fig. 13). However, no stand-alone directory board is apparent in the central lobby. The directory boards read ‘Level 1’ to ‘Level 0’ noting the various departments chronologically in order of need. A colour coding scheme is used here only to differentiate between ‘Level 1’ and ‘Level 0’. This directory has been amended as departments have been added and others removed as per the development of the facility. Members of staff have also attached their own signage to make visitors aware of department relocations.

Figure 13. Directory board

Moving through the hospital, almost all other signage is wall fixed, at both key decision points and department entrances. Additional signage created by staff also features frequently (Fig. 14). In one area on the ground floor male and female toilets are indicated with coloured protruding wall fixed signs (Figs. 15 & 16), despite no colour coding system being present for facilities in the initial directory board. Conflicting signage is located above the double doors between the two sets of toilets (Fig. 17).

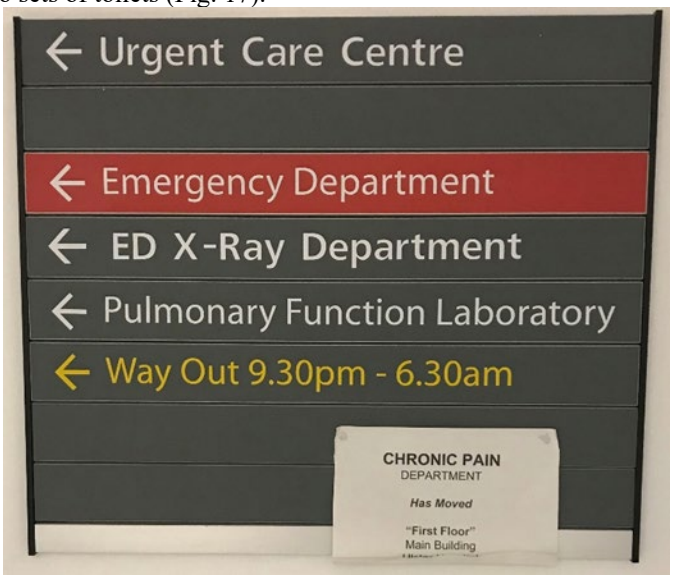


Figure 14. Wall fixed signage.

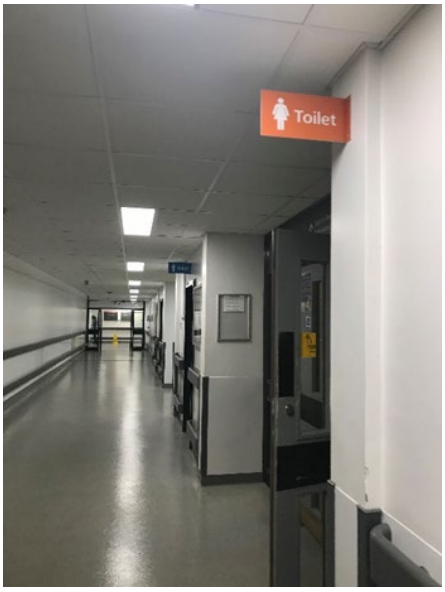


Figure 15 & 16. Female and Male toilet signage

Figure 17. Conflicting signage.

In another area, a yellow navigational line runs the length of the corridor on the floor (Fig. 18 & 19). This line originates from the Outpatient Department and is accompanied by blue and green lines. These lines are extremely inconsistent and are not acknowledged within any of the signage (Fig. 20) or directional information. It would seem that they were once part of the facility's previous wayfinding system prior to recent redevelopments.

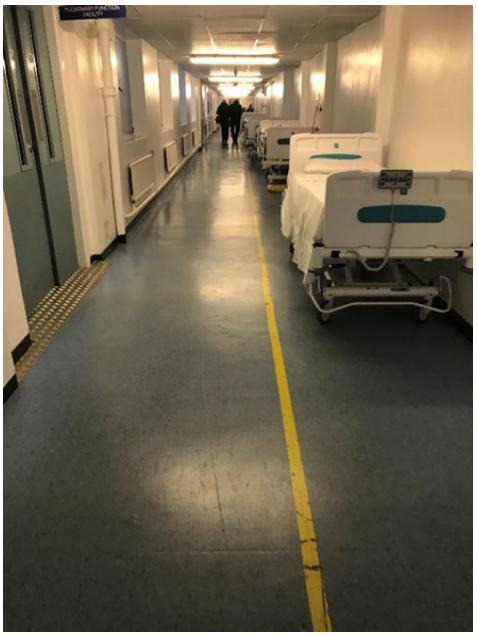


Figure 18 & 19. Coloured navigational lines on the floor.

Figure 20. Outpatient Department signage making no reference to colour scheme.

5. Case Study Analysis

Various issues and problems in the wayfinding systems have been highlighted and compared to the best current practice guidelines 'Wayfinding, Effective Wayfinding and Signage Systems' below.

5.1. OMAGH HOSPITAL AND PRIMARY CARE COMPLEX

Unexplained abbreviations were present and may be deemed confusing for wayfinding. The guidelines convey no consistent approach for abbreviations, simply stating that ‘a policy for your site should be agreed’ and ‘terms used on signs and other wayfinding information should be understandable to people with no medical background’ (emf-standards, 2005 p.38).

Information was grouped alphabetically as a long list. This disregards the guidance, which suggests that informational lists ‘avoid long, ungrouped alphabetical lists’ (emf-standards, 2005 p.77) and information should be grouped by its floor level, function or direction.

The document further advises that ‘destinations to the right are often aligned right to emphasise the way’ (emf-standards, 2005 p.78). The signage present does not always apply this.

Signage text size should be of ‘type sizes to be legible at the intended viewing distance’ (emf-standards, 2005 p.75). This information originally comes from the ‘HTM 65’, an earlier document referred to within, but is now deemed to be superseded. This may result in incorrect and illegible text signage.

The guidance document explicitly advises against the use of colouring coding for departments (emf-standards, 2005 p.37). It also alludes to avoiding ‘shades of colour that are similar to each other in the same colour-coding scheme’ (emf-standards, 2005 p.37). The guidance has been blatantly ignored to the detrimental effect of the wayfinding system in place (Fig. 21 & 22). The colours are similar shades creating confusion and a lack of visual contrast meaning a scheme like this is of no use to someone with visual impairments.

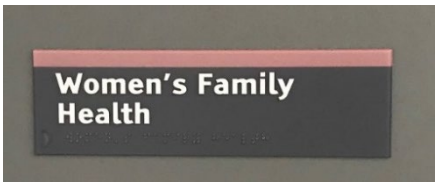


Figure 21 & 22. Door fixed colour coded signage displaying similar colour shades.

There is no guidance on how and if TVs should be used as an effective wayfinding method, but as the use of technology in everyday life increases, and advances are made, this is something that should be considered as a possible method of providing wayfinding information (Fig. 23).

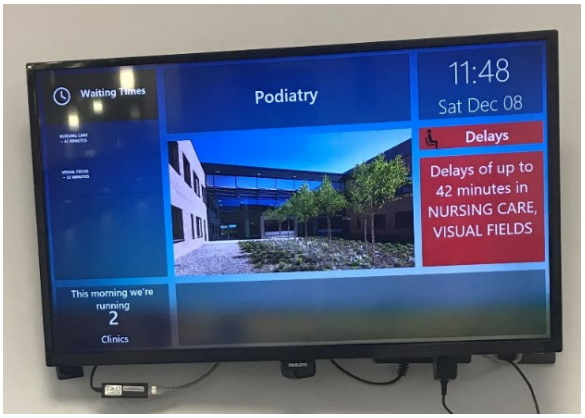


Figure 23. TV in podiatry department.

The functionality of the wayfinding system at the Omagh Hospital is exceptionally poor and not to the expected standard of a newer facility (Fig. 24-29). Sufficient time has passed since the opening in June 2017, but no remedial action has been taken to correct the inadequacies that exist.

Figure 24 & 25. Staff's own self-made signage.

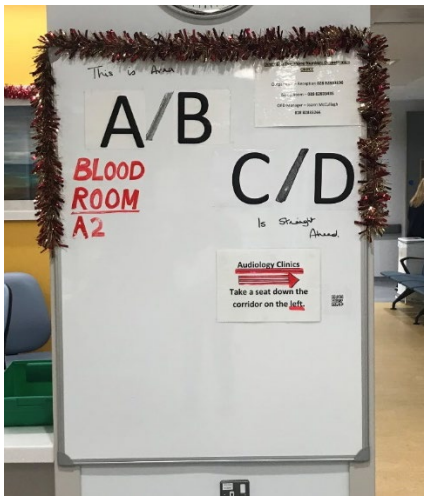


Figure 26 & 27. Staff having denoted appropriate waiting areas.

Figure 28 & 29. Additional signage created by staff.

5.2. ULSTER HOSPITAL DUNDONALD

The ‘Wayfinding, Effective Wayfinding and Signage Systems’ guidance document indicates that signs should be positioned so they are ‘visible and readable from all directions of approach’ (2005 p.89). Despite the directory board being fixed at a change of level it is not easily visible to new visitors. The best practice guidance document notes that signs should be ‘placed consistently so people know where to look for the information’ (emf-standards, 2005 p.89). While signage was placed consistently as wall fixed elements, this contradicts other guidance that signage should be visible from all orientations of approach.

Coloured navigational lines were present on the floor. This technique is not mentioned in the ‘Wayfinding, Effective Wayfinding and Signage Systems’ guidance document, leaving the designer without any best practice guidelines to follow and the potential for error and poor design. Colour-coding the Outpatient department is an example of a colour-coding system being used well. The colours used comply with the guidance document in that there are essentially eight suitable colours with pink and blue being two of them (emf-standards, 2005 p.36). Both of these colours are used to denote waiting areas ‘A’ and ‘B’ (Fig. 30 & 31).

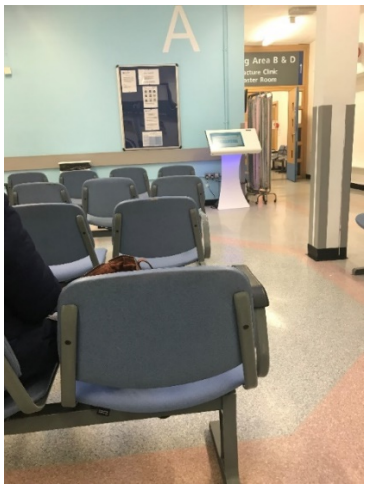


Figure 30 & 31. Colour scheme in outpatient department.

The Ulster Hospital is an established complex. If corrective measures have been taken, this may explain why there are fewer major problems with the wayfinding system. While there is still room for improvement, the issues discovered are less crucial. It could be argued that the longer a facility is established the more time there has been to discover wayfinding issues and remedy them. If suitable and enforced standards systems were in place, it would be possible to design it correctly from the start.

6. Conclusion

From the analysis, it is evident that both facilities have wayfinding systems employed which offer considerable potential. However, these systems followed sub-par guidance. Numerous inconsistencies and divergence from the guidance document have been exposed, demonstrating that without an enforced standard, confusion can be created and inefficiency increased.

Just as successful wayfinding design can diminish stress, an inadequate system can escalate an individuals' levels of anxiety while simultaneously creating further costs for the hospital (Sadler et al, 2008). The creation of a successful wayfinding system can only be achieved through competent pre-planning from the outset. When an extension is being added to an existing healthcare facility, the wayfinding systems should be designed to seamlessly integrate in a holistic manner.

Numerous shortfalls and inconsistencies have been identified in two local hospital settings. These oversights could be rectified through the implementation of a standard set framework for Wayfinding. A standard could be created by a range of relevant parties, such as designers, signage manufacturers, hospital officials and departmental managers. It could be managed by a regulatory body such as the Regulation and Quality Improvement Authority (RIQA). If such standards were applied across Northern Ireland, considerable benefits could result for all hospital users. Currently there is no guidance for incorporating flexible signage systems. This is an additional aspect that would help the healthcare industry with its ever-changing environment.

This research was limited since only two hospitals were audited. A larger selection of facilities could have been included to provide a more accurate assessment of the current state of wayfinding schemes and techniques employed in healthcare facilities local to the region. A larger range of data may have highlighted other problematic elements. As part of the project, interviews with members of the Estates Departments from both hospitals were planned. Unfortunately, this was not achieved mainly due to time constraints, the difficulty in contacting these individuals and the inflexibility of the hospital switchboard service. The opinions and assessment of professional personal in-situ would have undoubtedly yielded further issues for consideration.

Essentially this research paper acts as an initial study for a more complex and in-depth investigation into the standards of wayfinding within healthcare facilities in Northern Ireland.

References

ARNEILL A. and DEVLIN A. (2002). 'Perceived Quality of Care: The Influence of the Waiting Room Environment', Journal of Environmental Psychology, 22 (4), pp. 345-360 [Online]. Available at: https://ac.els-cdn.com/S0272494402902744/1-s2.0-S0272494402902744-main.pdf?_tid=9335a3cc-67f6-42b1-9a98-80f0b0457bb5&acdnat=1547654910_05f7e92423310acd7e0434413fc106c8 [Accessed: 16 January 2019].

ARTHUR P. and PASSINI R. (1992). Wayfinding: People, Signs, and Architecture. New York: McGraw-Hill.

BASKAYA A., WILSON C. and OZCAN Y. (2004). 'Different Spatial Settings of Two Polyclinics', Wayfinding in an Unfamiliar Environment, 36 (6), pp. 839-867 [Online]. Available at: https://journals.sagepub.com/doi/abs/10.1177/0013916504265445 [Accessed: 13 January 2019].

BERGER C. (2009). Wayfinding: Designing and Implementing Graphic Navigational Systems. UK: Rotovision.

CARPMAN J. and GRANT M. (2016). Design That Cares: Planning Health Facilities for Patients and Visitors, 3rd edn. San Francisco: Jossey-Bass.

DALKE H., LITTLE J., NIEMANN E., CAMGOZ N., STEADMAN G., HILL S. and STOTT L. (2006). 'Colour and lighting in hospital design', Optics & Laser Technology, 38 (4-6), pp. 343-365 [Online]. Available at: https://www.sciencedirect.com/science/article/pii/S0030399205001283 [Accessed: 12 January 2019].

DAVIS R. and WEISBECK C. (2016). 'Creating a Supportive Environment Using Cues for Wayfinding in Dementia', Journal of Gerontological Nursing, 42 (4), pp. 36-44 [Online]. Available at: https://www.healio.com/nursing/journals/jgn/2016-3-42-3/%7B1ca34606-3a2e-464d-9d91-b46f6b9581cf%7D/creating-a-supportive-environment-using-cues-for-wayfinding-in-dementia#divReadThis [Accessed: 11 January 2019].

EMF-STANDARDS. (2005). Wayfinding: EFFECTIVE WAYFINDING AND SIGNING SYSTEMS GUIDANCE FOR HEALTHCARE

FACILITIES (supersedes HTM 65 Signs). 2nd edn. UK: The Stationary Office (TSO).

FARR AC., KLEINSCHMIDT T., YARLAGADDA P. and MENGERSEN K. (2012). 'Wayfinding: A simple concept, a complex process', Transport Reviews, 32 (6), pp. 715-743 [Online]. Available at: https://www.tandfonline.com/doi/full/10.1080/01441647.2012.712555?scroll=top&needAccess=true [Accessed: 15 January 2019].

GARLING T., BOOK A. and LINDBERG E. (1986). 'A Conceptual Analysis and Suggestions for Post Occupancy Evaluation', Spatial Orientation and Wayfinding in the Designed Environment, 3 (1), pp. 55-64 [Online]. Available at: https://www.jstor.org/stable/43028787?seq=1#page_scan_tab_contents [Accessed: 14 January 2019].

GIBSON D. (2009). The Wayfinding Handbook, New York: Princeton Architectural Press.

GREENROYD F., HAYWARD R., PRICE A., DEMIAN P., and SHARMA S. (2017). 'A tool for signage placement recommendation in hospitals based on wayfinding metrics', Indoor and Built

Environment, 27 (7), pp. [Online]. Available at: https://journals.sagepub.com/doi/10.1177/1420326X17695375 [Accessed: 11 January 2019].

HOLSCHER C., BUCHNER SJ., BROSAMLE M., MEILINGER T. and STRUBE G. (2007). 'Signs and Maps - Cognitive Economy in the Use of External Aids for Indoor Navigation', Proceedings of the Annual Meeting of the Cognitive Science Society, 3 (29), pp. 377-382 [Online]. Available at: https://cloudfront.escholarship.org/dist/prd/content/qt1z3190s6/qt1z3190s6.pdf [Accessed: 16 January 2019].

JONES P. (2013). Design for Care: Innovating Healthcare Experience, New York: Rosenfeld Media.

KIM K. (2016). 'Wayfinding Design for the Amherst Senior Centre', Studies in Health Technology and Informatics, pp. 624-625 [Online]. Available at: https://europepmc.org/abstract/med/27534358 [Accessed: 14 January 2019].

LEVINE D. (2003). Universal Design New York [online]. IDEA [Online]. IDeA Publications. Available at: http://www.nyc.gov/html/ddc/downloads/pdf/udny/udny2.pdf [Accessed: 14 January 2019].

MARQUARDT G. (2011). 'Wayfinding for People with Dementia: A Review of the Role of Architectural Design', HERD, 4 (2), pp. 75-90 [Online]. Available at: https://journals.sagepub.com/doi/10.1177/193758671100400207 [Accessed: 13 January 2019].

MOLLERUP P. (2013). Wayshowing > Wayfinding, The Netherlands: BIS Publishers.

MORAG I., HEYLIGHEN A. and PINTELON L. (2016). 'Evaluating the Inclusivity of Hospital Wayfinding Systems for People with Diverse Needs and Abilities', Journal of Health Services Research & Policy, 21 (4), pp. 1-6 [Online]. Available at: https://journals.sagepub.com/doi/abs/10.1177/1355819616642257 [Accessed: 12 January 2019].

PASSINI R. (1980). Wayfinding in Complex Buildings: An environmental analysis, Man-Environment Systems.

PASSINI R. (1984). Wayfinding in Architecture (Environmental Design Series V. 4), Somerset: John Wiley & Sons Inc.

ROOKE C.N., KOSELA L. and TZORTZOPOULOS P. (2010). 'Achieving a lean wayfinding system in complex hospital environments: Design and Through-life Management', pp. 233-242 [Online]. Available at: http://eprints.hud.ac.uk/id/eprint/25930/1/2010_Acheiving_a_lean_wayfinding_syst_in_complex_hosp_envs.pdf [Accessed: 14 January 2019].

SADLER B.L., DU BOSE J. and ZIMRING C. (2008). 'The Business Case for Building Better Hospitals Through Evidence-Based Design', HERD, 1 (3), pp. 22-39 [Online]. Available at: https://journals.sagepub.com/doi/pdf/10.1177/193758670800100304 [Accessed: 13 January 2019].

SHORT E.J., REAY S. and GILDERDALE P. (2017). 'Wayfinding for health seeking: Exploring how hospital wayfinding can employ communication design to improve the outpatient experience', The Design Journal, 20 (1), pp. 2552-2568 [Online]. Available at: https://www.tandfonline.com/doi/abs/10.1080/14606925.2017.1352767 [Accessed: 11 January 2019].

THE GUARDIAN. (2015). Getting lost in hospitals costs the NHS and patients, Available at: https://www.theguardian.com/healthcare-network/2015/mar/05/lost-hospitals-costs-nhs-patients-navigation [Accessed: 14th January 2019].

THOMPSON D. and HAMILTON D. (2012). 'Guidelines for intensive care unit design', Critical Care Medicine, 40 (5), pp. 1586-1600 [Online]. Available at: https://journals.lww.com/ccmjournal/Fulltext/2012/05000/Guidelines_for_intensive_care_unit_design_.26.aspx [Accessed: 15 January 2019].

WRIGHT P., HULL AJ. and LICKORISH A. (1993). 'Navigating in a hospital outpatients' department: The merits of maps and wall signs.', Journal of Architectural Planning and Research, 10 (1), pp. 76-89 [Online]. Available at: http://psycnet.apa.org/record/1993-34970-001 [Accessed: 16 January 2019].

AN INVESTIGATIVE STUDY INTO THE DRIVERS FOR FINAL YEAR ARCHITECTURAL TECHNOLOGY STUDENTS FOR CHOOSING SUSTAINABILITY OR REUSABLE MATERIALS IN PROJECTS TO BENEFIT SOCIETY

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Abstract. Sustainability in education can only be proven if the theory is put into practice. Within the undergraduate university world, the nearest place to real life practice is the final year design project and accompanying technical report. Students in this stage of the Architectural Technology course at Coventry University are given the freedom to choose their own project and providing the challenges are of an acceptably high level they will be approved and thus fully encompassed in a design and research collaborative outcome. There are several ambitious sustainability challenges that regularly occur in technical research projects, such as, thermal conductivity improvements, maximising natural light into buildings and the use of timber in replacing steel or concrete. These projects usually have a similar output in each academic year, but occasionally there are projects which can inspire and start to enhance the world we live in. This paper investigates the current dwelling design for replaced slum inhabitants and a sustainable solution to building millions of new dwellings for the emerging Indian population. Current sustainable methods and technologies that can be incorporated will be investigated, but also to determine through an interview process why the student chose the topic and how earlier teaching of sustainability throughout his course has acted as inspiration.

Keywords: Architectural Technology, Education, Urban design, Sustainability, Re-usable Materials.

1. Introduction

Education within the Architectural Technology course at Coventry University has provided a basis that covers many aspects of both design and sustainability. This is covered in many formats from lectures, seminars, tutorials and laboratory work (Bibbings et al, 2017) together with student design competitions (Bibbings et al, 2018) and other working learning methods.

However, as educators we can deliver what we think students should learn to prepare them for their future careers, however it is essential to gauge how effective these methods have been and how much additional ‘own’ study, motivation and interest played a part in their development. The overall outcome from this research can help assess and review the value of content in the area of sustainability.

This paper focusses on a specific student, and, through an interview process determine how much of an influence his previous learning had on his final project and choice of dissertation as well as gain an understanding of how he chose to demonstrate this approach. This will enable a greater reflection from the staff involved as to the value of sustainability education throughout the course and to enable both staff and students to reflect on how their choices shape both their own future and that of others in the worldly context.

The necessity for this topic and understanding the impact of the final student project outcome will be explored further. Appreciating the position slum clearances hold in today's world and the current slum urban plan and those clearance developments that have gone before. This will be explored as a fundamental base knowledge in order to assess effectiveness of the final student project.

The results for this paper can be assessed by how the education has influenced the student to develop and drive the subject to achieve a project that can impact real life whilst providing a holistic sustainable approach. It is anticipated that this paper can open the need for this subject to be addressed by the wider academic community and for those persons, as educators, to consider undertaking themselves.

2. Literature review

2.1. SUBJECT BACKGROUND

It is imperative to appreciate that slums or informal settlements are not contained to one part of the world, they are wide spread (Roy, Et al, 2017) and becoming more of an issue in the expanding urban structure that the world is moving into, although it is admirable to attempt to replace all slums, it is accepted that upgrading slums is a priority for sustainable development (Meredith, 2016) worldwide. Slums are unauthorized and illegal structures, where inhabitants do not have legal title to the land that they occupy (Zhang, 2017). The New Urban Agenda adopted by the United Nations (UN) aims at upgrading slums and granting slum dwellers access to safe and affordable housing with basic service by 2030 (United Nations, 2017).
However, slum redevelopment in India is slow and fraught with controversy, the government currently refutes the high credibility of slums (Zhang, 2017), in fact, the government of Maharashtra has set a goal to make Mumbai slum-free by 2022.

Nairobi slum dwelling population (already 60% of population) is growing and likely to double within 15 years (UN-Habitat, 2011), the problem is right now and solutions must be sought by the next generation of professionals coming out of universities across the world.
The need to develop the solutions as an urban and building plan are essential, projects previously focusing on housing only have been known to fail (Muraya, 2006) and thus addressing the urban area as a whole must be considered.

Currently slum households lack one or more of the following conditions a) security of tenure; b) structural quality; c) durability of dwellings; d) access to safe water; e) access to sanitation facilities; (Roy, 2014) all of these need to be combined in a clearance project to achieve a successful solution. To provide an ideal solution the spatial patterns of slums in cities have to be explored (Friesen et al, 2018) and thus the urban plan. Often, services, facilities and town planning are not considered due to assumption that informal settlements disband in a relatively short time, however as they continue to grow this assumption could be considered as false.

Uddin (2018) highlights how slum dwellers experience a range of substandard, overcrowded and unhealthy housing conditions plus insufficient health, sanitation, water and waste disposal. This added to the insecurities of women, drug dealing, eviction and natural disaster. The Holistic approach must be undertaken to tackle these outcomes.

With this holistic approach in mind, the needs of local materials, recycled and re-use of materials in small and large scale development are a key strategy, again taken on board for the final outcomes of the paper. Hannula & Lalande (2012) consider low cost housing schemes and relate construction materials and simple technologies that can be used, such as, bamboo, timber, adobe bricks, compressed earth bricks amongst others.

Urban plans and images are provided to gain an understanding of the urban plan, construction and street scape of existing slum clearance projects and current slum conditions.

Figure 1 - Partial View of Site Plan of Auto-Constructed Houses and Lots Prior to Physical Regularization, Vila Radiante, East District, Porto Alegre. Sources: Municipal Housing Department eDEMHAB. Prefeitura Municipal de Porto Alegre. Physical regularization project by architect Sonia Maria da Silva. Edited by Ana Paula Pimentel Walker and Julia Yang (Walker, 2016).

Figure 2 - High quality auto-constructed homes preserved in the participatory slum upgrading process, Vila Radiante, East District, Porto Alegre. Photo credit: Ana Paula Pimentel Walker (Walker, 2016).

Figure 3 - the "formal city" and the "informal city" in Mumbai. (Zhang, 2017).

Figure 4 - An aerial view of the resettlements at Dummingkuppam settlement (Chakravarthy, 2014).

3. Background of education

Sustainable and environmental awareness is delivered in variety of ways; laboratory-based learning, lecture based learning and project based learning. The success or otherwise of the integration is measured by the students' abilities to incorporate both consciously and subconsciously the learning into their work (Bibbings et al 2018).

The greatest goal of this achievement in education is that given the opportunity to choose any subject related to the industry, they pick a sustainable project to explore on their own accord. This paper explores this choice theory and the outcomes and if the educational background has enabled a successful and meaningful project to be undertaken.

The final year of study provides a large-scale design project with accompanying technical report, as such the topic is explored in some depth over a whole academic year. For this, we are using this studio based approach, however there are other subjects being taught simultaneously using more traditional construction teaching methods with large scale theatres and tutorials.

In years 1 and 2 they get the foundation of their learning, this is outlined in depth in the Bibbings (2018) paper Striving for Sustainability; A staff and student approach, SDBE Conference 2017. An outline of this paper would include a series of small lectures about the importance and ways of thinking about daylighting, sunlight and shading as well as the position of the building on site and analysis of site conditions. Many briefs contain sustainable material requirements as a standard output. In year 2 this is built upon with a BREEAM Approved Graduate qualification and architectural industry practices as it allows the ability 'to drive sustainability across the built environment and on a global scale". The final outcome of their taught and professional certification content in year 2 requires them to integrate their

findings into a low energy commercial design project, which links the learning across all modules.

Linking knowledge in year 3, the students are expected to incorporate their learning into their project in a very visible way together with consideration of materials, site and surroundings which by now are standard practice.

4. Methodology

Although the problem of slum clearance is much greater than can be achieved by a student alone, this very real sustainable and social problem is being assessed with a student solution based on the sustainable education provided. The educational journey to a graduate has now arrived and we can look back on the successes and what have driven those successes plus detailing what areas may need to be improved. This will be assessed by interview with some led questions to keep the topics at hand, however it is essential that responses are not guided and thus forth given by honest opinion. The journey to this outcome, within the architectural technology degree program is vital to achieve a design project and accompanying technical report of a high enough standard for it to be realistic and accepted by the professional architectural practice standard, these are only achievable with a student with some experience in professional practice and skilled enough to undertake such a challenging brief.

5. Project outcomes

The title of the project was ‘a systematic sustainable solution to the slum clearance in India’ with a real life site for the design project provided by the Tamil Nadu Slum Clearance Board in India.

Sustainable design is usually less strict and clear. Most of the time it indicates to reduce the environmental impact through design (Hernandez, Kremer, L.C. Schmidt, & Herrera (2012). Though a sustainable design has a good intention, the usage of local, natural and renewable resources, and making sure that the future generations can enjoy a “good” quality of life (Felce & Perry, 1995). It is important to understand that sustainable development has environmental, social and economic factors also (Jones & Evans, 2013).

Estimates show that about one-third of the population that live in large cities live in slum or slum-like conditions (Swami, 2017). During the research, the causes for the growth of slums or the origin of slums are identified as follows:

- Industrialisation and consequent migration of rural masses to urban areas.
- Lack of employment opportunities and livelihood resources in rural areas.
- Absence of adequate facilities in the urban area
- Low wages
- Ineffective land reforms (Swami, 2017)

Though, there are slum redevelopment projects in India, the primary concern about approaching these slum developments are mostly financial factors, which will attempt to be proven in the case study of Dummingkuppam Resettlement, Chennai, India (figure 4). This results in compromising other two factors of sustainability that have been identified through the introduction: environmental and social factors.

A discussion which involves about the sustainability of landscape, infrastructure, construction of dwellings and introduction to active hubs will be discussed. The usage of renewable materials i.e. recycled or reusable materials may bring down the cost and the negative impact on the environment. There will be research study about similar materials such as 'Banana Leaf sheath', 'Rice Husk Particle Board', 'Bagasse Board' and 'Used Shipping Containers'.

To summarise the research problem, the reason behind the lack of sustainability of slum redevelopments in India and a solution to this problem will be provided through a detailed analysis about sustainability and its challenges.

People not only influence but change the environment as well as it influences and changes them. Hence, it is always a two-way process in which people get influenced in different ways by the spaces they create and modify (Carmona, Tiesdell, Heath, & Taner, 2010). Recognising the relationship between the environment ('space') and people ('society') is an important component for urban planners to design and reach the maximum of the social sustainability in a built environment. Defining the essential human needs have been identified as follows (Carmona, Tiesdell, Heath, & Taner, 2010):

1) Physiological needs – for warmth and comfort.
2) Safety and Security needs – to avoid harm
3) Affiliation needs – belong to and accept a community
4) Esteem needs – to feel valued by others
5) Self-Actualisation needs – artistic fulfilment and expression

Following the case study of the existing Dummingkuppam slum resettlement, people deserve an alternative approach that is more sustainable and the quality of their life needs to be the primary motivation for urban designers. This can be achieved by the following factors.

- Landscaping
- Transport Infrastructure
- Water Infrastructure
- Energy Infrastructure
- Solid Waste Infrastructure

Introduction of Active Hubs, which are multifunctional community buildings designed for people who live in an unsafe, monotonous, single/double storey environment. These active hubs are equally distributed all over the site within a 200m radius on an open space with an elevated view point, making it visible from long distances. The buildings are connected to well-linked routes, easy to access and act as the centre point of different zones. Inclusive planning and designing of the buildings can ensure the participation and involvement of the public throughout the design and development process, and the integration of groups provides a sense of belonging and ownership to the people which also stimulates social cohesion (Violence Prevention through Urban Upgrading, 2017).

The construction of dwellings also plays a vital role in improving the overall sustainability of the development. The construction of these dwellings can be made sustainable with the introduction of renewable materials which includes reusable and recycled materials, and with water-efficient construction practices.

Figure 5 - Community Hall by TNSCB in Thiruvottiyur, India (Tamil Nadu Slum Clearance Board, 2017)

Figure 7 - Distribution of Active Hubs within 200m radius, Illustrated by Kunalan Siddharthan

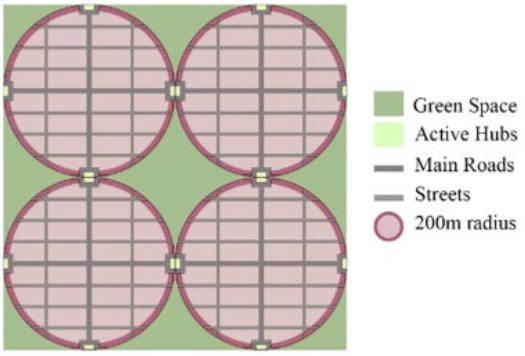

Figure 6 - Active Box by VPUU in Cape Town, South Africa (Violence Prevention through Urban Upgrading, 2017)

5.1. RECYCLED MATERIALS

This material research explains a few materials that are recycled from biological waste, and that can be substitutes to the present construction materials.

5.1.1. Banana Leaf Sheath

Banana leaf sheath is a waste from banana plantation that rots and is considered a nuisance value. Technology has been established to develop particle boards from this waste which can be used a ceiling tiles, door infill etc. This usage will decrease the demand for wood while using a biological waste simultaneously. This would also produce further income to the farmers who cultivate banana plantation (Indian Plywood Industries Research & Training Institute, 2018).

5.1.2. Rice Husk Particle Board

Rice husk is one among the most abundantly available agricultural residues. 2 million tonnes of rice husk are available in the country per annum. Multi-layered particle boards with the help of modified phenol cardanol formaldehyde resins, and it meets the requirement as per relevant specifications. This usage of rice husk particle boards prevents deforestation. These boards process high termite decay and fire resistant (Indian Plywood Industries Research & Training Institute, 2018). These boards can be used as perimeter/ internal lining boards, and as ceiling tiles.

5.1.3. Bagasse Particle Board

Bagasse is the residual pulp that is left after the extraction of sugarcane juice. India is the largest producer of sugar in the world, however, it stands 14th on the utilisation of bagasse for paper making since most of this waste is used as a ‘fuel’ and burnt in sugar mills. This waste is manufactured as particle boards which emit less formaldehyde and also fulfils the requirement of strength properties as per IS: 3087- “Specification for medium density particle boards” (Indian Plywood Industries Research & Training Institute, 2018). These boards can be used as door panels with veneer finish and other finishing materials such as skirting, cill boards, etc.

5.1.4. Used Shipping Containers

Shipping containers range in size starting from 20’ x 8’ container. A typical ISO shipping container is made up from weathering steel as specified within BS EN 10025-5:2004, this steel is also known as ‘Cor-ten®’ steel which is a trademark. Cor-ten steel is corrosion resistant and have properties comparable with those of grade S355 steels to BS EN 10 025, thus they do not need any additional coating to prevent from rusting or deterioration of the material. These shipping containers contain floors made up of planking wood or plywood, which is strong and durable, and can be reused if needed (Residential Shipping Container Primer, 2017). When they are stacked on top of each other, the shipping container or the Intermodal Steel Building Unit (ISBU) becomes affordable housing (Martinez-Garcia, 2014). These shipping containers can be stacked and the internal partitions can be amended to suit the plans, and the deconstructed partition lining can be reused as roof liners. When these containers are stacked

on top, they can be supported by timber beams to create a void in order to allow for MEP services.

5.2. PROPOSAL OUTCOMES

Figure 8 – perspective view of 1 and 2 bhk dwellings

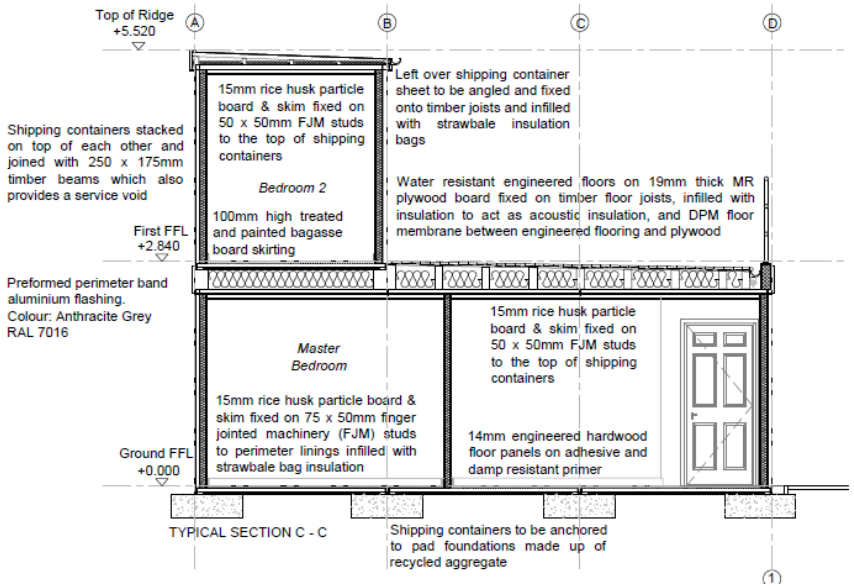

Figure 9 – Detailed section of the shipping container dwelling incorporating all sustainable products

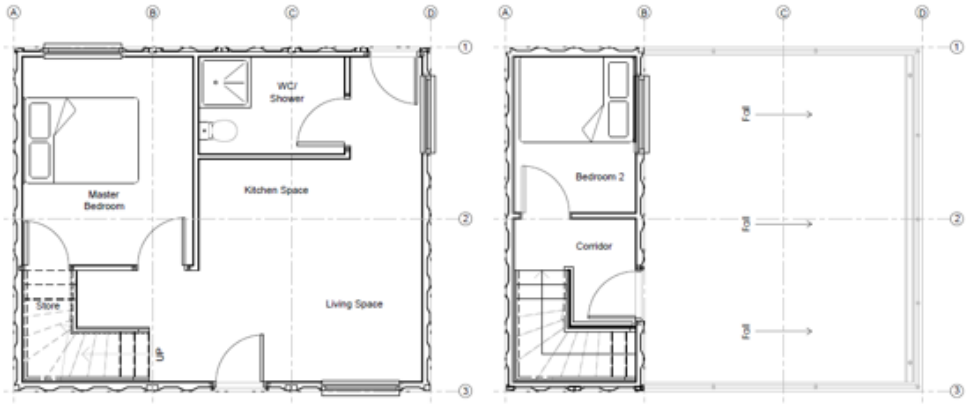

Figure 10 – typical plan of a two-bedroom dwelling.

6. Reflections

6.1. TUTOR REFLECTIONS

As educators it was essential to understand how the holistic learning of our sustainability across several modules comes together in the whole learning of the final graduating student. Has this student understood the fundamentals and more importantly do they understand how this can be implemented into a world that needs complex solutions right this minute, not in 30 years' time.

Discovering the learning that has influenced key challenges that are universal (such as the sustainable development goals) that our professionals of the future can incorporate and learning what is working well and building upon that is key.

The selection of work produced overall by the student herewith in this paper is limited, and shows an outline of the achievements that relate to the paper to give an overview. The materials and the detailing to make them operational as shelter and accommodation architecturally is admirable for the level of development expected at this time. This provides a timely reminder that the efforts of the educators of tomorrow are not wasted and the new professionals entering the world are aware of their surroundings and how they can make an impact in the world.

6.2. STUDENT REFLECTIONS

The motivation of the project came from a real life situation and a real life challenge, because when you go there and see the real people that live there its really dreadful, it is completely unhygienic and you wouldn't want to stay there for a minute! So, I was really motivated to help change how they live when it comes to hygienic conditions and the like. I experienced slums for the first time as a 9 year old in Chennai, the smell was awful.

My Dad was a civil engineer which led me to study Architectural Technology which has equipped me to meet some of the challenges to improve the lives of these slum dwellers. Understanding the detailed connections and complicated solutions helps enormously and once

I undertook the architectural development and planning module in the second here I learned to how to plan and develop as a landscape and not just individual buildings.

Overall the course has taught me well with construction technology, design studies, architectural development and planning, architectural design and practice part 1 and 2 together with detail design. In fact, I cannot pick just one it was everything combined that contributed to a sustainable project. Within one of these projects we undertook a project to reuse a shipping container which has inspired and led me to my project and the importance of materials within construction, the course as a whole has provided me with a knowledge of how to put these sustainable and reusable materials together.

My architectural technology development has also been aided with a year out placement which focused me on the role of the architectural technologist and other roles such as clients, sub-contractors, etc.

If I was to start this again, I would not change any of the design or materials outcome which was highly researched but I would improve my time management.

I feel that the education provided has provided me with a substantial foundation that, at this moment in time I cannot find any fault, I can only say positives about the approach and teaching strategies provided.

7. Conclusions

It can be concluded that our holistic approach has driven the strong sustainable ethic that can deliver solutions for real life problems such as slum clearances, there is a clear distinction in that several individual taught modules education have been combined and thus enabling the student to reach his potential which with further development could be executed in a real world scenario.

The final outcomes of the technical report and design project are a substantial piece of work and not appropriate to showcase within this paper, however the overview provided will give an indication of how the challenge was taken up, met and delivered a solution to a problem, within the boundaries of the higher education system in the United Kingdom (UK).

The successes of this project should be used as a spring board for further projects, developing the solution further and going forward it is imperative to reflect more closely on the importance of the year out placement in the education and development of choosing sustainable projects, if this is an anomaly of higher level sustainability plus developing the slum clearance project to provide this type of accommodation as a real life solution to slum clearance and the benefits, what or /if any are provided in the short, medium and long term future.

References

BIBBINGS, H, BIELUGA, P., MILLS, C. (2018). Enhancing Creativity and Independent Learning of Architectural Technology Students through the use of a Real Life Design Competition Module. Archnet-IJAR, 12(1): p. 376-387.

BIBBINGS, H AND BIELUGA, P. (2017). Enhancing Creativity and Independent Learning of Architectural Technology Students through the use of a Real Life Design Competition Module. Proceedings of 33rd PLEA International Conference 2017 Design to Thrive, Volume 2, July 2-5 2017, Edinburgh, Scotland.

BIBBINGS, H, MILLS, C AND BIELUGA, P. (2017). Striving for Sustainability; A staff and student approach. Proceedings of SDBE Conference 2017, December 2017, London, UK.

BOGDANOVIC, A., AUSTIN, S., AND BIBBINGS, H. (2016). A comparative case study of online international learning in architecture and construction education Proceedings of COBRA 2016 – Innovation, Practice and Research in Engineering Education, Sept. 19-22 2016, Toronto, Canada.

CARMONA, M., TIESDELL, S., HEATH, T., & TANER, O. (2010). Public Places Urban Spaces (Second ed.). Oxford: Elsevier.

ELSHARKAWY, H., AND ZAHIRI, S. (2017) Education for Sustainable Development of the Built Environment: Problem-Based Learning Approach for Embedding Sustainability, Passive and Low Energy Architecture (PLEA), Volume II (pp. 831-838). Edinburgh, United Kingdom, 3-5 July 2017.

FELCE, D., & PERRY, J. (1995). Quality of life: Its definition and measurement. Research in Developmental Disabilities, 16(1), 51-74.

FRIESEN, J., TAUBENDOCK, H., WURM, M., PELZ, P.F., (2018) The similar size of slums. Habitat International 73 (2018) p. 79-88.

HANNULA, E. & LALANDE, C., (2012) Going green: A handbook of sustainable housing practices in developing countries. Nairobi: UN Habitat.

HERNANDEZ, V., KREMER, O., L.C.SCHMIDT, & HERRERA, A. (2012). Development of an expert system to aid engineers in the selection of design for environment methods and tools. Expert Systems With Applications, 9543-9553.

INDIAN PLYWOOD INDUSTRIES RESEARCH & TRAINING INSTITUTE. (2018, February). Wood Composites. Retrieved from Indian Plywood Industries Research & Training Institute: http://www.ipirti.gov.in/woodcomposites.html

JONES, P., & EVANS, J. (2013). Urban Regeneration in the UK. London: Sage Publications.

MARTINEZ-GARCIA, M. (2014). Alternative Housing - The Shipping Container Home. Illinois: National Association of Realtors.

MEREDITH, T., MACDONALD, M. (2016) Community-supported slum-upgrading: Innovations from Kibera, Nairobi, Kenya. Habitat International 60 (2017) p. 1-9.

MURAYA, P.W., (2006) Failed top-down policies in housing: The cases of Nairobi and Santo Domingo. Cities, 23 (2), p. 121-128.

ROY, D., LEES, M.H., PALAVALLI, B., PFEFFER, K., SLOOT, P.M.A., (2014) The emergence of slums: A contemporary view on simulation models. Environmental Modelling and Software 59 (2014) p. 76-90.

ROY, D., LEES, M.H., PFEFFER, K., SLOOT, P.M.A., (2017) Spatial segregation, inequality, and opportunity bias in the slums of Bengaluru. Cites, 74 (2018) p. 269-276.

SALAMA, A (1995) New Trends in Architectural Education: Designing the Design Studio. Raleigh, N.C.

SWAMI, S. K. (2017). An Empirical Study of Growth of Slum Population in India. International Journal of Political Science, 10-13.

TAMIL NADU SLUM CLEARANCE BOARD. (2017). TNSCB Tenemental Photos. Retrieved from Tamil Nadu Slum Clearance Board: http://www.tnscb.org/tnscb-tenements-photos/

UDDIN, N.N (2018) Assessing urban sustainability of slum settlements in Bangladesh: Evidence from Chittagong city. Journal of Urban Management 7 (2018) p. 32-42.

UN-HABITAT. (2011) UN-habitat and the Kibera slum upgrading initiative.

UNITED NATIONS (2017). New Urban Agenda. Habitat III, Nairobi. http://habitat3.org/wp-content/uploads/NUA-English.pdf (accessed 10 June 2018).

WALKER, A. P. P., (2016) Self-help or public housing? Lessons from co-managed slum upgrading via participatory budget. Habitat International 55 (2016) p. 58-66.

BIM MANAGER, COORDINATOR, CONSULTANT, ANALYST…, WHAT DOES A CONFUSED AEC INDUSTRY NEED?

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Abstract. The rapid growth of Building Information Modelling (BIM) in the Architecture, Engineering and Construction industries since its introduction around 2002 has highlighted a skills shortage within the industry whilst also leading to some confusion over the roles involved with BIM, particularly the BIM Manager. These factors can make recruiting the perfect BIM Manager difficult; especially with evidence also suggesting retaining personnel is a problem with many averaging less than two years per post before moving on. These issues are down to the industry having poor awareness of the skills and expertise BIM Managers can provide. This paper seeks to investigate the requirements for becoming a BIM Manager in terms of experience, training, skills and knowledge, whilst also assessing the different responsibilities between the various BIM management roles currently being used within the UK Construction Industry in order to clarify the current confusion.

The investigation employed two research techniques. First, a comprehensive literature review that reviewed BIM roles and responsibilities at both project and corporate levels, before examining the characteristics of what is required to work with BIM. Second, a quantitative research survey that involved extracting key information from 25 BIM related job adverts that were posted throughout this study. The extracted data was then analysed to determine what is expected of potential BIM Managers in terms of education, working experience and skills. By comparing the findings of the two research techniques, it was possible to define what it takes to become a BIM Manager, whilst also separating responsibilities between management levels.

The findings of this research culminated in defining a Project BIM Manager Job description/advertisement that responds to industry requirements. This job descriptor features the optimised role responsibilities at an SME alongside improved academic, professional and competency requirements that should lead to a higher quality recruitment process for employers.

Keywords: BIM Manager, Role, competency, job descriptor.

1. Introduction

Building Information Modelling (BIM) is a process for creating and managing the information on a construction project across the whole lifecycle, enabling much greater collaboration between all the parties involved. The concept of BIM has existed from the 1970s however, it

was not until the early 2000s that it started being further developed and used within the Architecture, Engineering, Construction (AEC) industries where it has since proved to be a valuable tool when properly utilised.

Due to this rapid rate of BIM adoption along with its complex nature and ever-increasing potential there is a severe skills shortage (BRE Academy, 2016b) which follows Smith and Tardif's (2009) statement "it is expected that the demand for highly skilled design specialists will outstrip supply over the next 20 years". Despite the skills shortage there has still been a host of specialised BIM related job titles created, such as BIM Modellers, BIM Analysts, BIM Facilitators, BIM Co-ordinators, BIM Consultants and BIM Managers to name a few (Barison & Santos, 2010) but there is no published guidance on the responsibilities related to these roles. Instead they have always been decided by the hiring company, which will be dictated by its area of expertise and size. With all these roles, and many more such as the Information Manager (CIC, 2013) and the Project Information Manager (BSI, 2013), there are inefficiencies in the industry from overlapping roles and confusion of who does what?

Over the last 17 years, BIM has been developing at a quick pace and has since reached a point in the UK where BIM level 2 is mandatory for all public sector projects from 2016 (Cabinet Office, 2011) whilst also becoming a preferred route for private sector companies as well (Philip, 2013). This means companies within the construction industry who wish to be involved in large-scale projects need to be BIM competent; however, the rush to get to that stage has left a cloud of ambiguity over BIM related job titles and the responsibilities associated to each.

Information published with regards to BIM roles and responsibilities can also be very generic (some purposefully for broader coverage) and therefore does not suitably cover the varying scales of businesses which has a large impact on the distribution of responsibilities within it. There is also insufficient guidance on the skills and competencies required to be a successful 'BIM Manager' which leads to skill shortages through lack of training, poor recruitment practices and potentially a high turnover in personnel.

An extensive literature review identified the following as clear gaps to fill:

- What should the roles and responsibilities be when using BIM and how does the size of the project and/or organisation affect this?
- How can competent individuals be identified for these roles and what experience and skill levels must they have?
- Do the current sources of BIM education provide sufficient levels of learning for individuals to enter the industry and, if not, what are the gaps?
- Should the project BIM Manager be hired independently by the client or are they best employed by the main contractor?
- Could project level BIM management ever become part of general project management responsibilities or should/will it always be a specialised area?
- Would regular built environment clients benefit from greater consistency in BIM role titles and responsibilities, such as increasing their understanding of the BIM Execution Plan (BEP)?
- How can industry recognised guidelines & definitions be put in place that separate the project model development BIM management roles and responsibilities with those responsible for the overall implementation and strategic management of BIM within an organisation?

- Where can industry codes and standards be improved to provide better guidance to all these questions?

The aim of this paper is to identify the key managerial roles and associated responsibilities required from a BIM professional on both a corporate level and an individual project in order to a better and clearer implement of BIM. This aim is set to be achieved through the following objectives:

- Provide a comprehensive review of the various roles, responsibilities and requirements associated with BIM projects within the UK Construction Industry;
- Distinguish between the various roles of BIM users, with a particular focus on management positions in order to determine their specific responsibilities on individual projects considering both SME and large organisations;
- Determine the requirements for becoming a BIM Manager in terms of experience, training, skills and knowledge;
- Assess different responsibilities between various BIM management roles currently being used within the UK Construction Industry;
- Collate the key findings of the research in order to provide guidance on the key managerial roles and the associated responsibilities.

2. Background

For the AEC industries, today's digital era means technology is now the ideal platform for creating, managing and storing their data. The introduction of BIM is one of the most important and promising developments for these industries because of the unique, effective and efficient collaborative approach it brings throughout each project lifecycle (BIM Task Group, 2013c; RICS, 2014; Ghaffarianhoseini et al., 2017; Lester, 2017).

To justify some of the true benefits of using BIM tools and processes, BIM enables immediate and accurate comparison of different design options (Ghaffarianhoseini et al., 2017), the parametric features enable systematic and simultaneous changes to all linked components. The details of the change, as well as the author, date and time are recorded enabling the design at any point in time to be rolled back to a previous configuration resulting in BIM having a very rigorous design change control system (Crotty, 2012). BIM can also facilitate various design and construction simulations such as the analysis and comparison of energy performance options to help managers reduce their environmental impacts and operating costs (Haines, 2016).

2.1. EVOLUTION NOT REVOLUTION

As of its introduction around 2002, BIM remains one of the most recent acronyms to appear within the AEC industries (Race, 2013) however the concept of BIM is not new with Eastman et al. (2008) referring to an article called "Building Description System" published in the now defunct AIA Journal by Charles Eastman in 1975. This article described elements and processes such as "interactive defining elements", "any change of arrangement would have to be made only once for all future drawings to be updated", "cost estimating or material quantities could be easily generated" and "contractors of large projects may find this representation advantageous for scheduling and materials ordering" – all of which are now

routine in today's BIM technology. Prior to this paper though, Barnes & Davies (2015) refer to the true origin of BIM as the emergence of Computer-Aided-Design (CAD) in the 1950's. CAD was originally seen as a fad that wouldn't catch on, but it soon became the standard tool to use in the AEC industries for creating drawings for all sizes of companies and projects (Crotty, 2012). Rutland (2017) and Suchocki (2017) have both reported similar short-term trend doubts have previously been cast about BIM but agree with McPartland (2016a) that BIM isn't a fad and will one day be business as usual just as CAD became.

The development of Bew-Richards' maturity wedge in 2008 brings more explanations of BIM concept not only within the UK but also across the world. There are several versions of that model, one of which is the version published in PAS 1192-2: 2013 (BSI, 2013). The maturity model is presented in figure 1 purely on four levels of BIM maturity.

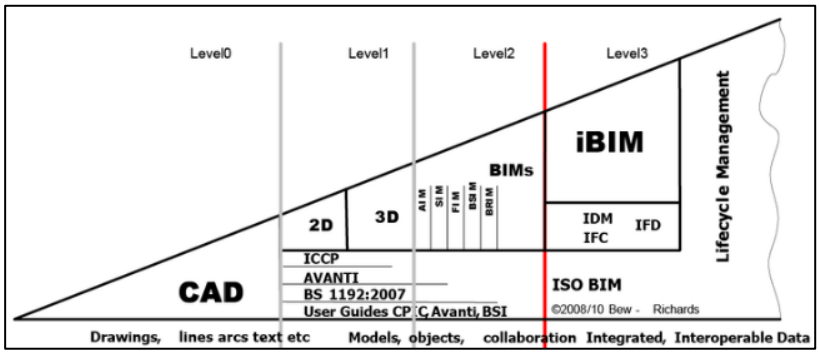

Figure 0.1. BIM maturity diagram (RIBA, 2012; BSI, 2013)

Within the UK, the Government have been one of the major drivers for the increase in BIM adoption. Their 2011 Government Construction Strategy (Cabinet Office, 2011) stated that the construction industry was lagging behind other industries in using digital technology, due to a lack of compatible systems, standards and protocols and the widespread requirements of clients and designers. It then went on to declare that the Government will require a fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) to be used on all public sector projects as a minimum by 2016 for the following reasons:

- The implications of alternative design proposals can be evaluated with comparative ease;
- Projects are modelled in three dimensions (eliminating coordination errors and subsequent expensive change);
- Design data can be fed direct to machine tools, creating a link between design and manufacture and eliminating unnecessary intermediaries; and
- There is a proper basis for asset management subsequent to construction.

Another key objective of the 2011 Government Construction Strategy was reducing capital cost and the carbon burden from the construction and operation of the built environment by 20% and BIM was central to this ambition due to its potential of allowing more efficient ways of working at all stages of the project life-cycle. To help achieve these objectives, the BIM Task Group was formed bringing together expertise from industry, government, public sector, institutes and academia (BIM Task Group, 2013a). As early as 2015, HM Government (2015) reported that their Level 2 BIM programme had already played a significant role in £840 million of savings in 2013/2014. Prior to the 2016 mandate, a suite of BIM standards was

developed as publicity available standards (PAS) to facilitate the implementation of BIM level 2 and lead to level 3 under the remit of the Digital Built Britain Strategy (HM Government, 2015). Furthermore, early adopter departments will be sought to help understand the full potential benefits of BIM Level 3.

Since BIM's introduction in the industry, there have been several research papers and published books that have highlighted the benefits BIM can bring to the built environments design, construction and asset management stages. Table 1 summarises the benefits identified.

TABLE 1. Benefits of BIM from various literature sources

Author / Reference	**Benefits of BIM**
Alreshidi, Mourshed & Rezgui (2017)	- Workers have the flexibility to work from any location and still be heavily involved in the collaborative process. - BIM can be used with Cloud technology for portable access.
Eastman et al., (2008)	- Generate accurate and consistent 2D drawings at any stage of the design. - Automatic low-level corrections when design changes are made. - Identifying clashes in the design before construction. - Improved energy efficiency and sustainability. - Better manage and operate facilities.
Ghaffarianhoseini et al., (2017)	- Substantial technical advance on traditional CAD, offering more intelligence and interoperability capabilities. - Increases knowledge management by enabling more detailed information to be captured and developed in the design stage. - BIM is bringing standardisation benefits through quicker such as exchange standards allowing for better collaboration. - Optimised 4D planning and scheduling through integrated tools. - Visual verification of design intent and knowledge sharing through virtual design and construction increase the clients' satisfaction levels.
Kubba (2017)	- Improved productivity due to easy retrieval of information. - Coordination of the construction reduces construction time and eliminates change orders. - 3D geometry fosters confidence in Prefabrication enabling higher quality, lower labour costs, and accelerated schedules. - Contractor and Subcontractors' costs and risks are reduced. - Embedding and linking of vital information such as vendors for specific materials, location of details, and quantities required for estimation and tendering.
Lester (2017)	- Easier to work with a BIM model and to explore the building in 3D with rich information, than looking at hundreds of drawings and having to understand the industry drawing conventions. - Overall project cost savings.
Zou, Kiviniemi & Jones, (2017)	- Assist in early risk identification, accident prevention and risk communication.

On the other hand, the previous positive examples of BIM just discussed are not guaranteed on all projects involving BIM. There have been cases of 'bad BIM' caused by, amongst others,

contractual constraints, procurement problems and an under-skilled work force. Holzer (2016) compiled a list (Table 2) of common bad BIM pitfalls based on the responses from 40 of the world's leading BIM Managers about what has caused BIM projects to go wrong in their experience. Kubba (2017) also suggests a number of firms using BIM tools are unable to reap the benefits of their investment due to these pitfalls. To address such issues, Kubba (2017) states that it is "strongly recommended to bring on board a new professional with a special role specialising in the application of BIM technology, standards, modelling and who would also undertake the coordination needed in BIM contexts. Such a BIM Manager (the precise title of such a specialist is immaterial) would be an integral part of the project team and would be a small investment compared to the potential benefits".

TABLE 2. - Examples of where BIM can go wrong (Holzer, 2016)

Bad BIM	**Cause and Effect**
Pseudo BIM	Those who use BIM tools simply to produce their 2D documentation more efficiently, but disciplinary coordination or data-integration opportunities are not considered as the geometry is being separated from the intelligent data attached within the models. This lack of information sharing (which is/can be another major issue in itself) can have severe effects on other project members.
No BIM Execution Plan (BEP) or Not Using it Properly	BEP's are an agreed way of working and sharing information therefore not adhering to or the complete lack of one reduces the chance for teams to work synergistically towards common BIM goals.
No Data Integration / Over-modelling	This is defined as either an over-focus on geometric modelling with little to no data attached or when the datasets are developed in parallel to existing BIMs meaning the two remain disconnected allowing for the possibility of misaligned data. Over-modelling with too much unnecessary detail can result in models being too heavy to use.
Lack of Well defined Client objectives	When clients request undefined or even over-specified goals, without an understanding of how the data will be generated, managed and used. This can lead to the project team second-guessing what is wanted.
Lacking tool Ecology	Trying too hard to resolve all design aspects within one model with one software platform whereas using a suite of tools with inter-operability would be a more efficient solution.
Model Inaccuracy	BIM models should be created with construction tolerances in mind however if the modelling is done by users with little knowledge about the specific trade it is unlikely to be considered which could lead to buildability issues on site.
Workarounds	Whilst workarounds can be important in achieving specific goals outside the suggested method, they can become too complicated and designed to only benefit the workaround author, which could negatively affect other authors down the line.

2.2 BIM AT A PROJECT LEVEL: ROLES & RESPONSIBILITIES

There are a number of different roles required to support a project that is utilising BIM. Wienerberger (2017) believes that the most important aspects to consider regarding BIM roles are that they are well defined and that the individuals in those positions are trained, competent and have the correct authority to carry out the role. Thoughts that are echoed by Barison and Santos (2011). People within these positions can have BIM orientated job titles such as a BIM

Modeller, BIM Analyst, BIM Facilitator, BIM Consultant, BIM Technician, BIM Coordinator, BIM Leader, BIM Information Manager and BIM Manager (Barison & Santos, 2010; Joseph, 2011; Mathews, 2015). Whilst other titles such as CAD draughtsman, Revit Modeller, Revit Coordinator, CAD Manager and VDC Manager are also being used (Mathews, 2015; Uhm, Lee & Jeon, 2017). It is important to note that job title is not the key aspect, as these can vary between companies, but it is the roles and responsibilities of each project team member (Uhm, Lee & Jeon, 2017). These should be relatively similar between companies as they are producing a comparable final output whilst following the same BIM focused protocols, codes and standards, especially for attaining BIM Level 2 (BRE Group, 2017).

Tables of agreed roles and responsibilities are normally included in the BIM Execution Plan (BEP) once a prospective supplier has been selected. The post-contract BEP template document available from the Construction Project Information Committee (CPIC, 2017), has a 'role authorities' table (Table 3) and also features a BIM model 'responsibility matrix' where someone is allocated to each of the aspects in table 4 for each stage of the project. It also indicates the software and file formats they will be using for added information.

TABLE 3. Role authorities table from the post-contract BEP template (CPIC, 2017)

Role	Authority
Project Information Manager	Enforce the Project BIM Standard and ensure delivery of the Information requirement in the EIR.
Lead Designer	Enforce spatial coordination
Task Team Manager	Enforce documentation standards
Interface Manager	Negotiate space allocation
Task Team Information Manager	Reject non compliant models, drawings & documents
CAD Coordinator	Enforce CAD related Project BIM Standards

TABLE 4 - Role authorities table from the post-contract BEP template (CPIC, 2017)

Model Authoring	Model Analysis
Space Planning	Brief Development
Site, Urban Design Context	Alternative Design Options Analysis
Site and Existing Buildings	Design Performance Analysis
Architectural Model	Sun and Shadow Studies
Structural Design Model	Structural Analysis
HVAC Design Model	Thermal Simulation
Building Services MEP Design Models	Sustainability Analysis
Lighting Design Model	LCA Analysis
Electrical Design Model	Model Clash Detection Rendition
Hydraulics Design Model	Cost Planning and Control
Interior Layouts and Design Model	Construction Scheduling / 4D Animation
HVAC Fabrication Model	Security Analysis
Structural Steel Fabrication Model	Code Checking and Regulatory Compliance

Curtain Wall Fabrication Model	Acoustic Analysis and Design
Road and Civil Design	Disabled Access and Egress
Landscaping and External Works Options	Fire Protection
Renovation and Refurbishment	FM, Operation and Maintenance
Facility Management Model	Automated/Linked Specifications
Construction Model	Heritage Documentation and Assessment
-	Solar Envelopes
	Over-shading
	Daylight Analysis
	Solar Analysis
	Photovoltaic Collectors

2.3 BIM MANAGER – A ROLE STILL BEING DEFINED

Knutt (2015) and Holzer (2016) both suggest that describing what BIM Managers do is a difficult task. As what was once associated with responsibilities for supervising BIM model development has now become associated with information management, change facilitation, process planning and technology strategies. However, due to the benefit they can bring, AEC companies are continuing to hire BIM Managers even though their precise function and responsibilities frequently require redefining due to the speed at which BIM is evolving (Knutt, 2015; Kubba, 2017).

Scott Chatterton (2015) is a BIM Manager who states “that when I joined my current firm a number of years ago as their first BIM Manager, my role was to develop standards and templates etc. and to maintain those standards, similar to the traditional role of a CAD Manager”. However, he goes on to highlight that as these standards, protocols and processes developed quickly over time his role naturally transitioned to tasks way beyond basic standards maintenance. As the firm’s BIM Manager, he has now implemented BIM processes and strategies that his BIM employees use to facilitate the BIM process throughout all stages of the project. His role as BIM Manager has progressed past the point of maintaining standards to now being responsible for all aspects of BIM throughout the firm. He adds that this is an evolution that never happened as a CAD Manager. Thus, it is not to say that CAD Managers cannot and should not be BIM Managers, it is just to highlight that, additional knowledge and training is required before the official switch in titles should be made (Light, 2013).

3. Methodology

Quantitative research is the primary approach used (UoB, 2017; Liu, 2015). Comparative analysis is focused around real published job adverts in order to determine employers’ sought requirements for a BIM Manager in terms of experience, training, skills and knowledge; and responsibilities that are expected of the BIM Manager role.

The focus on widely used employment website as listed in 3.1 below, instead of AEC specialist, for data sources is intentional. The rationale lies in the fact that some of the skills required for a BIM Manager may come from other disciplines beyond AEC such as IT, data management and manufacturing. Furthermore, a pilot exploration of job websites revealed that job adverts on AEC specialist websites also appear on the ones selected for better reach and

presumably in recognition that the skills sought may come from other unrelated disciplines and professions.

3.1 DATA COLLECTION

Job advertisements come in various forms, sizes and level of detail however, each should at least provide the information in table 5 for potential candidates to base their applications around.

The published job adverts are taken from the online job sites listed below and have been found by primarily using the search term "BIM" along with management titles such as "Manager", "Leader" and "Director".

- Indeed - https://www.indeed.co.uk/ The #1 job site in the UK
- LinkedIn - https://uk.linkedin.com/jobs/ The largest professional social network service
- Monster – https://www.monster.co.uk/ A major UK job site.

TABLE 5 - Information typically found within a job advertisement

	Purpose
Job Title	When creating a job advert this is one of the most important things to get right. The job title should be clear, descriptive and concise in order to make it easier to find for those interested. For example, "Call Centre Worker" is more likely to be a suitable candidate's search term than "Front Line Customer Support Facilitator". (Mills, 2014)
Role Responsibilities	The main tasks the successful applicant will be expected to undertake. They should be related to the company's business objectives so the applicant can envisage how the position fits into the company's plans. (Monster, 2017)
Person Specification	The minimum skills, competencies, qualifications and level of experience the applicants should have. (University of Kent, 2013)
Company Information	Relevant additional information.
Location	
Salary/Benefits etc.	

3.2 DATA ANALYSIS

Each job advert found using the data collection techniques described in Data Collection section had the key information listed in table 5 extracted and entered into a database on Excel which was used to collate information such as the various competencies and skills required.

A range of statistical analyses are then performed on the collated data with the outputs shown through a mixture of graphs and tables. These can be seen in the results and discussions section below.

4. Results and Discussions

A total of twenty-five current BIM related job adverts were reviewed and analysed during this research. A summary of the role being advertised and the employer is given in table 6.
The adverts were found using the search term "BIM" along with management titles such as "Manager" and "Leader". Of the twenty-five adverts reviewed, ten were titled "BIM Manager" with the remaining fourteen all being unique titles as shown by the summary in Table 7.

Despite a relatively small sample size of just twenty-five adverts, the variation in titles highlights that BIM management titles are decided very much on a company basis rather than a standard/common approach.

TABLE 6. List of the job adverts reviewed in this research

Advert	Role Title	Company	Found On
1	Digital Engineering Manager	Balfour Beatty	Indeed.com
2	BIM Manager	Plowman Craven	Indeed.com
3	BIM Manager	WSP	Indeed.com
4	BIM Manager	Galliford Try	Indeed.com
5	UK BIM Manager	Jacobs	Indeed.com
6	BIM Model Manager	MACE	Indeed.com
7	CAD/BIM Manager	Unknown[1]	Indeed.com
8	Programme BIM Manager	Transport for London	Indeed.com
9	BIM Implementation Manager	Interserve	Indeed.com
10	BIM Manager	NG Bailey	Indeed.com
11	BIM Manager	Turner & Townsend	LinkedIn.com
12	BIM Manager	Trant Engineering	LinkedIn.com
13	BIM Manager	Unknown[1]	LinkedIn.com
14	BIM Technical Consultant Manager	Autodesk	LinkedIn.com
15	BIM Manager	Unknown[1]	LinkedIn.com
16	BIM Lead	Unknown[1]	Monster.co.uk
17	Regional BIM Manager	Unknown[1]	Monster.co.uk
18	CAD/BIM Lead	Aecom	Monster.co.uk
19	Principal CAD/BIM Manager	Aecom	Monster.co.uk
20	BIM Manager	Kier	Monster.co.uk
21	Head of BIM - Europe	Multiplex	Indeed.com
22	BIM Mechanical Manager	Unknown[1]	Indeed.com
23	BIM Manager	Waldeck Consulting	Indeed.com
24	BIM/CAD Regional Manager	Unknown[1]	Indeed.com
25	Information Manager	WSP	Indeed.com
Note: 1) Employer unknown as position is being filled through recruitment agencies.			

A total of 29 responsibilities were considered from the literature review and compared with those set out in the twenty-five job adverts. The number of times each responsibility was deemed to match at least one from each advert is presented in Figure 2, with its total occurrences on Figure 3.

The most common responsibility, which was recorded a total of 39 times across 20 adverts highlighted the importance of ensuring all work is performed in line with the company's own protocols. The creation and updating of these internal procedures were also found to be one of the most common responsibilities as it featured on 18 of the 25 adverts. Seven other responsibilities matched on at least 15 of the adverts indicating their importance in the sound management of BIM within a company. These include assisting in the creation of project BEPs, being responsible for staff training, providing technical assurance and keeping up-to-date with the latest BIM news and developments.

TABLE 7. Breakdown of the roles reviewed from the adverts

Title	**Number of Adverts**
BIM Manager	10 (40%)
BIM Implementation Manager	1 (4%)
BIM Lead	1 (4%)
BIM Mechanical Manager	1 (4%)
BIM Model Manager	1 (4%)
BIM Technical Consultant Manager	1 (4%)
BIM/CAD Regional Manager	1 (4%)
CAD/BIM Lead	1 (4%)
CAD/BIM Manager	1 (4%)
Digital Engineering Manager	1 (4%)
Head of BIM - Europe	1 (4%)
Information Manager	1 (4%)
Principal CAD/BIM Manager	1 (4%)
Programme BIM Manager	1 (4%)
Regional BIM Manager	1 (4%)
UK BIM Manager	1 (4%)

All 29 of the responsibilities were matched at least twice over the 25 adverts showing the wide range of tasks a BIM Manager can be asked to do. This agrees with the statements by Knutt (2015) and Holzer (2016) in Section 2.3 that it is now a difficult task to describe what a BIM Manager is, as what was once associated with responsibilities for supervising BIM model development has now also become associated with information management, change facilitation, process planning and technology strategies. To add to this, quite often job adverts will only state the main responsibilities associated with a role, this was the case for some in this research. This means, the number of occurrences recorded for each responsibility in this analysis should be considered as a minimum, as in reality the BIM Manager will be accountable for more than just the main responsibilities advertised.

After all twenty-five job adverts had been processed, the total occurrences of each responsibility and the number of job adverts which featured the responsibility was determined (Figures 2 & 3). This gives a good overview of what the industry is looking for, in terms of

requirements and responsibilities when hiring personnel for BIM management roles without going into the details of each role advertised.

The level of education results is shown in Figure 4, with experience in Figure 5. Education requirements were stated in 16 of the 25 adverts, indicating that for 9 employers the candidates' academic qualifications are not a decisive factor in their recruitment. However, this was found to be not the case for Multiplex, as their Head of BIM position requires potential candidates to have a minimum HND or Bachelor's degree in architecture, engineering or construction along with a BIM related MSc. This was the only request for a postgraduate level degree, whilst there were six adverts that required a minimum undergraduate level degree, seven for HNC/HND and three which specified an industry related degree is desirable but not essential indicating industry experience is of greater importance. These three adverts however, (by Plowman Craven, Galliford Try and MACE) do not properly define their expectations of experience; they instead state that candidates must have a background of working within the construction industry. This, 'appropriate level of experience in a relevant field' requirements matched with another 18 of the 25 adverts, potentially indicating that the majority of employers are unsure what experience level the role requires. However, another more likely reason could be that due to BIM still being a relatively new technology they are aware that very few people will have the 5, 10+ years' experience that is typically required for senior roles in other professions. Balfour Beatty set the most stringent experience requirements found in this research, as they require all Digital Engineering Manager candidates to have a minimum of five years' experience working with BIM technologies, a minimum of five years' experience working as a BIM/CAD Manager and a minimum of ten years' experience working in an Engineering/CAD environment. Two adverts (numbers 7 and 17) which were both posted through recruitment agencies gave no direct experience requirements, however they do state that candidates must have the ability to manage people and have worked with BIM technologies previously.

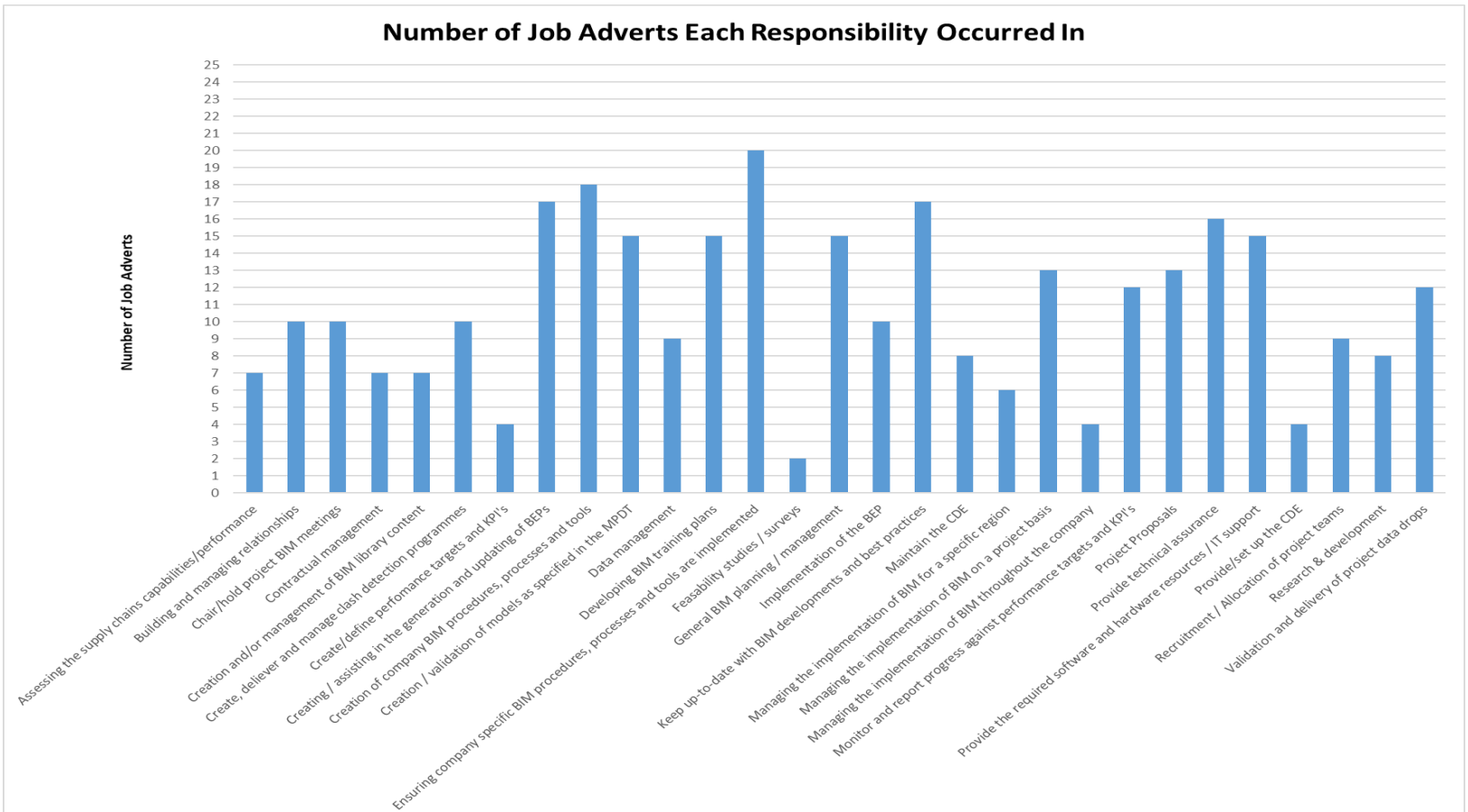

Figure 0.1. Graph showing the number of job adverts each responsibility featured in

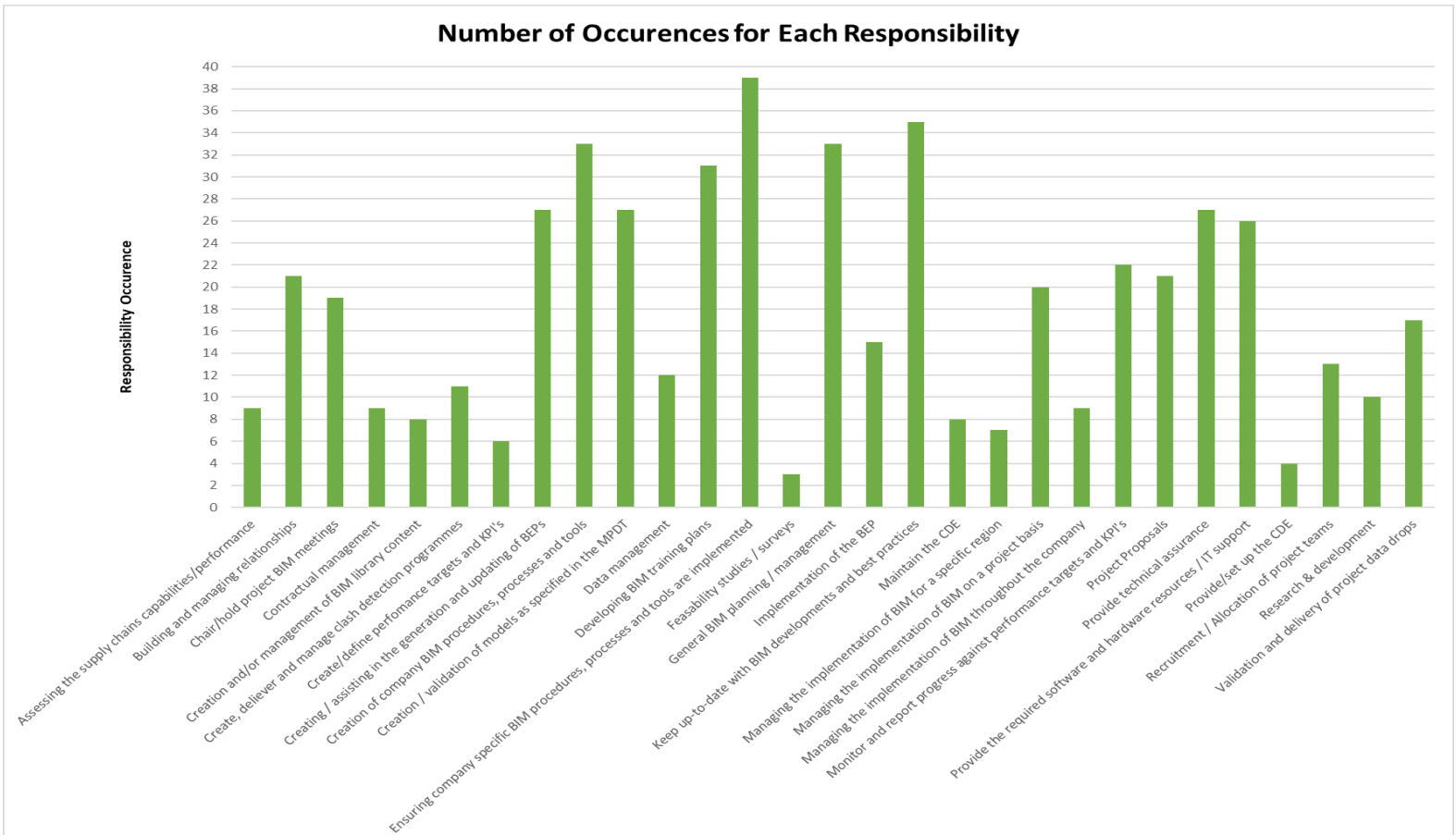

Figure 3. Total number of occurrences of each responsibility in all 25 job adverts

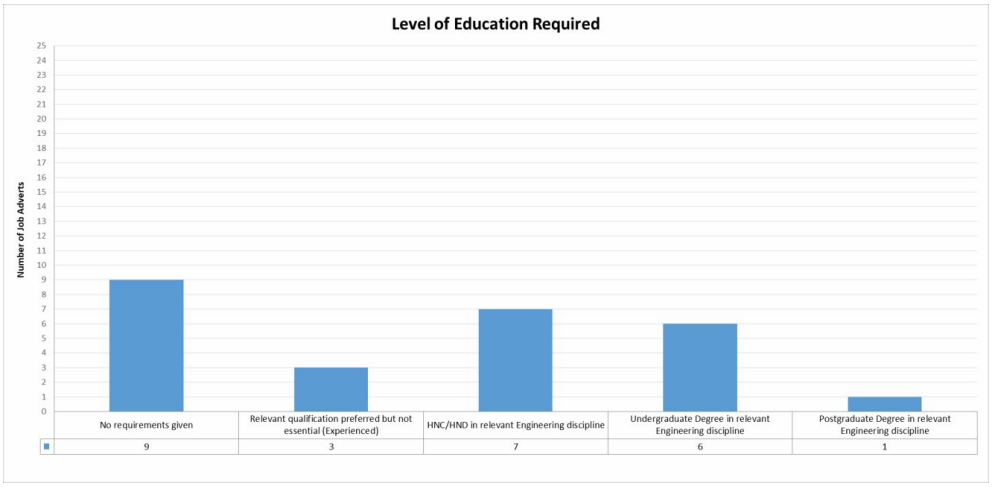

Figure 4 – Level of education required from the 25 job adverts processed

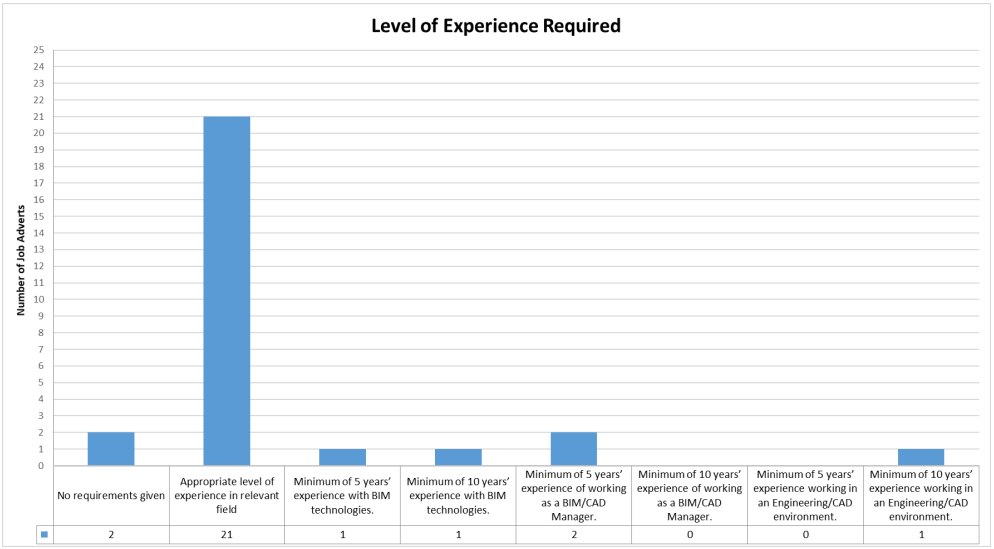

Figure 5. Level of experience required from the 25 job adverts processed

On the basis of information from reviewing the 25 job adverts alongside a comprehensive literature review, a full job description for a competent project level BIM Manager has been defined.

In terms of academic qualifications, they should ideally hold an undergraduate degree in a relatable subject such as architecture, engineering or construction. A postgraduate qualification related to BIM would also be extremely beneficial however, as the relevant courses are relatively new and still being developed, very few candidates will have this, therefore experience can be used instead. It should become an essential requirement in the future when courses have been refined due to closer links between the industry and academic institutions.

Previous experience as a BIM Manager shouldn't be essential when hiring a Project BIM Manager because the skills and knowledge can be found in other BIM users who have had a good amount of exposure to the technology and way of working. Therefore, it is suggested a minimum of 5 years' experience working with BIM technologies along with a minimum of 5 years' experience of working in an engineering/CAD environment would be sufficient industry experience for the role.

A BIM Manager must have a strong range of technical, contextual and behavioural skills and attributes. They need to have knowledge of building designs and the engineering required along with the specialist software packages that are commonly used. Interpersonal skills, like teamwork and leadership are also very important for BIM Managers, as well as the ability to manage resources and projects effectively. Personal attributes such as being self-driven and motivated alongside a genuine enjoyment of the profession is also required for the company to reap the rewards of having a BIM Manager. Results of the 'person specification' i.e. the requirements of technical, contextual and behavioural skills/attributes are presented in figures 6, 7 and 8 below:

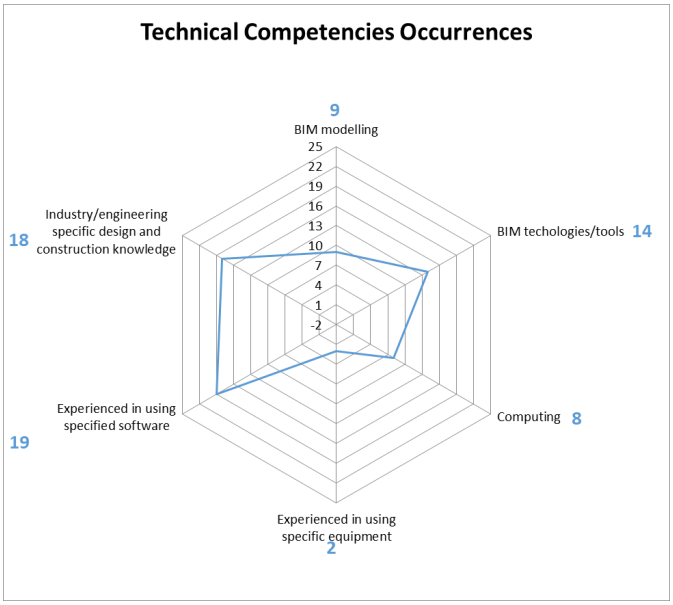

Figure 6. Technical competencies required from the 25 job adverts processed

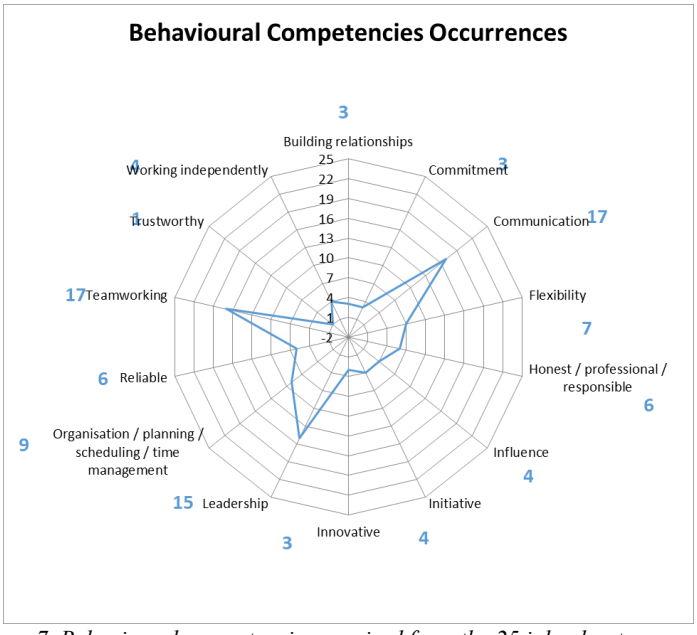

Figure 7. Behavioural competencies required from the 25 job adverts processed

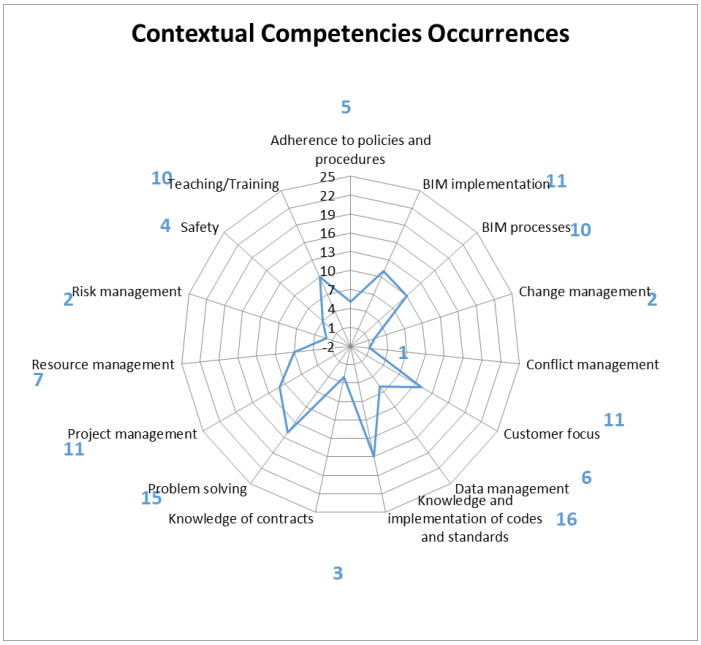

Figure 8. Contextual competencies required from the 25 job adverts processed

A full job description/advert for a Project BIM Manager has been created and is shown below:

Title: Project BIM Manager

Role Summary: Reporting to the BIM Director, the Project BIM Manager will be responsible for the day-to-day management of small project teams ensuring the successful delivery of BIM orientated client projects.

Responsibilities:

- Actively contributing to the development and improvement of company BIM processes and protocols.
- Building and managing relationships with all project stakeholders.
- Carry out multi discipline clash detection reports, and contribute to clash detection meetings and solutions.
- Chair BIM orientated meetings to discuss specific areas of the project.
- Checking and approval of the required drawings and 3D models (as specified in the MPDT) prior to model federation and handover to the client.
- Contribute and collaborate with technical personnel for developing and implementing new/future technologies.
- Day-to-day BIM support.
- Defining staff development areas and programs and providing ongoing feedback, training and development.
- Ensure all project data is correctly established and maintained in accordance with company standards and project requirements.
- Ensuring handover compliance through correct data seamlessly transferred at the correct project stages.

- Evaluate and make recommendations regarding BIM software. Ensure the hardware has sufficient capabilities. Acting as a technical interface with IT support services.
- Implementation of company BIM processes and protocols on all work for quality control and assurance.
- Keeping up-to-date with the latest technology and how it's used.
- Lead the delivery of BIM deliverables for a project.
- Management of the company's internal BIM library ensuring all content meets British Standards requirements.
- Provide guidance on any technical and process issues associated with the BIM delivery.
- Representing the company at industry events and conferences.
- Resource management through assisting with the appointment of design teams on BIM projects including the recruitment of new personnel.
- Responsible for all things BIM in the tender stages.
- Review and report on progress against company and project specific targets and KPI's.
- Set up and maintain the CDE in the absence of a dedicated Information Manager.
- Sharing knowledge, experiences and lessons learnt.
- The implementation and maintaining of Project BIM Execution Plans (and EIRs) to ensure the company fulfils its deliverables to the required quality.
- Understand the company's contractual obligations on a project particularly in reference to model ownership and transfers.
- Working with clients to determine/understand their requirements and define the company's methodology within a BIM Execution Plan.

Demonstrable Knowledge, Skills and Competencies:

Technical

- A solid grasp of all aspects of civil, structural and building design with the ability to advise on and challenge design details, concepts and solutions.
- BIM Modelling: Experience in the preparation, use, interrogation and validation of BIM models and drawings.
- BIM Technologies/Tools: Working knowledge of BIM technologies such as the setting up and maintaining the CDE, clash detection, model federation and using 4D construction scheduling.
- Computing: Must be IT literate and a proficient user of Microsoft packages. Programming knowledge would be beneficial.
- Proficient in the use of at least one of the common industry CAD and BIM design software packages such as Autodesk (Civils 3D, Revit, Plant 3D, Navisworks), Bentley (MicroStation, Bentley View), Teckla, Aveva PDMS etc.

Contextual

- A clear understanding of Building Information Modelling and its benefits to the built environment.
- Ability to balance resourcing requirements to deliver various projects.
- Ability to explain and provide guidance to less experienced project members to aid their development.
- Be able to resolve issues in a timely manner.
- Builds relationships with internal customers, external suppliers and support teams.
- Commercial and financial acumen.

- Familiar with applying BIM Standards in accordance with UK best practice (Chiefly BS 1192:2007 and PAS 1192-2:2013 standards).
- Strong organisational and analytical skills with the ability to manage multiple projects and priorities simultaneously.
- Working knowledge of engineering contracts, preferably NEC3.

Behavioural

- Ability to communicate effectively, both orally and in writing, with people at all levels across the organisation and externally.
- Ability to lead teams and influence people at all levels across the organisation, to drive true change.
- Ability to use time productively and work under pressure.
- Able to work effectively both individually and enjoy contributing to the wider team to achieve targets and objectives as required.
- Driven to achieve results and goals, both personally and on projects.
- Flexible attitude to work and showing a willingness to take on additional responsibilities.
- Professional appearance and manner.

Experience Required

- Minimum of 5 years' experience with BIM technologies.
- Minimum of 5 years' experience working in an Engineering/CAD environment.

Academic Qualifications Required:

- Undergraduate degree related to the built environment such as architecture, engineering or construction (essential).
- Postgraduate degree related to Building Information Modelling (desirable).

Additional Requirements

- Member of a relevant professional organisation with the ambition to achieve Certified/Chartered BIM Manager status.
- Willing to travel and represent the company at BIM industry events.

5. Conclusions

The rapid growth of BIM since its introduction around 2002 has highlighted a skills shortage within the industry whilst also leading to some confusion over the roles involved with BIM, particularly the BIM Managers. A lack of understanding of the role has led to poor recruitment practices and a high turnover of staff therefore this study aimed to provide guidance on the responsibilities of a BIM Manager and the requirements to be one.

A thorough literature review was performed covering key areas such as BIM related roles and responsibilities especially at project level, the skills and competencies required to work with BIM. Additional quantitative research was performed through a job advert analysis. A total of 25 BIM Manager (or similar) job adverts were reviewed, all of which were 'live' during this research so the requirements are a true representation of the current industry requirements.

Considering the findings from both parts of the research a detailed description of a Project BIM Manager was created. An HNC/HND is a sufficient academic qualification to apply for 76% of the job adverts reviewed. However, the literature review revealing a current skills shortage from education not producing enough suitable candidates it is recommended that

companies become more stringent and escalate their academic requirements to a minimum undergraduate degree related to the AEC industries whilst highlighting a postgraduate qualification relating to BIM would be a serious advantage. Academic institutions and the industry need to form closer links so the current BIM related courses could be refined so fresh graduates are suitably skilled for entry-level roles straight away.

Concerning experience, the results show that most employers are requesting candidates have an 'appropriate level of experience in a relevant field' rather than specific requirements such as 10 years+ as a BIM Manager. It was discussed that this is most likely due to BIM still being a relatively new tool which is now only just beginning to be the 'norm' for built environment projects. This means there will not be many candidates who have 10+ years of experience in a similar role. Therefore, based on the research it is suggested that personnel with 5+ years' experience working with BIM technologies and in an engineering/CAD environment will have developed sufficient skills and knowledge to become a Project BIM Manager at a SME where the project teams will be smaller. All current and future BIM Managers should be encouraged to complete an accredited scheme to become a Certified BIM Manager as this demonstrates one's abilities, competence and knowledge to both employers and clients.

In terms of responsibilities, a distinction has been made between those of the Project BIM Manager and those of more senior personnel such as a BIM Director. Essentially the corporate BIM management roles are the strategists whilst those at the project level are in the trenches doing the work and recording their performance against targets and KPIs.

The aim of this research was to identify the key managerial roles and associated responsibilities required for the successful implementation of Building Information Modelling (BIM) on both a corporate level and on an individual project basis. This has been achieved through the set objectives. However, there has been a greater emphasis on the project level roles, responsibilities and requirements so future studies could be performed to look into the corporate side in greater detail.

References

Barison, M. and Santos, E. (2010). An overview of BIM Specialists. Nottingham University Press.

Barison, M. and Santos, E. (2011). Competencies of BIM Specialists. Nottingham University Press.

Barnes, P. and Davies, N. (2015). BIM in Principle and Practice. 2nd ed. London: ICE Publishing.

BIM Task Group (2013a). About | BIM Task Group. [Online] Bimtaskgroup.org. Available at: http://www.bimtaskgroup.org/about/ [Accessed 12 Jul. 2017].

BIM Task Group (2013b). BIM EIRs – Overview. [Online] Bimtaskgroup.org. Available at: http://www.bimtaskgroup.org/bim-eirs/ [Accessed 26 Jun. 2017].

BIM Task Group (2013c). BIM EIR FAQs | BIM Task Group. [Online] Bimtaskgroup.org Available at: http://www.bimtaskgroup.org/bim-eir-faqs/ [Accessed 6 Jul. 2017].

BRE Academy (2016a). Benefiting from BIM Level 2. [Online] Building Research Establishment. Available at: https://bre.ac/wp-content/uploads/2017/02/BIM- Readiness.pdf [Accessed 20 Apr. 2017].

BRE Academy (2016b). Boardroom to Building Site: Skills Gap Survey. [Online] Building Research Establishment. Available at: https://www.bre.co.uk/filelibrary/BRE%20Academy/Skills-survey.pdf [Accessed 20 Apr. 2017].

British Standards Institution (2013). PAS 1192-2:2013 Specification for information management for the capital/delivery phase of construction projects using building information modelling. London: BSI Standards Limited 2013.

Cabinet Office (2011). Government Construction Strategy. [Online] London: UK Government. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/61152/Government-Construction-Strategy_0.pdf [Accessed 20 Apr. 2017].

Chatterton, S. (2015). Being a BIM Manager. [Online] Bim4scottc.blogspot.co.uk. Available at: http://bim4scottc.blogspot.co.uk/2015/01/being-bim-manager.html [Accessed 6 Aug. 2017].

Construction Industry Council (2013). BUILDING INFORMATION MODEL (BIM) PROTOCOL. [Online] London: Construction Industry Council. Available at: http://cic.org.uk/download.php?f=the-bim-protocol.pd [Accessed 20 Apr. 2017].

Construction Project Information Committee (2011). CPIx - BIM ASSESSMENT FORM. [Online] Construction Project Information Committee. Available at: http://www.cpic.org.uk/wp-content/uploads/2013/06/cpix_-_bim_assessment_form_ver_1.0.pdf [Accessed 28 Apr. 2017].

Construction Project Information Committee (2013). CPIx – Post Contract-Award Building Information modelling (BIM) Execution Plan (BEP). [Online] Construction Project Information Committee. Available at: http://www.cpic.org.uk/wp-content/uploads/2013/06/cpix_post_contract_bim_execution_plan_bep_r1.0.pdf [Accessed 26 Jun. 2017].

Crotty, R. (2012). The Impact of Building Information Modelling. 1st ed. London: Taylor & Francis.

Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2008). BIM handbook. 1st ed. Hoboken, N.J.: Wiley.

Ghaffarianhoseini, A., Tookey, J., Ghaffarianhoseini, A., Naismith, N., Azhar, S., Efimova, O. and Raahemifar, K. (2017). Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges. Renewable and Sustainable Energy Reviews, 75, pp.1046-1053.

Haines, B. (2016). The Benefits of Lifecycle BIM for Facility Management. [Online] FM Systems. Available at: https://fmsystems.com/blog/the-benefits-of-lifecycle-bim-for- facility-management/ [Accessed 7 Jul. 2017].

Harty, J., Kouider, T. and Paterson, G. (2016). Getting to grips with BIM: a guide for small and medium-sized architecture, engineering and construction firms. 1st ed. London: Routledge.

HM Government (2015). Digital Built Britain: Level 3 Building Information Modelling - Strategic Plan. London: Crown Copyright.

Holzer, D. (2016). The BIM Manager's Handbook: Guidance for Professionals in Architecture, Engineering and Construction. 1st ed. John Wiley & Sons.

Knutt, E. (2015). The BIM Manager: breaking new ground. [Online] Bimplus.co.uk. Available at: http://www.bimplus.co.uk/news/bim-manager-breaking-new-ground/ [Accessed 30 Jul. 2017].

Kubba, S. (2017). Handbook of Green Building Design and Construction. 2nd ed. [ebook] London: Elsevier, pp.227-256. Available at: http://www.sciencedirect.com/science/book/9780128104330 [Accessed 25 Jun. 2017].

Lester, A. (2017). Project Management, Planning and Control. 7th ed. [ebook] Oxford: Elsevier, pp.509-527. Available at: http://www.sciencedirect.com/science/book/9780081020203 [Accessed 24 Jun. 2017].

Light, D. (2013). CAD is not BIM. [Online] Autodesk-revit.blogspot.co.uk. Available at: http://autodesk-revit.blogspot.co.uk/2013/03/cad-is-not-bim.html [Accessed 6 Aug.

2017].

Liu, S., Xie, B., Tivendal, L. and Liu, C. (2015). Critical Barriers to BIM Implementation in the AEC Industry. International Journal of Marketing Studies, 7(6), p.162.

Mathews, M. (2015). Defining Job Titles and Career Paths in BIM. In: CITA BIM Gathering 2015. [Online] Dublin: Dublin School of Architecture. Available at: http://arrow.dit.ie/cgi/viewcontent.cgi?article=1008&context=bescharcon [Accessed 29 Jun. 2017].

McPartland, R. (2016a). Top 10 BIM myths debunked. [Online] NBS. Available at: https://www.thenbs.com/knowledge/top-10-bim-myths-debunked [Accessed 17 Jul. 2017].

Philp, D. (2013). Private sector catching up fast on BIM's potential. [Online] Construction News. Available at: https://www.constructionnews.co.uk/analysis/expert- opinion/private-sector-catching-up-fast-on-bims-potential/8650438.article [Accessed 20 Apr. 2017].

Royal Institute of British Architects (2012). BIM Overlay to the RIBA Outline Plan of Work. Royal Institute of British Architects.

Royal Institute of Chartered Surveyors (2014). What is BIM? [Online] Rics.org. Available at: http://www.rics.org/uk/knowledge/glossary/bim-intro/ [Accessed 23 Jun. 2017].

Rutland, C. (2017). Is BIM in its own economic bubble? [Online] Bimplus.co.uk. Available at: http://www.bimplus.co.uk/people/bim-its-o5wn-ec6onomic-bu8bble/ [Accessed 17 Jul. 2017].

Smith, D. and Tardif, M. (2009). Building Information Modelling: A Strategic Implementation Guide for Architects, Engineers, Constructors, and Real Estate Asset Managers. 1st ed. Hoboken, N.J.: Wiley.

Suchocki, M. (2017). BIM in infrastructure - Not just a fad. [Online] Institution of Civil Engineers (ICE). Available at: https://www.ice.org.uk/news-and-insight/the-civil- engineer/january-2017/bim-in-infrastructure-not-just-a-fad [Accessed 17 Jul. 2017].

Wienerberger (2017). BIM Role definitions: PAS1192:2. [Online] Wienerberger.co.uk. Available at: http://wienerberger.co.uk/about-us/bim-role-definitions-pas11922 [Accessed 26 Jun. 2017].

‘NOT ALL BUILDING WILL BE NEW’

Subtitle: The implementation of BIM in the Renovation, Refurbishment and re-use of buildings.

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Abstract. O’Brien Finucane Architects (OBFA) is a private architectural practice based in Dublin, Ireland. The practice undertakes projects in both the private and public sectors and is currently working on multiple developments which aim to deliver new housing, integrated with legacy historic structures located in existing town cores. Ireland is experiencing a housing crisis and the re-purposing of older buildings in established and serviced locations across towns and cities is current Government policy.

Ireland is late in the adoption of BIM processes. The construction sector, while buoyant, is a small market in comparison to the UK and wider European markets. There is now a growing emphasis on effective scheduling and information management in construction projects to reduce wastage and increase productivity. This has led to a rise in the adoption of BIM in the Irish Construction Sector initially through delivery of the larger and more complex building programmes. Although not yet mandatory from government, increasingly signature developments now must be delivered through BIM Level 2 processes and must deliver BIM modelling to commissioning authorities for review. As an SME architectural practice, OBFA recognise the importance of BIM and have committed to adopting and developing processes for managing and modelling building information. This has required the development of different practice roles and technologies.

Change is never easy, especially for smaller businesses. Fundamental change in core methods and relationships is even harder. Generally, resources and funding are limited when compared to what is available to large multidisciplinary teams. ‘Buy-in’ from partner disciplines, smaller consultancies, smaller employers, is essential.

OBFAs’ position is to utilise and adopt what we have and learn by doing. In this case we are focused on learning how to adopt and adapt BIM to existing historic buildings; buildings from an era that predated digital thinking.

In the Irish construction sector, a significant percentage of all construction will involve existing buildings. It will involve smaller buildings with smaller budgets. A notable corollary is that there will be a large number of these projects. This means that it is essential that the principal tenets of BIM be applicable to smaller projects. Overly complex systems and processes must be simplified so that they remain relevant and viable.

Keywords: BIM, Local Market, implementation, optimization, Existing fabrics.

1. Introduction and Context

Where we address 3 issues – Small Practice, Less of Big/More of Small and the Patina of Age.
In general, the Architecture Engineering Construction Operation (AECO) industry has been facing a paradigm shift to a more efficient and productive method of operation. However, small firms are often left behind when it comes to technology and training for BIM due to lack of skills and resources to support that section of the construction sector, they are working in.

Ireland is particularly vulnerable to this and is late in the adoption of BIM processes due to an innately smaller market. There is now a growing emphasis on effective scheduling and information management in construction projects to reduce wastage and increase productivity. Empirical data on how a building envelope and its systems perform are now mandated to meet energy reduction goals.

Most of the buildings in Ireland date from the period 1900-1970. We also have a rich stock of historic buildings dating from the 17th, 18th and 19th centuries. These buildings remain in active use and are essential to maintaining a sense of architectural place in the cities and towns around the country. The texture of this built environment is what gives our towns their sense of place.

Ireland is now a deeply integrated part of a larger European whole and it will need to continue to maintain and improve its building stock as it modernises and develops in the coming decades. We will build new buildings, but we will also need to look after our historic stock. Accordingly, the challenge is to learn how to apply new modern data-based processes to buildings that are not bright, shiny and new. We must apply them to buildings that have an historic patina, a context, ones that are bitty, lob-sided and old.

2. Planning & Strategy

2.1 PROJECT

Where we deal with a mix of old and new, too much information and ask who is doing what.
The subject project incorporates an important site in Portlaoise, a large town located in the midlands of Ireland. It requires the conservation and repurposing of two historic buildings; an 18th century convent with a 15th century tower and a 19th century school building. It is an important development both in itself but also in its role as part of an aspiration to remake the town core and repopulate the main street of the town.

Before we start any form of BIM implementation, as a practice we needed to identify where we currently stand and what we are trying to archive at the end. The outcome may not be a clean implementation of BIM accordance with ISO 19650 but might be a flavour of this – altered to suit the client's real world requirements and their ability to manage the end result.

This decision will affect the practice, people, processes and technology. The design processes are slightly different compared with designing a new building on a green field site. We are required to set out project relevant processes. These are the targeted collection of existing site information, translation of data into the digital model which allows the architect to design in response to this data.

Some of these tasks are well suited to the role of the technologist and it requires their involvement at the commencement of the project – the earliest stages. This requires the agreement and support of the practice directors.

- Prepare the project data environment.
- Assist in setting the scope and type of site and building survey information.
- Assist in liaison with partner disciplines to agree additional information requirements.

2.2. PEOPLE

OBFA employs two qualified architectural technologists. The role has been traditionally seen as one of technical detailing and the preparation of documentation for construction that is driven by the designer. More and more however this role is expanding into the role of information manager. BIM implementation will reinforce this aspect of the role in practice.

Once we have analysed individual staff strengths and weaknesses, it will allow the management team to direct resources towards improving the right skills in the right places. In this instance, the design architects required regular and persistent training on BIM authoring tools along with an introduction to the International Standard Organization framework. This is done by both in house training and outsourced training resources and CPD.

This allows and requires the management team to plan future training and identify individual roles and responsibilities within those projects that involve with BIM processes as the process matures.

2.3 PROCESSES

Ireland is expected to introduce a BIM mandate in some form over the coming years. This will likely align with UK principals and will adopt the recently codified ISO 19650.
The construction sector in Ireland is regulation heavy and projects sit under Health & Safety, Building Control, Sustainability, Procurement and Contractual environments. While each of these subsets have some interaction between them they are also partly siloed. The introduction of BIM and the management and assembly of building data will touch on all of the above and will bring another suite of challenges.

It was decided to adopt the established processes associated with BIM delivery in the first instance. This allows points of common reference and provides a high-level path to follow.
We adopted:

- The preparation of a BIM Execution Plan as a guidance document
- Exploration of the relevant aspects of ISO 19650
- Model Structure & Processes
- Adoption and implementation of Common Data Environment

We did not make formal appointments for common BIM roles as this was felt to be restrictive and the roles could not be resourced.

3. Information Standardisation

How we streamline our processes with standards & information

3.1 BIM EXECUTION PLAN

A BIM Execution Plan, is a valuable and necessary part of any new construction project. It is essential when working in any collaborative project to ensure that everyone working on the project is on the same page, cooperating and collaborating (Zigurat Global Institute, 2017)

In this scenario, the BEP was not part of the contract requirement, and the employer did not mandate it. The Design Team saw the benefit of implementing and rolling out the document as a guidance document to all project members. In order to manage information-flow our BIM execution plan (Fig.1) assisted us in managing the different information requirements at the various design stages. These include:

- Key design stage / timelines
- Information requirement from various disciplines
- Common data environment
- Information exchange format
- IT infrastructure (software version and format exchange)
- Deliverable at various design stage
- BIM Goal & Uses
- BIM Roles and responsibilities
- Model structure
- Model development specification
- Model Content Requirement.
- Processes

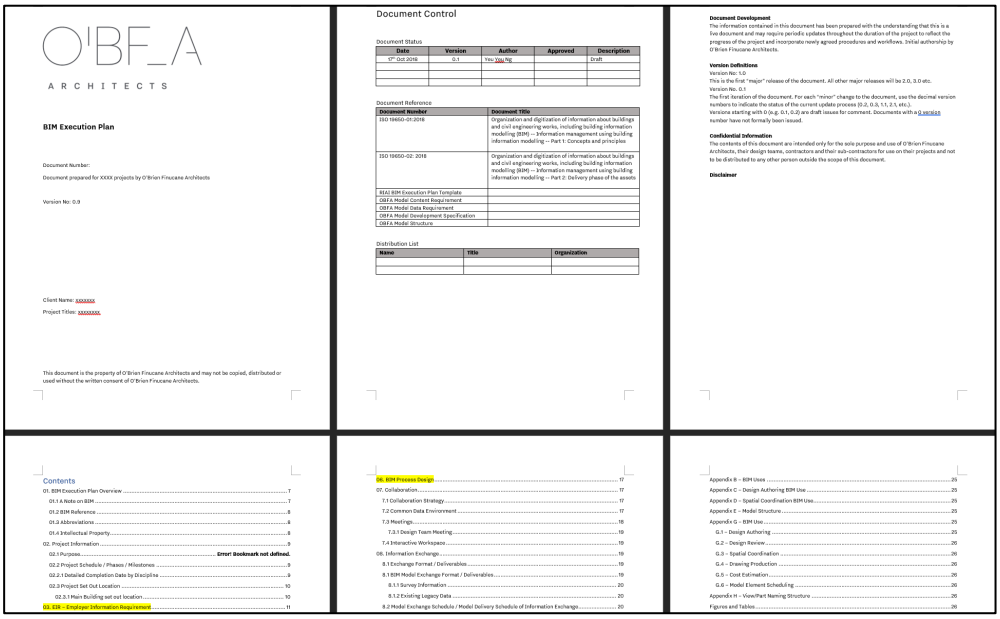

Figure 1. Project BIM Execution Plan

3.2 STANDARD – ISO 19650

The International Standard Organization (ISO) have released the ISO 19650: Organization and Digitization of Information about buildings and civil engineering works, including building information modelling (BIM) – This is in two parts: Information management using building

information modelling Part 1 Concept and principles and Part 2: Delivery phase of the assets in 1st January 2019 to facilities the BIM adoption across the globe (Fig. 2).

What all organisations require now is a period of stability with regard to these standards in order to allow their orderly implementation; to become part of normal practice. This is particularly important for small practice where the impact of the change has a greater effect on the overall business. During the BIM implementation, we need to consider the ISO standard as this will set the standard for our future projects

Figure 2. International Standard Organization (ISO 19650)

3.3 MODEL STRUCTURE

The project involves multiple buildings on a complex site with historic context of importance. Our BIM model structure had to accommodate this.

The model structure is an outline map on how to structure the BIM model(s) (Table 1). In this instance, due to the complexity of the project, we split the model into the following:

TABLE 1. Model Structure Outline

Master SetOut Model	All BIM models are linked to this model to give an overall view of the project.
Site Context Model	Consisting of topography and surface information about the site
Point Cloud Model	Point Cloud scan model of the existing condition and character of the site
Block A Model	Building A – Conservation and alterations to a substantial historic structure

Block B Model	Building B – Minor Alterations, Conservation to an historic structure.
Block C Model	Building C – Existing School building, partial conversion to residential apartment
Block D Model	Building D – New Residential Building
Block E Model	Building E – New Residential Building
Block F Model	Building F – New Residential Building

We implemented the model structure (Fig.3) accordance to project brief and used this as a way to assist with staff allocation of work and improve the model performance. This is important in a small practice environment where designers and technologists are working on multiple projects concurrently. It also allows us to use the different models as direct design tools.

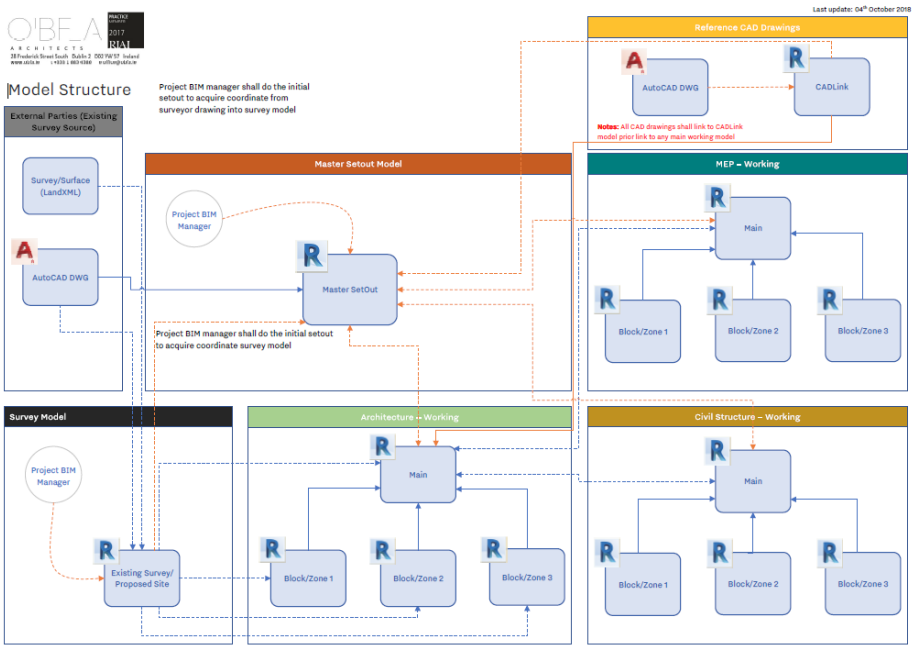

Figure 3. Project Model Structure

3.4 MODEL DEVELOPMENT SPECIFICATION

Model development specifications (Fig. 5) are developed in house and in conjunction with the structural engineer and services engineer whom we are regularly working with. This specification document outlines to each discipline how they should be model within the BIM authoring tool. For example, architecture shall model the wall from level to level rather than from ground level to roof level. The specification also outlines what to include and exclude from 3D modelling. For example, all cable below 25mm diameter MEP shall not be a model.

Due to the project complexity, we needed to develop the specification to manage and assist us in what information is contained within the model. This is to facilitate the coordination/collaboration in the later stages such as prior of tender/construction and is an easy to examine the models.

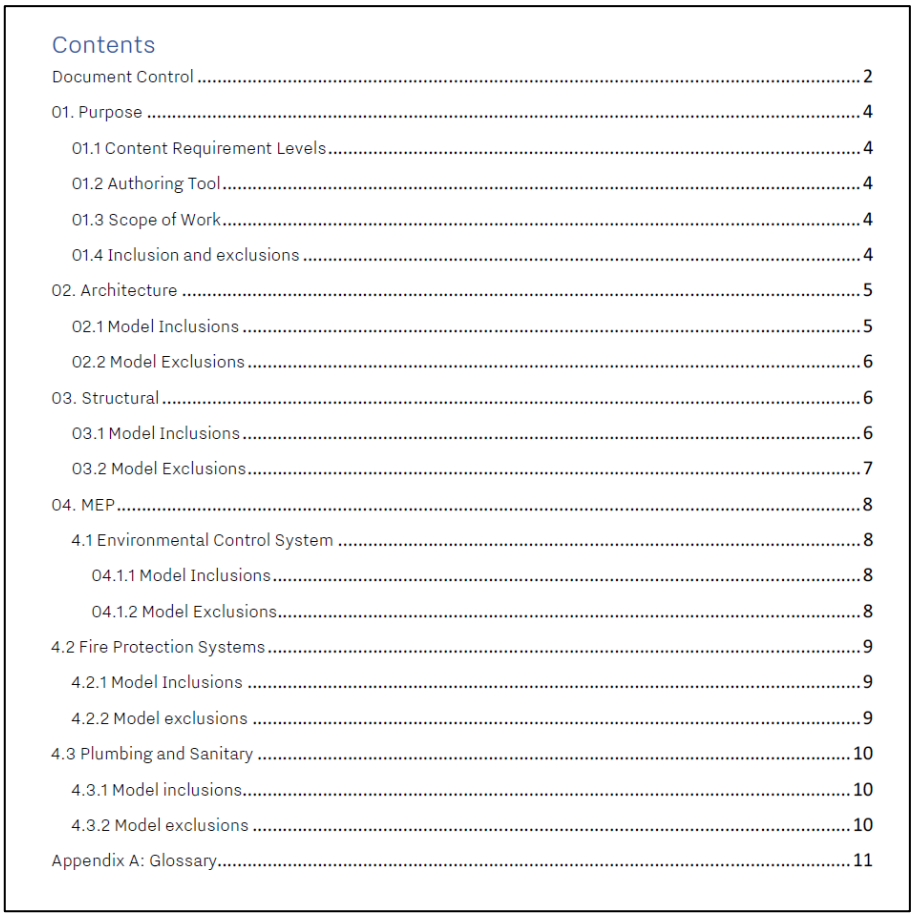
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Figure 5. OBFA In-house Model Development Specification Content

4. Technology

How we implemented the technology to enhance our processes.

When it comes to technology, there are many options on the market, and often businesses are confused about what is best for them. This is particularly relevant for smaller practices as it represents a significant financial and operational commitment. To make that commitment, one needs surety. Our practice determined to make a transition from CAD based drawings to modelling from inception and have decided to work with the Autodesk suite of products.
Our reasons were:

- We wanted to maximize compatibility with partner engineers, the majority of whom work within the same suite.
- We want to reduce the risk of data corruption in format changes.
- We wanted a base of software that would allow the practice to take on larger more complex projects should they be commissioned.

We also needed a cloud solution to exchange information with other design teams without meeting physically and a central location for our in-house teams to store and create WIP

content and data. This is a rapidly changing environment and sophisticated CDE resources remain priced beyond most small practices. This will need to change to assist more widespread adoption.

4.1 CENTRAL LIBRARY RESOURCES

Central library (resources) play a considerable part in implementing orderly BIM for any project. It is easy to allow information to be scattered across an entire network database. This makes it harder to re-use the information that has been developed previously. (Fig. 6)

Therefore, the practice created a central network server within the network to allow individual users within the company to utilize and re-use the content. This extends beyond BIM model data as it also applies to other data such as Images or AutoCAD blocks.

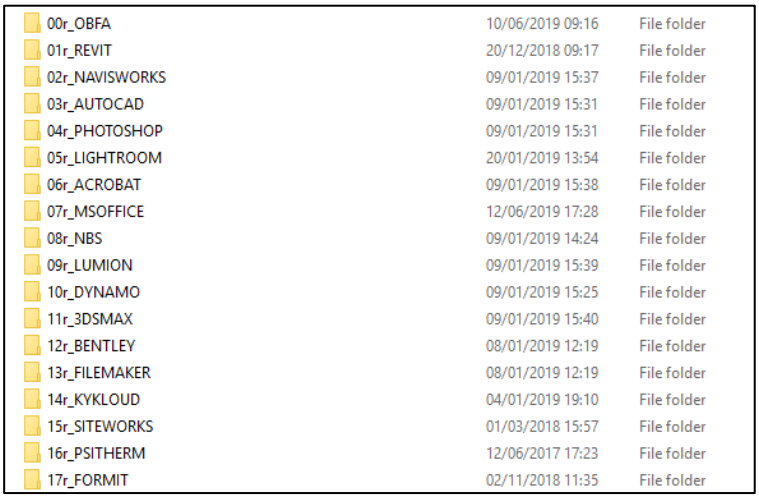

Figure 6. OBFA Office Central Library Resource

4.2 COMMON DATA ENVIRONMENT

OBFA have had a somewhat ‘blunt’ introduction to the world of Common Data Environment (CDE) requirements as defined in the PAS1192 and BS1192 documentation. These documents outline what organisations working in the construction and engineering industries need to do in order to reach a BIM Level 2 compliance on their projects.

For this project, we established internal (shared with office colleague) and external (shared with external design teams) common data environments.

Not all information will be stored on the cloud and shared. First, we need to streamline how our information is shared within the architectural team. In this instance we have revamped the folder structure within the practice to streamline the information flow and marry with project delivery and BIM collaboration requirements. (Fig. 7)

Figure 7. OBFA Office Folder Structure (left: Previous, Right: Current)

When shared information with external parties such as the design team is required, we have implemented BIM 360 Document Management System from Autodesk. This has allowed us to incorporate additional processes that involve multi-step approval before the issue of any contents to external parties - including the client.

4.3 DIGITAL DESIGN REVIEW

We incorporate and handle all the information including drawings, specification etc. in BIM 360 when we share with external design teams. We also take an additional step forward by incorporating an internal design review on the system. All information is uploaded to the CDE to allow three steps of approval before publishing to a shared folder and allow other design team member to access it. (Fig. 8.)

Three Step Approval Checklist:

An Initial review is by the project BIM manager

- Check the model/drawings are align with BIM execution plan
- Check the model/drawings are align with ISO such as LOD and naming convention.
- Quality Check & Quality Assurance (QAQC Process) – drawing output that meet office standard

The second review is by the lead project architect / technical manager

- Check the design are align with the design brief

- Check the design are align with authority's regulation such as fire compartmentation etc.

The final review is by the project director

- Final check before issue to external parties.
- Sign off the documentation quality before it is published to external parties.

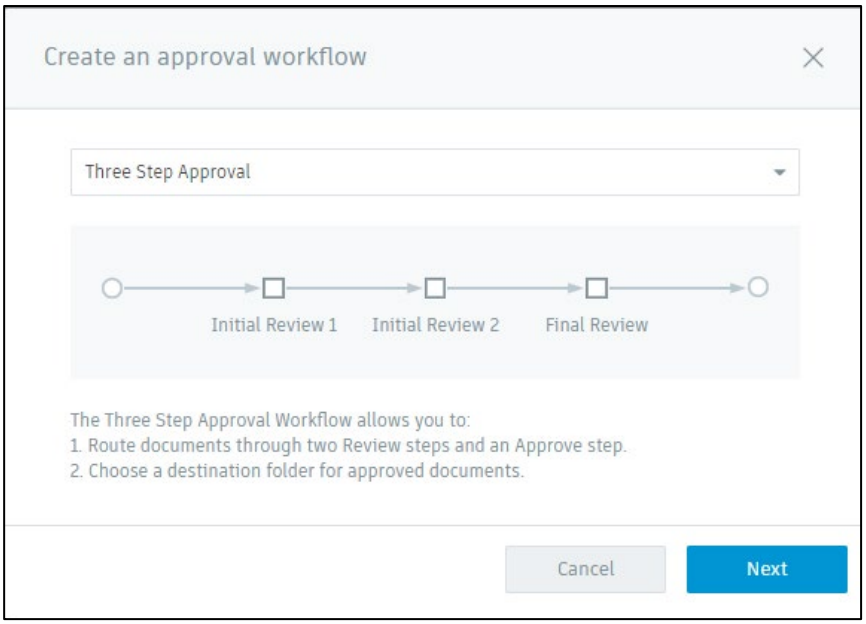

Figure 8. Design Review Approval Setup for the project

Once the initial review has been submitted to the respective person, they will receive an email notification that there is review pending the action. The review period can be set depending on the project timeline. This allows the design leader to control the review process and also improve our deliverable output.

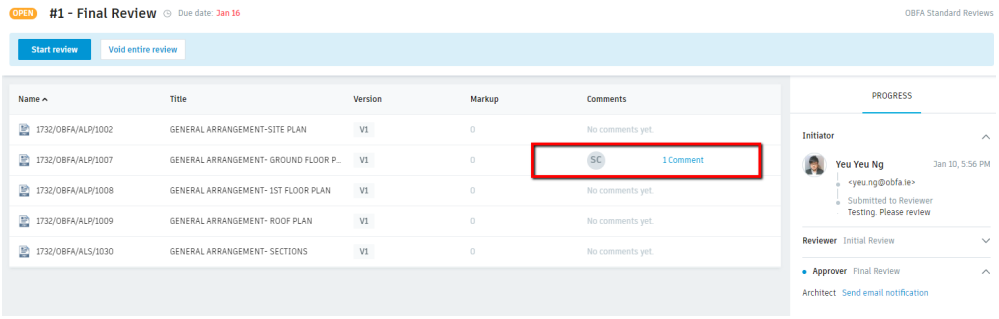

Figure 9. Design Review Approval Record with comments from others

4.4 POINT CLOUD

Technically a point cloud is a database containing points in the three-dimensional coordinate system. However, from the typical workflow perspective, the only important thing is that point cloud is a very accurate digital record of an object or space. It is saved in the form of a vast number of points that cover surfaces of a sensed object. (3deling, 2016)

Points in a point clouds are always located on the external surfaces of visible objects because this is the spot where the beam of light from the scanner reflected from the object.

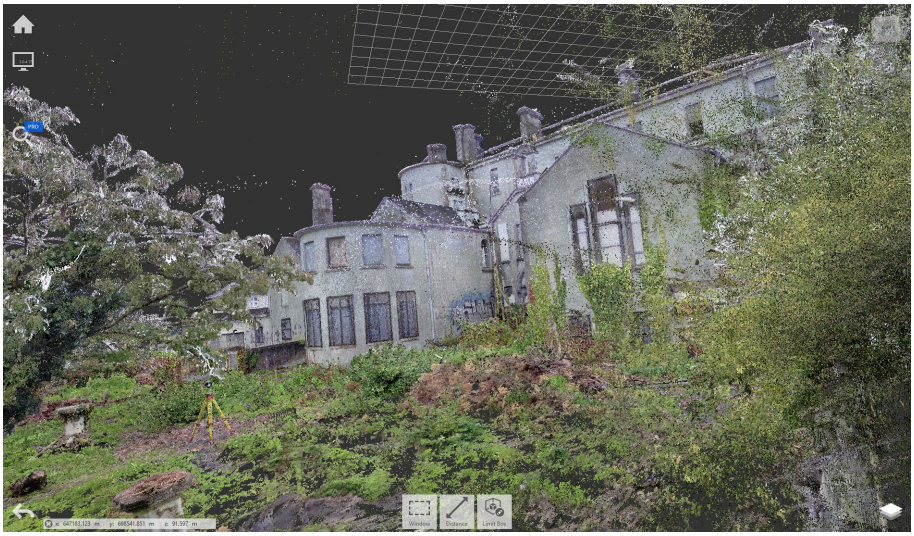

Figure 10. Point Cloud Scan on existing historic building

Point cloud scanning has become a critical process for this project as it involves period buildings which have a conservation value. A high-quality archive record of the existing site is both essential and useful. Traditionally, we would just have taken a series of photograph and a manual record the site condition, to replicate the information later in a digital 3D model. However, this is not very productive, involves manual input, and is prone to error.
The use of Point cloud scanning has sped up our processes in both design and modelling whilst providing a ‘point in time’ high-resolution record of the site before we commence any construction work on site. This record also provides surety when dealing with existing buildings. In this instance, dealing with a late 15th century tower an exact record of the existing condition, form and assembly of the tower is necessary, so that conservation architects can carefully examine the building and provide appropriate context and guidance to its conservation.

4.5 DATA ANALYTICS

One of the reasons for implementation of BIM in this project is to focus on the potential for an intelligent 3D model that contains value information throughout the project life cycle. We have all the information contained in the model but what else can we do with this data? To explore this, we have looked to Microsoft Power BI software to analyse data that we have generated from the model and portray it in a visual form.

The GUI can give us a greater understanding of the model data and in some way can assist the architect and BIM manager to visually inspect the data across the whole project more easily. It also helps the BIM manager to manage the data and to identify any errors.

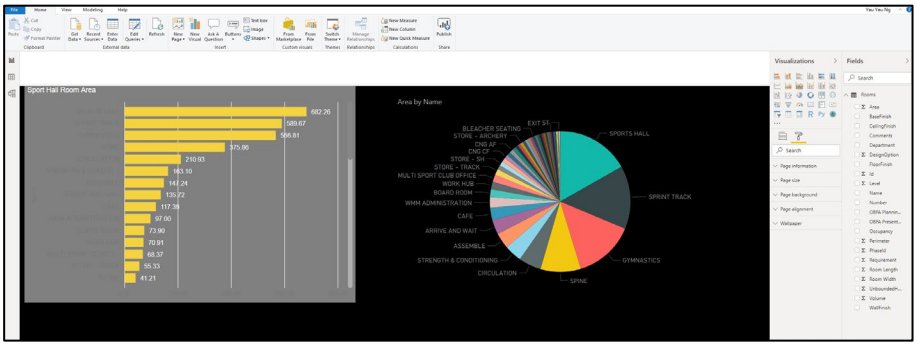

Figure 11. Power BI User Interface with model data

Model data also gives us a visual of a models' health. We can extract model information such as elements, warnings, file size, view counts, sheet counts, room data etc. and translate this data in the Power BI software. (Fig. 12)

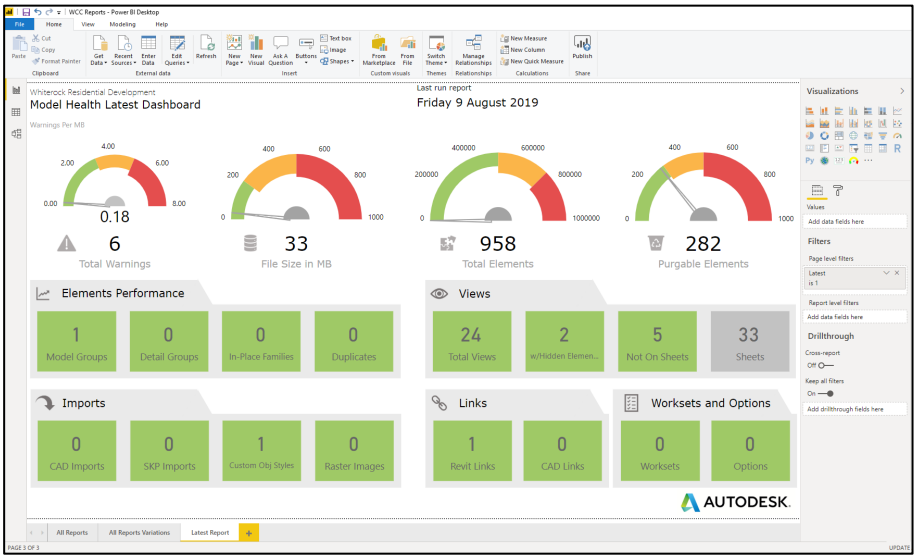

Figure 12. Data extracted from model display in Power BI

This allows us to closely monitor model health on a weekly basis in visual form, rather than opening the model in the native form and examining manually. Weekly reports also give us a model health trend to monitor over time. In this instance, if there is spike from the model health, we can identify whether this is human error or due to a deadline, people are rushing to create project elements (Fig 13).

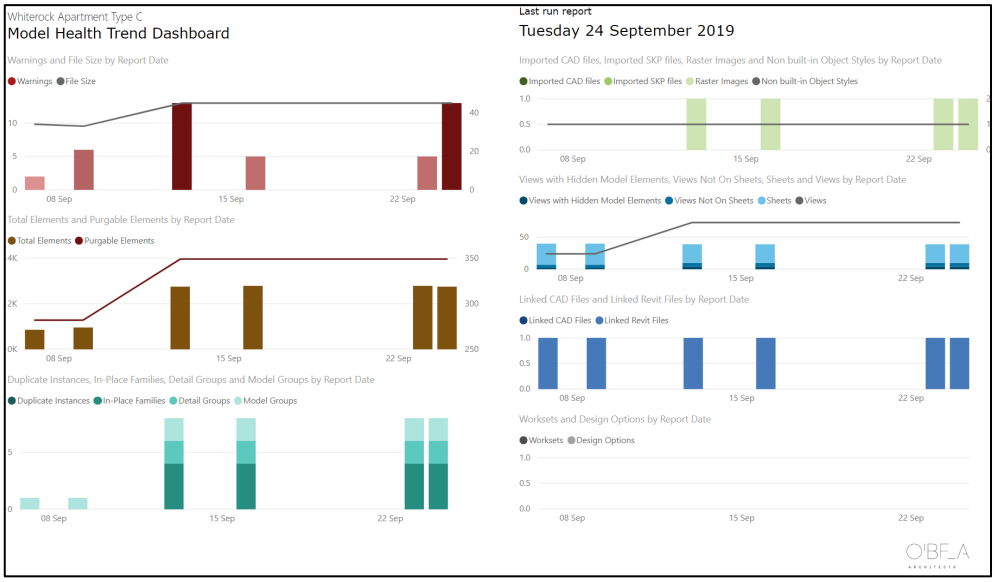

Figure 13. Model Data Health Trend in Power BI

We have also explored the fact that we can integrate data in Power BI to allow the client to interact with the mode data (Fig. 14) such as individual room areas. For example, the client can select a room category such as circulation space on the floor plan. Where this area is located across multiple floor plans the graph will respond.

This can be of benefit to a client in the long term as it can assist the client in analysing each room against factors such as income per square meter, tenant information etc. by helping them digitize the information. As the model data is available when we generate it during the design to construction stage, we can potentially utilize the same data and pass it to our client.

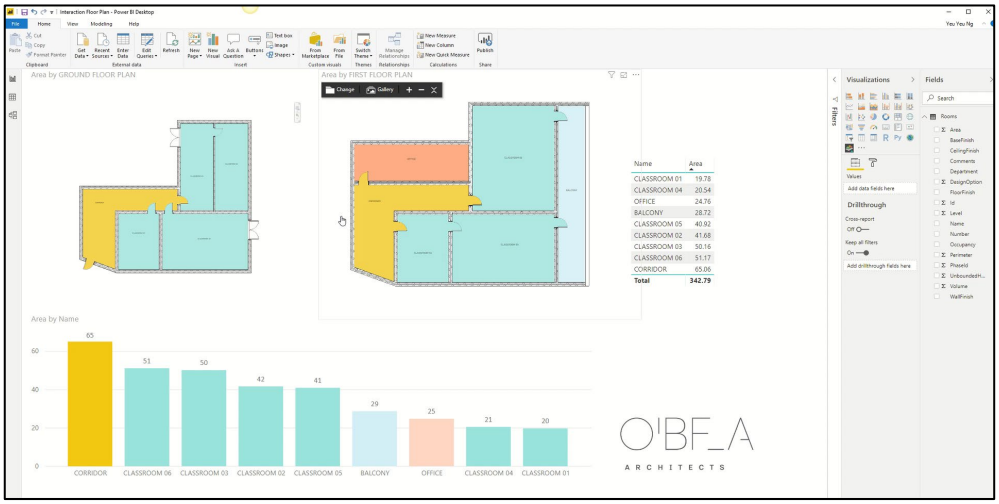

Figure 14. Power BI Interactive Plan with room data information

5. Conclusion

As BIM implementation is underway and spreading across this project with the integrated project team, it is important to maintain a positive mindset; to stay focused, flexible and engaged with all team member regularly. Having said that, there is always a room to further improve the processes; therefore, a regular review of the workflow and processes is helpful, to adapt to change so the BIM process remains useful and enabling rather than impeding.
The following summary are the things we consider worth doing when implementing BIM for this type of project:

- Regularly evaluate processes
    - Re-evaluate the processes with the project team to seek feedback for any further improvement.
    - Further research to save, improve and provided additional services.
- Involvement
    - Always work close with the project team member
    - Don't leave the work to the other staff
- CPD (Continued Professional Development)
    - Regular software training
    - Attend seminar or conference
    - Design a training topic focus on the staff needs

One thing that we discovered during BIM implementation during this project is that for other projects we usually don't involve architectural technologist at the start of the project (early design stage). However, we have found it very useful to bring the architectural technologist to the project at the earlier stage to determine the processes and technology used for the project, while architect is taking the lead in design.
This completes the three key areas for the implementation of BIM on an existing building in an SME environment where it relates to Design, Process and Technology.

6. Acknowledgements

I would like to thank Mr Ciaran O'Brien (O'Brien Finucane Architects Director) for the advice, support and opportunity to implement BIM for this project.

References

Chartered Surveyor Ireland, 2019, Building Information Modelling. Viewed 13th June 2019 https://www.scsi.ie/professional_groups/quantity_surveying/building_information_modelling_bim0

Zigurat Global Institute, 2017, what is a bim execution plan (bep) and when is it used? Viewed 13th June 2019 <https://www.e-zigurat.com/blog/en/bim-execution-plan>

Design Building Wiki, 2019 Common Data Environment (CDE). Viewed 12th June 2019 <https://www.designingbuildings.co.uk/wiki/Common_data_environment_CDE>

David Butts 2019, Managing BIM projects without going crazy. Viewed 14th June 2019 https://medium.com/autodesk-university/managing-bim-projects-without-going-crazy-f7b46177f0ef

Grad Ireland, 2019, Building Information Modelling / Architectural Technology. Viewed 14th June 2019. <https://gradireland.com/career-sectors/construction-civil-engineering-and-qs/building-information-modellingarchitectural-technology>

OVERCOMING RESISTANCE TO BIM: ALIGNING A CHANGE MANAGEMENT METHOD WITH A BIM IMPLEMENTATION STRATEGY

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Abstract. The adoption of Building Information Modelling (BIM) in the Irish construction industry has risen from 10% in 2011 to over 70% in 2018. Where there is criticism towards BIM concerning its ability to reduce environmental impact, it is not about the ambition to adopt BIM but more so the capacity to embed BIM within the industry. The National BIM Council introduced a Roadmap to Digital Transition for Ireland's Construction Industry 2018-2021, which defines a strategy to transform the construction industry to digital. This research paper explores how small to medium size companies within the Architectural, Engineering, and Construction (AEC) industry in Ireland can respond to both organisational and individual resistance to the implementation of BIM processes in practice. A literature review and stakeholder interviews from organisations at various stages of implementing BIM have demonstrated that to change how the industry works there must be an overall goal to adopt BIM. In order to achieve business goals, it is important to investigate change management processes which can support the reduction of resistance from employees. While it has been found that implementation needs to come from a bottom-up approach, more importantly it is top-down from management that will make BIM practices the norm. As a response to the industry's introduction of BIM and the transition to digital, companies are embarking on organisational change through the review of business structures and operational strategies. To reduce resistance companies have come up with new approaches, such as introducing an implementation team, developing training programmes, and altering the organisational structure with new roles and responsibilities. A BIM adoption roadmap that aligns change management methods with a BIM implementation plan can bridge the gap and ensure that BIM becomes commonplace within an organisation.

Keywords: BIM, Adoption, Digital Transition, Change Management, Implementation, Roadmap.

1. Introduction

As the Architectural, Engineering and Construction (AEC) industry in Ireland embarks on the transition to a more digital and collaborative working environment, businesses are being challenged to meet the sophisticated demands of clients (Council, 2017). With the rapid adoption of Building Information Modelling (BIM) across the globe, companies are reviewing their organisational structures and changing the way in which they carry out their day to day tasks. It has been identified that one of the largest barriers to overcome is the behavioural

resistance to change that is found amongst both client and the construction industry (Farmer, 2016).

Within the Irish industry small to medium size companies are defined as having less than 50 employees and an annual turnover not exceeding €10
Million (Ireland, 2007). Verheugen (Publications, 2005) describes micro, small and medium-sized enterprises as the engine of the European economy, and that these companies are a vital source of jobs while creating entrepreneurial spirit and innovation within the EU. Table 1 below highlights the size of architectural firms in Ireland recorded from a survey carried out to study the strategic leadership of architectural firms in Ireland (Flemming, Flood and Bosak, 2011). With an astounding 86% of firms in Ireland employing five or less staff, it is essential to assist these firms during such a widespread industry transition to digital, and the welcomed introduction of BIM.

TABLE 1. Architectural firm size Ireland 2010

Total No. of Employees	2010 (%)
1	45
2	14
4	8
5	5
6-10	8
11-20	4
21 +	2

Research in the area of BIM tends to focus on finding solutions to technical difficulties with BIM (Lindbald and Vass, 2015). There has been less research carried out focusing on how BIM implementation influences work practices, and the processes required by an organisation to reach overall goals and employee expectations (Lindbald and Vass, 2015). Lasting BIM adoption has stalled not because of technology or business, but because of human factors. Managing employee expectations is vital. “BIM doesn’t work” (Deutsch, 2011), that is in many cases true as BIM does not work for those whose expectations are too high. BIM does not work for someone who does not know how to use it, and for someone unwilling to change how they think and work.

With the publication of the NBC Roadmap to Digital Transition for Ireland’s Construction Industry 2018-2021, Knoster, T (1991) states “Without Vision, you will have confusion; without Skills you will foster anxiety; without Incentives you will meet resistance; without Resources you will breed frustration; without a Plan you’ll make false starts” (Council, 2017). This statement provides insight of the requirements that the management of AEC practices must consider with the introduction of BIM to the Irish construction industry.

2. Review of Literature

The literature reviewed for this paper considers the changes that have come with the adoption of BIM from both an industry and a business perspective. The Irish construction industry is growing concerning BIM adoption with 76% of respondents to the Irish BIM study reporting confidence in BIM skills and knowledge. 79% of those also reported an increase in demand for BIM in Ireland (Hore, McAuley and West, 2017).

2.1. BARRIERS OF BIM

The focus of current research looks mostly at the industry, company and project level of BIM adoption. Several obstacles which have been identified include; low awareness, lack of training, dissolution of the industry, difficulties in changing traditional work methods, the introduction of new roles and responsibilities, as well as software interoperability. However there has been one impediment which has not been investigated, and that is the perception of BIM by users (Howard, Restrepo and Chang, 2017). Individual users of information systems react in different ways to new technologies. Users of technologies may; reject it completely, partially use it, resist it, unwillingly accept it, or fully embrace it (Laumer and Eckhardt, 2012).

The UK National BIM survey 2018 identified that the largest barrier to BIM adoption within organisations that have yet to adopt BIM is the lack of in-house expertise (71%), closely followed by no client demand (69%), lack of training (61%), and cost (50%) (NBS, 2018). In comparison to the findings from the UK market, within the Irish industry, the top five barriers reported (Hore, McAuley and West, 2017) were client awareness, implementation within smaller companies, lack of standardisation and protocols, lack of in-house expertise, and issues regarding data ownership and liability. It is expected that with the growth of BIM, traditional work methods will diminish as more and more clients see the benefits of BIM.

Another significant obstacle affecting BIM adoption may be the demographic of the industry and the enthusiasm to adopt new technology. It has been identified by the Irish Prospects to 2016 (Ireland, 2015) that the ageing of the Irish workforce and the availability of new graduates to the industry are key barriers to be overcome. Technology is playing an increasingly more critical role in the construction industry, the most recent trends within the green building and BIM shift in technology implementation. Technology brings many opportunities to workforce development including non-construction audiences. The opinions of Uddin and Khanzode (Uddin and R. Khanzode, 2014) is that BIM is enhancing people's careers both with existing professionals and in creating new career paths for young professionals (WU and R.A. ISSA, 2014). It is believed that the Irish construction industry can address skill shortages through the utilisation of BIM, increasing the attractiveness of the construction industry to young professionals according to Construction 2020 (Hore, McAuley and West, 2017). Given the uptake of digital technologies within the industry, this is expected to increase the demand for highly skilled labour (Marley, 2015). To address skill shortages, it is clear that more needs to be done to reverse the stereotypes associated with the construction industry. It seems, even amongst those working in the construction industry that the perception is comprised of hard hats and hi-vis vests. There is a lack of awareness in terms of careers in construction management, and offsite activities such as design (Marley, 2015).

2.2. CHANGES BIM BRINGS TO A COMPANY

A case study in Sweden of how a large public client is initiating BIM implementation within their organisation has identified the changes which occur with BIM implementation and categorises these changes into four areas; BIM management systems, BIM measurements, BIM skills, and BIM education (Lindbald and Vass, 2015).

BIM management systems look at changes such as; defining the lowest level of BIM use within the organisation, the mentoring of BIM, new role descriptions such as BIM coordinator and BIM manager, and the adoption of industry standards. BIM measurements investigate the level of knowledge within an organisation regarding BIM and the attitudes towards BIM, this also includes measurements of BIM such as key performance indicators (KPIs). Meanwhile the BIM skills level looks at competencies and framework agreements for BIM coordinators and BIM managers, as well as BIM education considering BIM training courses (Lindbald and Vass, 2015).

Research which aims to extend the Unified Theory of Acceptance and Use Technology model to understand the perceptions of BIM users resulted that Performance Expectancy does not directly affect Behavioural Intention, thus signifying that BIM is often perceived as an unrewarded addition to traditional work processes (Howard, Restrepo and Chang, 2017). The findings from this survey show the need to redefine organisational strategies, standards, and incentives to advance user acceptance of BIM.

2.3. ORGANISATIONAL CHANGE

Organisational change is described as a process which is undertaken by a company to change its working methods or aims (Dictionary, 2019). Organisational change is categorised into two categories, planned and unplanned change. Planned change is described by Windell L French (McGuckian, 2000) as a deliberate effort to modify an organisational system to respond to environmental and internal forces.

The evidence of a relationship between BIM and organisational change can be argued as it is suggested in research that BIM is a driver for change (Watson, 2010). Succar (2009) suggests that in order to achieve successful BIM implementation, a company must first make use of the potential benefits and understand the need of how BIM implementation is dependent on changes within an organisation. Froese (Froede, 2010), suggests similarly that for BIM to reach its full potential within a company there is the requirement to alter the skills and work practices of its users. Succar (2009) describes within the research framework presenting BIM in a multidimensional setting, that the higher the maturity stage of BIM implementation within a practice, the requirement for larger changes will gradually increase.

Adopting BIM without a plan is described by Deutsch (Deutsch, 2011) as taking a trip unaware of the baggage that can slow you down, and with regard to BIM these items relate to workflows, learning curves, interoperability, insurance, identity and role, mindset, and communication (Deutsch, 2011).

2.4. INDIVIDUAL RESISTANCE

Individual resistance to change resides in the basic human characteristics such as individual's perceptions, personalities and needs. In understanding the importance of change, having the clearest vision or plan is not enough to succeed. There are a number of barriers to implementing change and individual resistance is one of them (Dudovskiy).

Due to the likelihood of employee resistance, change should only be done to accomplish an overall goal and not for the sake of it. Change provokes resistance as people can be afraid of the unknown, do not have an understanding for the need to change, or share the same vision for change (Yuh-Shy, Unknown). Employees may see change as a threat to their current position within a company and therefore resist the change. This type of change is primarily due to the lack of communication between managers and employees causing rumours and speculation (Dudovskiy).

Change occurs at the individual level and for a company to successfully change all individuals within the organisation must change; therefore it is essential to understand how change affects one person at a time (Inc.). ADKAR is an acronym that represents the five key milestones an individual must achieve to succeed with an overall goal. These five milestones are; awareness, desire, knowledge, ability, and reinforcement.

TABLE 2. Change management milestone definitions

ADKAR	Definition
Awareness	Business reason for change
Desire	Desire to engage with change
Knowledge	Having the information to change
Ability	Action planning / implementing change
Reinforcement	Ensuring that change sticks

3. Research Description

The objective of this research area is to explore the following:

- The potential barriers faced by BIM implementation within micro, small, and medium AEC practices in Ireland,
- The identification of the changes BIM brings to AEC practices and how those changes may transpose into challenges,
- The effect of changes introduced by BIM implementation on the people within AEC practices,
- How AEC practices are currently overcoming resistance which has arisen from BIM implementation,
- Aligning a change management plan with BIM implementation to allow BIM to become common practice within AEC practices in Ireland.

This research was carried out through literature review of currently available published material, and stakeholder interviews with AEC practices at various stages of BIM implementation.

3.1 PRE-INTERVIEW QUESTIONNAIRE

Participants were chosen from three different levels within AEC companies in Ireland. The three levels defined were;

- General Management,
- BIM Management,
- BIM Users.

A pre-interview questionnaire was completed by each participant to give insight to the research area and to allow for openness and transparency from the interviewees when partaking in the semi-structed face-to-face interviews. The questionnaire was completed by six of the seven interviewees and covered the following topics:

- Background and professional experience.
- Understanding of BIM and BIM maturity levels.
- Understanding of company's vision for BIM.
- The most significant barriers to BIM.

3.2. SEMI-STRUCTURED INTERVIEWS

Seven individual qualitative interviews were used for the purpose of stakeholder research to collect data from individuals currently working through BIM processes daily. The face-to-face interviews were carried out with a selection of employees from each level within companies in the Irish AEC market. Figure 1 identifies the number of interviewees in each category.

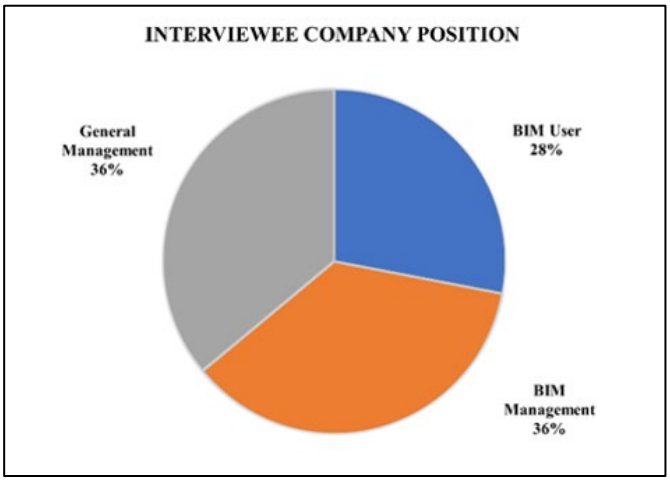

Figure 1. Chart demonstrating company position interviewed.

4. Results

The results discussed are based on deductive analysis of qualitative data collected from semi-structured interviews with individuals from AEC companies currently implementing BIM, along with data collected from the pre-interview questionnaires. Descriptive analysis of interview data was carried out using Excel. All interviews were commented on by the researcher and responses were categorised with general topics discussed.

TABLE 3. Data source figures

Data Source	Respondents
Pre-interview Questionnaire	6
Semi-structured Interviews	7
Total	13

4.1. AWARENESS OF BIM

The interviewees were asked a series of questions to determine an understanding of BIM within the office environment. Concerning the company's vision for BIM this was something that most stakeholders found difficult to define. Five of the seven respondents discussed in one way or another that they believed their company's vision for BIM was to deliver all projects within the office through the BIM process. While this was the consensus, many of the interviewees from both a management and employee level felt a clearer vision was something that would benefit the company and individual's understanding of what the company is working towards. Figure 2 below illustrates the results from the pre-interview questionnaire regarding understanding of company vision for BIM.

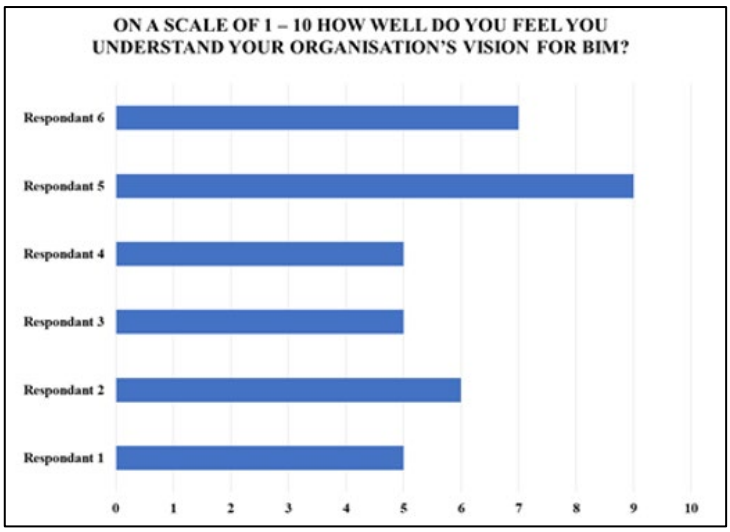

Figure 2. Understanding of company's vision for BIM

Interviewees were asked to describe why there would be a need for BIM implementation within the company which 57% responded that due to the organisation's client demand it was necessary. 14% responded that it would be a requirement due to the company working on government contract jobs, which under the BIM mandate due to be published later this year it would become necessary to deliver jobs through the BIM process. Others felt that company size had to do with BIM implementation, and if BIM wasn't implemented the company would be left behind.

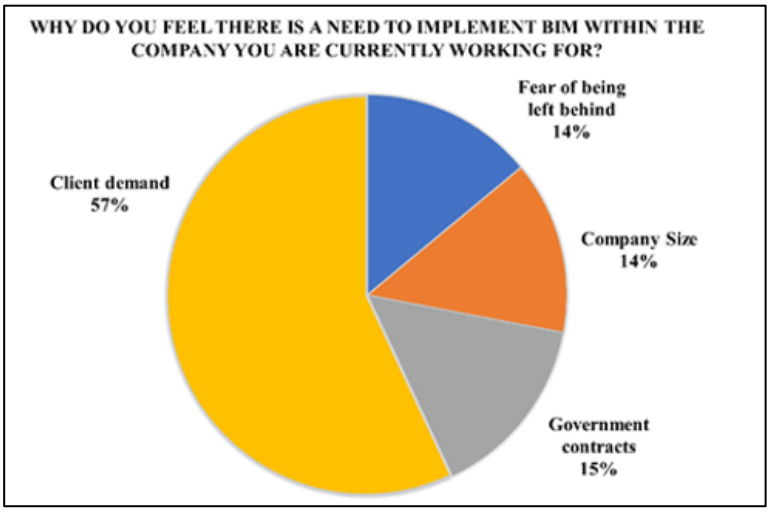

Figure 3. Why there is a need for a company to implement BIM.

In understanding the awareness of BIM within the companies, management were asked a series of questions relating to corporate BIM strategies, the introduction of new roles and responsibilities, and how these roles are defined within the companies. The response to these questions was mixed from individuals within the same companies. The response was that corporate BIM strategies were in place, but it was not something written down and is a broad statement that alters depending on what the client for a specific job wants. Concerning new roles and responsibilities 67% of respondents agreed that the BIM process had brought new roles to the companies, while the new roles are not defined within the company's organograms. One interviewee discussed the longevity of these roles and whether these roles would be better assigned to existing roles within the company.

4.2. BUILDING DESIRE WITHIN COMPANIES

Building on desire within the companies' employees were asked about the involvement of managers regarding BIM implementation. 50% of the respondents reported that managers were actively and visibly involved, while the remainder respondents said that some of the management were more involved than others but in general everyone was trying to come to terms with the understanding of the BIM process. Respondents felt that management could provide more clarity with a visible BIM implementation plan, standards, and protocols, as well as management having a more meaningful understanding of what goes on regarding the modelling aspect of BIM. A topic which was discussed with all interviewees was personal views regarding openness and transparency during an organisational change such as BIM implementation, and 100% of all respondents felt that this is extremely important to avoid the harvesting of resistance within teams throughout the offices.

When looking at desire from a company management perspective, managers were asked to describe any incentives the companies had considered to aid the implementation of BIM. All mangers who were interviewed spoke about educational assistance as an incentive to employees, while employees were aware of the educational assistance it did not appeal to some as it would involve additional hours outside of work. 67% felt that there needs to be more done to show employees the benefits to their working life with the introduction of BIM processes,

and that, that alone is an incentive in itself. Further incentives would be worth considering as there was a general feeling that it would be beneficial in achieving the overall vision for BIM.

4.3. LEARNING ABOUT KNOWLEDGE

The structure around knowledge within the interviews was based on gaining an understanding of in-house standards and protocols, as well as how companies were managing the growth and spread of knowledge within the practices.

Interviewees from the management category within the companies were asked questions regarding in-house standards and protocols of which 66% responded yes that there were standards and protocols in place, but that these were very much a work in progress and not always adhered to by staff. When the employees within the companies were asked a similar question regarding in-house standards and protocols, there was an uncertain response from many of the interviewees. 75% of the respondents were unsure if there were standards and protocols in place, or respondents were aware of some form of standardisation but did not know what this standard was. Interviewees from the employee level were asked if standards and protocols would be beneficial to the day-to-day tasks of the company, of which 100% of respondents agreed some form of structure is required in order to know what should be achieved.

Similarly, both management and employees were asked questions regarding strategies for building knowledge within the companies. Management discussed the availability of educational assistance to staff, as well as a continuous professional development (CPD) program within the offices. While these are in place one interviewee spoke about the need for more formal training as it was very much dependant at the moment on staff being self-driven to want to learn and upskill in the area of BIM. 50% of respondents from the employee level responded that there is an unawareness of any specific training plans regarding BIM, but that there is assistance available if desired. The remainder 50% agreed there was a form of training plan in place for individuals and this was covered within CPDs and within annual KPI reviews.

4.4. ABILITY

While looking at the ability section of the interviews, here an analysis of how companies action the previously studied area of knowledge was reviewed. With management the following topics were discussed; BIM implementation plans, change management strategies, provision of time and tools to learn new processes, and any changes in the output of work since the introduction of BIM to the offices. 66% of respondents stated that there was no BIM implementation plan within the office or that it was not something that was used. The mangers felt that this is something that would be beneficial to the company and that it needs to be made visible to all staff. Respondents also felt the implementation plan should cover BIM as a general topic and not just the information model.

In relation to a change management strategy each respondent covered this aspect differently. Respondent one felt that BIM was not a dramatic change to the company and therefore it had not been put through previous change management techniques. Respondent two felt that change management is a challenging aspect for smaller companies due to the need of recourses to manage it. Respondent two also felt that BIM very much introduced a social

aspect in a manner whereby it requires the need to interact with others, as well as the cultural change aspect of BIM. There was a general feeling towards cultural change that difficulties are experienced with all aspects of it. The third respondent described change management as a work in progress. The shift from 2D to 3D within the office was a significant change that was probably not managed in the way it should have been, the interviewee felt that this may have been the case due to initial resistance from the management team when first introducing BIM processes.

When reviewing the questions asked at the employee level within the companies, the main focus was on the provision made for people who are changing daily work processes. All respondents at this level felt that the provision of CPD training was available to them, that the managers are aware of the competency level within the office regarding the new software, and that this is something that is taken account for within project planning as well as team structures. Two out of the four respondents often felt that a lot of the focus is about getting the modelling aspect of information right which does not always benefit the project. One respondent in this area felt that previously there was a safety net provided by management within the company, but that this seemed to no longer be evident something that can harvest anxiety within employees trying to learn new information.

4.5. REINFORCEMENT

Within the reinforcement section of change, management interviewees were asked to identify the barriers which had been exposed within the company during the implementation of BIM. Within the pre-interviewee questionnaire, interviewees were asked to rank a list of identified industry barriers to BIM in order of importance Figure 4 below identifies the results from the pre-interview questionnaire. The most significant barrier identified was differences in expertise (13%), closely followed by no contractual framework for BIM (10%), and cost of implementation (10%).

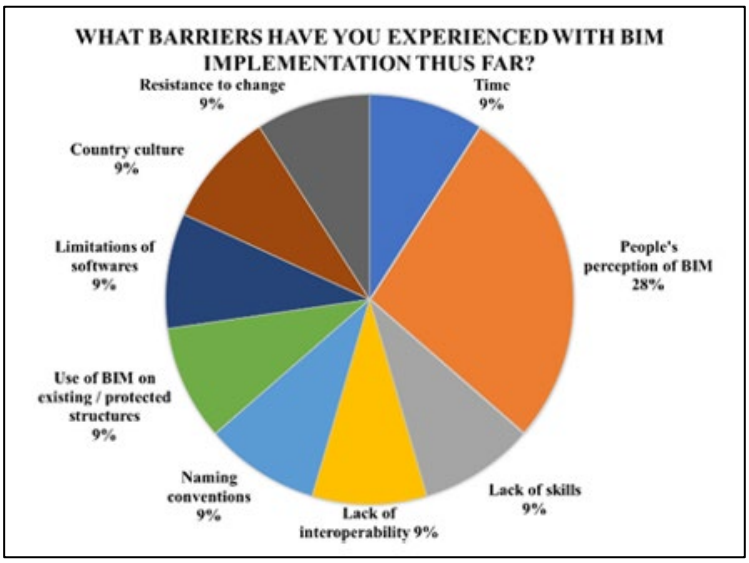

Figure 4. Significant barriers to BIM adoption in the Irish construction industry.

Figure 5 highlights the personal barriers interviewees have experienced which were expressed during the interviewing process. The results from these questions have similarities

with regard to lack of collaboration and time, but many of the responses highlighted by individuals differs from the barriers the industry is facing. The most significant barrier in this case, is time with 28% of respondents highlighting this as a personal barrier.

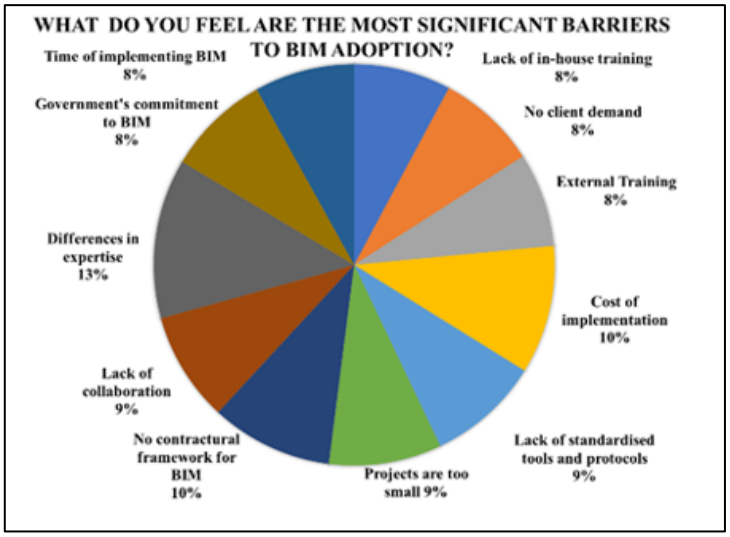

Figure 5. Personal barriers faced during BIM implementation.

Interviewees were also asked to describe the valuable lessons which the companies have learnt through the introduction of BIM processes. 57% of respondents felt that the most valuable lesson learnt is the importance of the collaborative work environment which BIM has introduced. A number of interviewees expressed the reluctance to work with other consultants in the future who do not a least provide a 3D information model. 26% of respondents also took valuable lessons learnt from the less linear process concerning BIM. One interviewee described the process as “everything is happening at once”, while another described the work that is currently going on within the industry as “we are building at an exaggerating rate which is only made possible by BIM”. Other valuable lessons learnt described by interviewees included; the value in a 3D information model, federated site models and clash detection.

Finally, within reinforcement, it was essential to look at the way people were working on a day to day basis. Interviewees were asked if it was often easier to revert back to traditional work methods before the implementation of BIM when external pressures of time etc. were applied. Figure 6 below illustrates the findings from this, whereby 57% of responded yes, it is often easier to revert to traditional work methods.

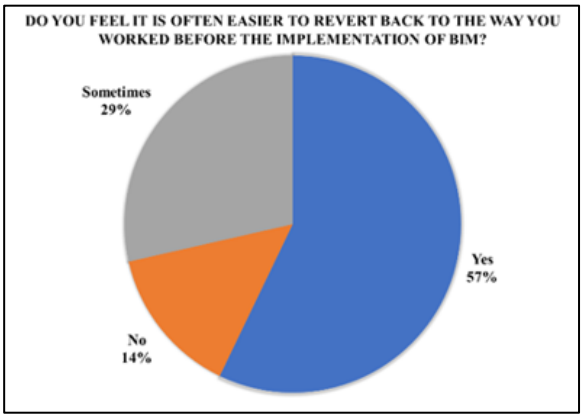

Figure 6. Interviewee likelihood to revert to traditional work methods.

5. Findings

Having analysed the findings of the semi-structured interviews and research into the area of change management methods. Figure 7 below represents fourteen key issues identified within twelve BIM implementation plans. These issues have been identified through a comparison study of implementation plans from three categories; software, academic, and AEC industry professionals (M. Ahmad, Demian and D.F Price, 2012). Figure 7 also defines the stages covered by the Prosci ADKAR change management model which highlights the five key milestones an individual must achieve for change to be successful (Inc.).

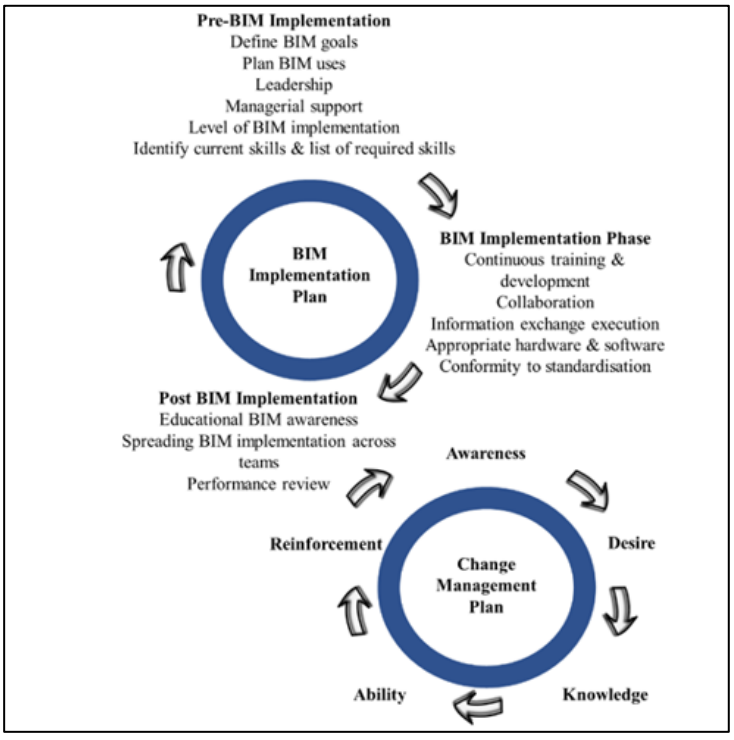

Figure 7. Identified stages of BIM implementation and change management.

The findings of this research paper are represented in Figure 8 which represents a BIM adoption roadmap aligning change management methods with a BIM implementation plan.

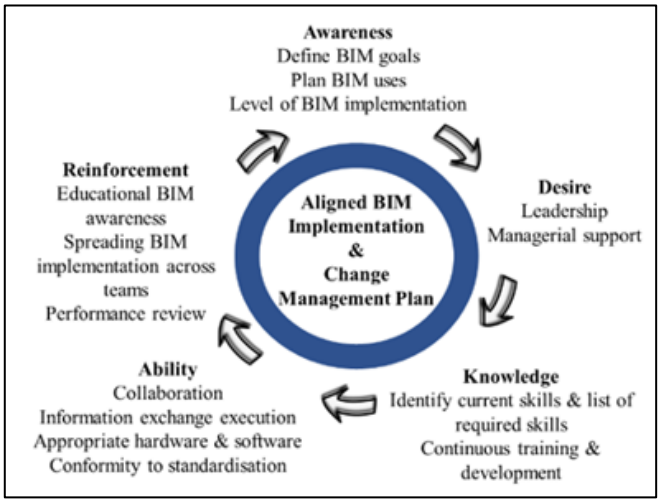

Figure 8. BIM adoption roadmap aligning change management methods with a BIM implementation plan.

6. Conclusions

Comparison between the literature review and the analysed data from the pre-interview questionnaire and semi-structured interviews provided initial direction on how companies are currently managing the implementation on BIM within AEC practices in Ireland. The data collected from the literature review identified some of the barriers to BIM which the industry is facing, and furthermore, the data collected during the interview process identified a different set of obstacles to which SME practices have been exposed. The literature review also identified the changes that BIM brings to a company such as the new roles and responsibilities identified within the BIM process. The interview process with AEC company stakeholders investigates these changes and how companies are managing change within the business. The consensus from the interviewing process resulted that generally, BIM is a significant change to the daily operation of a practice in Ireland and that it is a change that needs to be carefully managed to avoid resistance from both an organisational and individual perspective. Respondents felt that a BIM adoption roadmap that aligns change management methods with a BIM implementation plan could only benefit the transition period, by providing measurable milestones and allow for reflection on change.

Further research into BIM implementation and change management methods is necessary to resolve issues highlighted by the respondents regarding the management of a large-scale change such as BIM. Future work to trial the proposed roadmap will be necessary to show the benefits of delivering BIM with change management.

References

COUNCIL, N. B. (2017) Roadmap to Digital Transition

For Ireland's Construction Industry 2018-2021.

DEUTSCH, R. (2011) BIM and Integrated Design: Strategies for Architectural Practice. New York: Wiley.

DICTIONARY, C. (2019) Organisational Change.

DUDOVSKIY, J. 'Implications of Individual Resistance to Change', Research Methodology.

FARMER, M. (2016) The Farmer Review of the UK Construction Labour Model

FLEMMING, K., FLOOD, P. AND BOSAK, J. (2011) Strategic leadership of architectural firms in Ireland: The role of emotion management and innovation. Doctor of Philosophy, Dublin City University, Dublin City University.

FROEDE, T. M. (2010) 'The impact of emerging information technology on project management for construction', Automation in Construction, (19), pp. 531-538.

HORE, A., MCAULEY, B. AND WEST, R. (2017) Building Information Modelling in Ireland 2017.

HOWARD, R., RESTREPO, L. AND CHANG, C.-Y. (2017) 'Addressing individual perceptions: An application of the unified theory of acceptance and use of technology to building information modelling', International Journal of Project Management, (35), pp. 107-120.

INC., P. An introduction to change management guide. Available at: https://empower.prosci.com/introduction-to-change-management-guide (Accessed: 24th April 2019).

IRELAND, E. (2007) SME Definition. Available at: https://www.enterprise-ireland.com/en/about-us/our-clients/sme-definition.html (Accessed: 24 March 2019).

IRELAND, T. S. O. C. S. (2015) Irish Construction Prospects to 2016.

LAUMER, S. AND ECKHARDT, A. (2012) 'Why Do People Reject Technologies: A Review of User Resistance Theories ', Information Systems Theory: Explaining and Predicting Our Digital Society Centre of Human Resources Information Systems, University of Bamberg: Springer Science+Business Media, pp. 63-86.

LINDBALD, H. AND VASS, S. 'BIM implementation and organisation change: A case study of a large Swedish public client', 8th Nordic Conference on Construction Economics and Organisation: Elsevier B.V., 178-184.

M. AHMAD, A., DEMIAN, P. AND D.F PRICE, A. 'BIM implementation plans: a comparative analysis', Annual ARCOM Conference, Edinburgh, UK.

Marley, F. (2015) Exploring the impact of the aging population on the workforce and built environment: The Chartered Institute of Building. Available at: https://policy.ciob.org/wp-content/uploads/2016/01/CIOB-research-Exploring-the-impact-of-the-ageing-population-on-the-workforce-and-built-environment.pdf.

MCGUCKIAN, R. (2000) *Communicating for Organisational Change.* Doctor of Philosophy, Dublin City University

NBS (2018) *National BIM Report 2018*.

PUBLICATIONS, E. A. I. (2005) *The new SME definition - User guide and model declaration*. Available at: https://www.enterprise-ireland.com/en/About-Us/Our-Clients/SME-Definition-Guide.pdf.

SUCCAR, B. (2009) 'Building information modelling framework: A research and delivery foundation for industry stakeholders', *Automation in Construction,* (18), pp. 357-375.

UDDIN, M. AND R. KHANZODE, A. (2014) 'Examples of How Building Information Modeling Can Enhance Career Paths in Construction', *Practice Periodical on Structural Design and Construction,* 19, pp. 95-102.

WATSON, A. 'BIM - A driver for change', *International Conference on Computing in Civil and Building Engineering*: Nottingham University Press.

WU, W. and R.A. ISSA, R. (2014) *Key Issues in Workforce Planning and Adaptation Strategies for BIM Implementation in Construction Industry*

YUH-SHY, D. C. (Unknown) 'Individual Resistance from Employees to Organizational Change', *The Journal of Global Business Management*.

QUALITY AND RELEVANCE IN TEACHING
Digital Learning processes for BA Graduates in Architectural Technology and Construction Management

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Abstract. Development of digital learning courses across institutions 2017 - 2019. The project aims to describe the process of preparing digital online learning courses across the sector. The Ministry of Education has allocated DKK 5 million to the project. Nine business academies participate, and these are the building construction (BK), Service economists (SØK) and Finance economists (FØK) programs. The participants involved from the academies all have different business and teaching skills. The aim of the project was to develop online learning courses across the academies, thus pooling resources nationally rather than regionally. The previous government introduced a period of six years; from 2016, where two percent were to be saved in the education sector. This should result in a saving of four billion kroner on higher educations. Thus, academies have to look at the way they have been teaching until now. This means more students in the classes and a change in the way teaching has been carried out previously with focus on the individual student, to now being more based on lectures as done at the universities. The project has had several tests with large variations in the results. The project has been challenged by the fact that it has been a "voluntary" learning process, where the students have had to spend their free time completing. The LMS is one of the most important factors when talking about learning across the sector. Right now, different Learning Management Systems (LMS) are used at the individual academies due to current procurement rules. Until it is realized that a common LMS is a necessity for a joint offering, digital learning across the sector will not become a reality. The project participants who have prepared the learning courses are without any influence on the sub-elements to be implemented at their individual academies. Therefore, it is important to involve the management of the academies, so that they automatically become a part of the project's results throughout the process. It is

imperative to look at which measures can be taken to meet the pressure that the individual programs are currently facing.

Keywords: Learning Management System, Digital Learning, Online learning, Digital resources, Five Stage Model.

1. Introduction

The Danish education sector is greatly impacted by the fact, that the previous government introduced a budget reduction of 2 % annually for a period of six years; from 2016 – 2022. This action is intended to save DKK 4 billion in the area of higher education. As a response, the academies had to examine the way they had taught and practiced previously and try to embrace new ways of fulfilling the ECTS goals for the students. This has resulted in e.g. that more students have been accepted and placed in the classrooms and changes in the way teaching has been performed with a previous focus on the individual student, to lectures in auditoriums or large class rooms much as is practiced in universities.

Therefore, several of the academies - internally - seek to apply supplementary digital online learning processes, where students can learn, when they are susceptible to learning. The overall purpose of the Kvalitet og Relevans i Undervisningen (KRU) project is to develop national, interdisciplinary and digital learning courses that ensure relevance and quality in education at the business academies in Denmark. Thus, the students gain the digital knowledge, skills and competencies that match the tasks that the jobs of the future offer. The project focuses on skills that relate to those used in the labour market and in companies in the 21st century, 21st Century Skills.

2. Developing digital learning courses for students attending architectural technology and construction management across institutions.

The project consists of three sub-projects, including one project focusing on learning centres and two focusing on learning processes. The architectural technology and construction management (BK) and Service Economics (SØK) programs are both included in one of each type of subproject. The project is supported by the Ministry of Education with a funding of DKK 5 mill. and will run from August 2017 to December 2019.

The project partners consist of the following educational institutions for the KRU project:

- UCL University College
- EASJ – Zealand Academy of Technologies and Business
- KEA - Copenhagen School of Design and Technology
- EASV - Business Academy Southwest
- VIA - Via University College

The project is owned by SmartLearning, which has facilitated a collaboration between the country's nine academies and the Copenhagen Business Academy as legal responsible. SmartLearning is responsible for the joint academy and resource centre of the business academies, and has more than 20 years of experience in providing online continuing education to businesses.

The purpose of entering the collaboration between the various academies is based on the volume of students. By establishing a digital collaboration across the academies, a total number of approx. 25,000 / year students is achieved. The volume of students corresponds to a medium-sized university in Europe, which means that we can help set the agenda for future teaching. The KRU aims to see whether digitalization of education can improve quality regionally and nationally, by better utilizing digital resources across the sector.

2.1 DIGITAL LEARNING COURSES FOR ARCHITECTURAL TECHNOLOGY AND CONSTRUCTION MANAGEMENT

The purpose of the learning process for BK is to gain insight into the possibilities of digital collaboration across the sector. This should hopefully result in:

- The staff of the participating academies acquire skills to teach in the new e-didactic teaching arena
- The students have access to online digital teaching material across the academies as well as the opportunity for online collaboration
- Leadership at the various academies gain insight into the potential of digitalizing teaching as well as collaboration across the sector

In this way, learning opportunities are created for students who want more offers that can help prepare them for the profession they will join after completing their education. With digitalization of the classroom, you also have the opportunity to develop learning environments that allow the students to study and learn at the pace and level, which match the individual student's needs.

By the end of the project, the intended output will consist of developed materials for conducting a digital online learning process that have been thoroughly tested. Testing must be completed over three stages corresponding to a completion in autumn and spring 2018 as well as the final completion in autumn 2019.

3. Learning Management System (LMS)

The project had a mandatory requirement which was the use of LMS Moodle, which is the platform used by SmartLearning to implement their online courses. Like many other platforms, the LMS Moodle has a lot of different functionalities and tools that can be set up to guide students through the learning processes, focusing on either the teaching material or the individual student's learning styles.

Using the predefined platform for the LMS in the project has contributed to many challenges in developing a learning process across the whole sector. This is partly due to the fact that different platforms are used at the individual institutions, such as Canvas, Itslearning, Fronter19, etc. The challenges can therefore be divided into two categories consisting of:

1. The teachers who will prepare the learning courses
2. The students who will use / complete them.

The teachers who participated in the preparation of these learning courses did not necessarily have the prerequisites for setting up the various tools, and the implementation of the teaching. This may have contributed to unnecessary frustration for the students who were to complete the courses and may also have contributed to a lower participation and completion rate. In addition, the participants have had very different approaches to the project in terms of

their professional skills and teaching experience. As the project is external to all participants in relation to the academies at which they are employed, there are no plans for the project regarding implementation of the results.

The students involved in the various test runs have had very different prerequisites for participating in the learning courses offered. Some students use Moodle as their standard LMS, while others may have used one of the other aforementioned LMS's. Thus, many students not only had to acquire a new way to learn, but also had to familiarize themselves with a new LMS. These two parameters, based on the feedback obtained by the students, resulted in several participants not having the energy, motivation nor incentive to participate in the further implementation.

4. Developing the digital learning course

KRU is, as previously described, an external project that attempts to develop learning programs that are scalable, where the developed concept can be made larger or smaller depending on the needs of the education program. In the course of learning for BK, two types of implementations have had our focus. The first focused on an asynchronous teaching environment in which students could complete the activities at the time of day that suited them. The other type of implementation was with a similar freedom and facilitated more. Here the lecturers would be available online for a predefined time period Monday through Friday.

As the project was external, implementation of the learning courses could not take place during regular teaching hours but had to take place in their spare time. This was because the students should not be forced to choose between their compulsory subjects and the supplementary learning course offered. The students' participation was also voluntary and the only recognition they would gain was "supplementary" learning that was beyond their curriculum.

The process that we planned for the students was based on four stages.

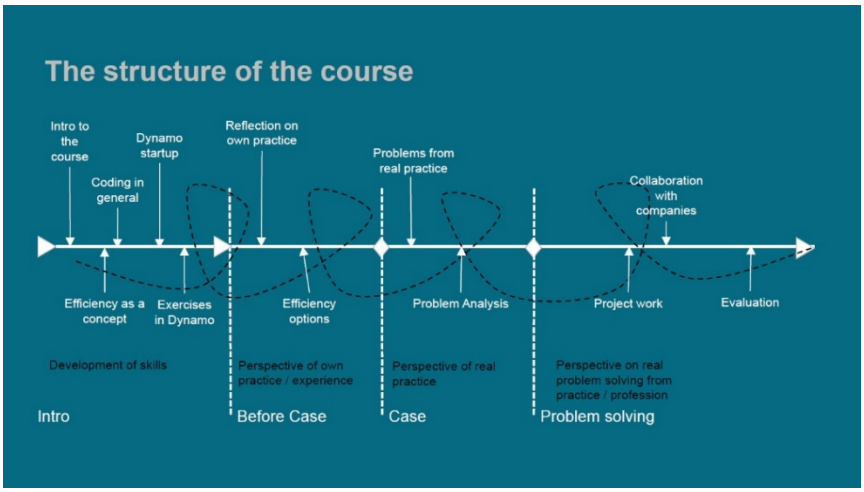

Figure 1. Showing the overall structure for the planning of the learning process.

- Step 1: The students were introduced to a professional subject, whereby they had to acquire some skills in order to proceed to step two.

- Step 2: Here the student had to relate to his/her own practice. These may have been things that they had previously worked with or some experience they had gained through working on their multidisciplinary projects from their regular in-class teaching.
- Step 3: Here the students had to deal with a specific problem that they had intentions to solve based on their own experiences.
- Step 4: The students receive a specific problem from an external partner, which they then had to solve in groups. External partner could provide the students with relevant cases. They were obligated to allocate a minimum of resources to guide and evaluate the students' output. In this way, the students start to establish a network in their upcoming field. Unfortunately, the last part has never been implemented in the experiment, as the resources were not allocated to establish viable collaboration to the industry.

In connection with the planning of Step 1 - Intro, a process diagram was prepared with the intention to help make the process visible to the project participants and ensure the optimal learning for the students.

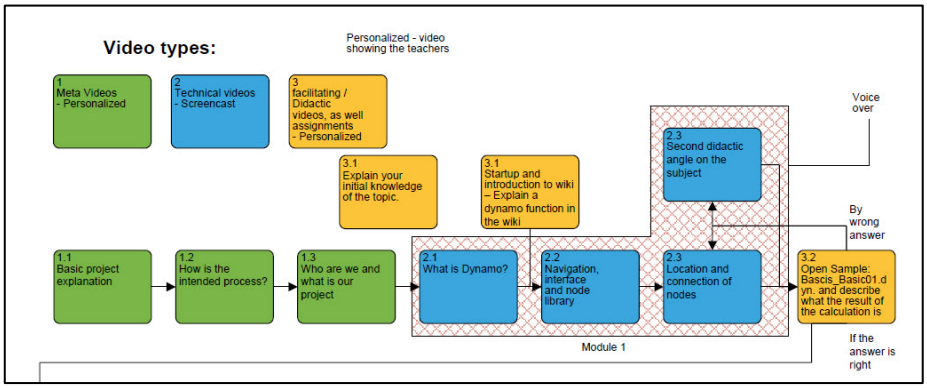

Figure.2. Showing the process diagram with teaching progress sub-tasks as well as video types (KRU, 2017-2019)

The process diagram is divided into three categories of videos consisting of meta, technical and facilitative videos, which can be defined as follows:

- Meta videos: These videos introduce the students to the course itself, the practical details and the intention of it.
- Technical videos: These videos introduce the academic material the students should work with. In this project there are videos showing the working method in the digital tool Dynamo which is a plug-in to Revit (subject selected for the courses).
- Facilitating videos: These videos introduce the students to the work of 21st Century Skills on which the progression of the curriculum is based.

The online Dynamo course for BK has been conducted on several occasions both externally and internally at UCL with very different results. There have been courses with high attendance and completion of the course, and low attendance with no implementations. The large variation in the learning courses meant that we set out to investigate the background of the participants. Due to a lack of experience regarding digital learning environments, we realized that we had not addressed the social relations in an online learning environment.

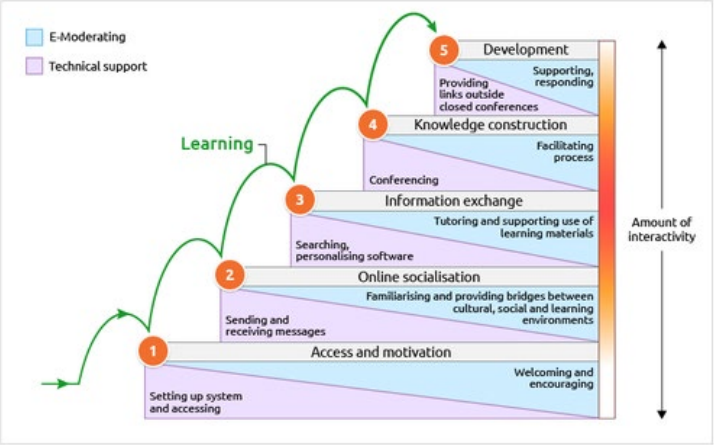

Figure 0.3 – Showing E-tivities in the Five Stage Model, Salmon, 2013, p. 16

Therefore, the third implementation was built with the principles of the "Five Stage Model", focusing on the individual E-tivities (phases). In particular, we focused on the two lower ones that relate to “Access and Motivation” and “Online Socialization”. "Access and Motivation" was used since most of the students would not have in-depth knowledge of the LMS used for course implementation. It was therefore important that they introduced students to the various elements, at a level that was based on the individual's prerequisites. “Online Socialization” was used in an attempt to create the framework for the online community that would help support student learning in a practice community (Lave & Wenger, 2003)

We created several compulsory tasks for the students, such as the presentation video (E-socialization of the course participants), in which the student had to tell the other participants about themselves based on criteria from the project group. This was done in order to put a face to the names of the participants as the course was intended to function as an asynchronous learning process. This meant that the students did not have the opportunity to form relationships as in a regular classroom setting but had to relate to the presentation uploaded by the individual students.

The third level "Information Exchange" we tried to solve by setting up "chat rooms", "discussion forum" and "online video tutorials", where we as lecturers were available online face-to-face by a webcam between 14-16 pm. Monday through Friday. This time slot was chosen so that we did not force the students to priorities the digital learning process over in-class teaching in the morning and afternoon hours.

The fourth "Knowledge Construction" and the fifth phase "Development" intended that students participate in a dedicated forum for "Further development and knowledge sharing" and through a database that acted as "Case Bank", should be able to communicate their results or shortcomings on these in an attempt to acquire and share knowledge.

Unfortunately, the third course of learning was scheduled at a poorly chosen time, which meant, that none of the students who had signed up, managed to complete the course. However, the continuous feed-back reactions that we received from the students indicated that they did not want the social relationships in the learning process, when it was supplementary learning that they were trying to achieve. Or as one student expressed:

I don't think the course type is for me. I am not interested in having to comment on other people's posts and make presentation videos. I just want to start some learning without having

to do everything, which for me, is irrelevant first. I really want to master Dynamo, but I guess it then will have to happen in other ways.
Best regards Thomas "Implementation" BIM - Dynamo "

We have decided that in the fall of 2019 we will complete two more learning courses which will run simultaneously. One will be focusing on the individual student without the previous assignments and without the purpose of achieving Communities of Practice. The second one with a greater visibility of the lecturer for the scaffolding of the individual students. In this way, we hope to gain a greater understanding of what motivates students in an online learning environment.

4. Conclusion

The development of digital learning courses has become the new "Buzzword" in large parts of the education sector. These digital learning courses shall in the long term, help ensure the students receive the necessary learning.

Many different learning processes are being prepared internally at the various academies, but there is no national strategy for how to handle the online digital process. The KRU project's results are characterized by being an external project with no connection to the individual academy. For the students it has been a voluntary participation without any recognition (ECTS points), which meant that many students have chosen not to participate.
The lecturers who have participated in the KRU project have gained competencies in the preparation of the e-didactic learning environment. The problem, however, is that the project participants' workloads have not been duly considered. As described earlier, this presented some challenges due to large variations in the individual's competencies and interest in the project.

The students have gained access to online digital teaching material with the KRU project but have had major challenges as regards the LMS used. In order to be able to streamline digital learning environments across the sector, it is necessary that we solve the problem regarding the various LMSs at each academy.

The management at the various academies could have used or contributed to the unique opportunity that has been elaborated in the KRU learning process to a higher degree. In future projects, more focus should be placed on involving all levels to ensure anchoring of the results in each academy.

Acknowledgments

I would like to thank my project team Birgitte, Line, Jacob, Rasmus, Mikkel and Lars for their participation. The project has had many challenges but we have all achieved some results that we can use in the preparation of digital learning courses.

References

Deloitte, 2019. Analyse af muligheder og barrierer for e-læringsforløb samt forslag til nye forretningsmodeller på voksen- og efteruddannelsesområdet. Deloitte

Hattie, J. Søndag. Marts 2013. Se Hatties topliste: Hvad virker i undervisningen. Hentet fra Gymnasieskolen.dk: https://gymnasieskolen.dk/se-hatties-topliste-hvad-virker-i-undervisningen

Hattie, J. 2013. Synlig læring - for lærere. Dafolo.

Hiim, H., & Hippe, E. 2009. Undervisnings planlægning for faglærere. Gyldendalske.

Holgaard, J. E., Ryberg, T., Stegeager, N., Stentoft, D., & Thomassen, A. O. 2014. PBL - Problembaseret læring og projektarbejde ved de videregående uddannelser (1. udgave udg.). Frederiksberg : Samfundslitteatur.

Illeris, K. 2009. Læring (2. udg.). Frederiksberg C: Roskilde Universitetsforlag.

Lausch, Jens Ager Hansen & Bente. 2010. Klasseledelse i erhvervsuddanelserne (1. udgave udg.). Odense SØ: Erhvervsskolernes forlag.

Lave, J., & Wenger, E. 2003. Situeret læring og andre tekster. København: Hans Reitzels forlag.

Rogers, Y., Sharp, H., & Preece, J. 2011. Interaction Design - Beyond Human-Computer Interaction. John Wiley & Sons Ltd.

Wenneberg, S. B. 2010. Socialkonstruktivisme - Positioner, problemer og perspektiver.

Aarkrog, V. 2018. Teorier om læring - Anvendt i erhvervsudannelsernes didaktik. København: Munksgaard.

Appendix 1

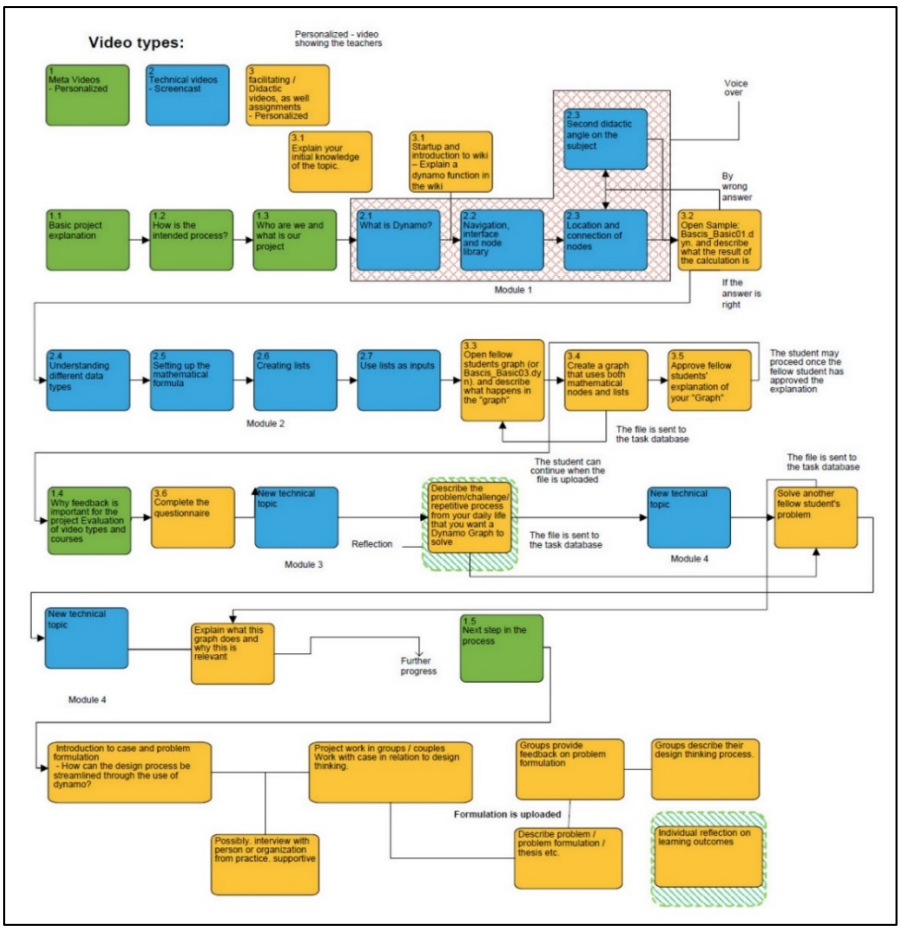

Figure 0.1 - Showing the overall process diagram with teaching progress sub-tasks as well as video types (KRU, 2017-2019)

REFURBISHMENT OF BUILDINGS WHILE MAINTAINING THEIR IDENTITY AND THEIR HISTORY

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Abstract. The activity named "refurbishment of buildings" contrary to the activity of "restauration" very often covers a hidden ambition to make the building look like a brand-new design, which is in fact not refurbishment but "modernization". Modernization hides older features and structures and pretends to be the state of the art, but most often fails to reach its goal. Most commonly, the result is a mismatch to both old and new – a kind of kitsch (Barrett and Kruse, 2016).

It often takes place when the actual building is not very old and therefore not recognized as an interesting message from the past as it would probably have been, had the age been about 100 years or more. Buildings 30 – 90 years old tend to possess appearances somehow outdated but without the old buildings different charming characteristics. Characteristics that most people will appreciate and try to maintain (Vadstrup, 2004).

Today "modernizing refurbishments" take place due to increased requirements in building regulations and ecological trends combined with recently developed possibilities plus the fact that the buildings after 30-40 years appear a bit worn. On this account, we are about to lose significant architectural messages from newer periods of time. Very often, the well-meant refurbishing activities result in less interesting and less valuable buildings and structures and even more damaging is the fact that the important historical telling about that period might be more or less lost when it comes to architecture (Illies and Ray, 2014).

Consequently, this paper suggests an initial survey and advisory report to identify significant historical characteristics whether these are mainly architectural or structural or a combination of the two. The survey needs to be systematic and undertaken by professionals on behalf of the local authorities. A specific method is suggested by the paper, which also suggests that the application for building permit must account thoroughly for how the advisory report has been followed in the presented project.

Keywords: Building, Refurbishment, Modernisation, historical characteristics, method.

1. Appreciation of buildings 30 – 90 years old

This is not easy. The phenomenon called "fashion" is a psychological and mental factor in most people including the building professionals. All try to follow the ongoing development in what interests in professional circles and in society as well. Everybody tends to be tired of specific features and physical phenomena when seen very often in a period. To be first with the new is a highly appreciated position in society. Because of their leading role in the shaping of buildings, the professionals are the first to introduce a new trend and therefore automatically also the first to leave an established order. Despite of this, the good professional is also eager to make his or her designs good pieces of architecture, which is a quality that will prove to stand the test of time and not only impress when it is brand new (Lawson, 2006).

Some might say that we live in a period where more buildings than earlier tend to be fashion only and therefore are lacking architectural qualities. What is it that characterizes buildings that deserve to be appointed pieces of architecture? They impress the mind in a subtle way. Not by size, not by being smart or trendy even if they also can be all that. No, good architecture leaves a picture in the mind that one remembers but can hardly explain in other ways than calling it a piece of art with utility applications (Botton, 2014; Illies and Ray, 2014). In architecture the art is most often imbedded in the close relation between the purpose of the building and the way it performs (Barrett, 2011). A professional judgement requires the ability to identify architectural significance in the building itself and distinguish it from other noticeable factors like for example who designed it or how well known it is (Gideon, 1967; Grafe, 1960).

The value of a building, new or old, depends mainly on its performance. How does it act in its own right and how well does it integrate in its environment? Both factors are very important for its value. A nice building in a dump area has very little value and the same counts for a bad building in a very nice area because it tends to pollute its surroundings and can't live up to the surrounding standard. Once all valuable old buildings had a period when they were not the state of the art anymore and had not yet achieved any ability to establish historical interest in society. Only the few buildings that became famous from the very beginning tend to be appreciated by society when they have reached that period. This will normally be among the professionals who know the building as a historical architectural monument – often one that has served as a role model. However, their judgement might be ignored by powerful people, with no interest in the survival of the buildings, who want to replace them or refurbish them in a way that will, most likely, turn them into structures of less architectural value or simply replace them with something brand new. Two Danish examples of this are the Viking Ship museum in Roskilde, about which there is an ongoing public debate, and the Hoje Gladsaxe tenement buildings both placed at Zealand DK (Faber, 1977; Kühn-Nielsen, 2000).

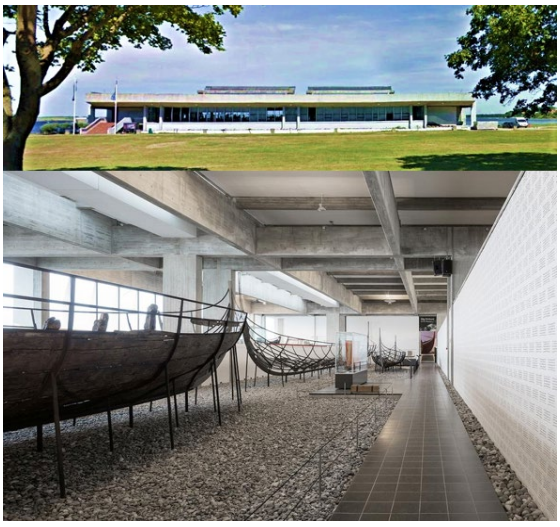


Figure 1. The Viking Ship museum in Roskilde- outside and inside. Google Earth, 2019 and the newspaper Politiken, 2019

The Viking Ship museum is a listed building, which the museum leadership has convinced certain politicians to believe should be replaced with a new structure. That ignores the fact that all professionals see it as a historical architectural Danish monument expressing the

architectural style called brutalism in a most interesting and significant way, which is even more impressive in the interior than in its exterior (Damgård-Sørensen, 2001).

The Gladsaxe tenement buildings are placed in the landscape outside Copenhagen where they overlook an area of open land down to the motorway. Each building block was originally seen as s series of horizontally stacked white balcony ribbons parted from each other by deep dark shadows. From a distance it was a fine elegant contrast to the green hills they were placed on and it looked rather impressive seen from the motorway (Faber, 1977). This, their most significant characteristic, vanished 40 years later when the blocks were refurbished as it can be seen below.

Figure 2: At the top the Hoje Gladsaxe tenement buildings as they appear today. Below are two images showing how they looked at both main facades before and how they now look much newer after the refurbishment of the park facade. Google Earth, 2019

The described concrete brutalism characteristics of the tenement blocks were replaced with a glass facade with quite as many vertical as horizontal frame members. Thus, the original horizontal white concrete ribbon significance was replaced with a less strong appearance indicating that the blocks belong to a newer period. The historical statement is gone, and the architectural integrity is corrupted. The flats might be more comfortable, but that might have been achieved without such significant changes in the historical appearance.

Both examples were very typical for their period and they were noticed by both professionals and all society (Møller, 1996). Now, groups of ignorant people aim to or have already been successful in destroying their historical telling and their most impressive architectural characteristics (Faber, 1977). How can this tendency to underestimate the value of not new and not yet old pieces of architecture be met with qualified means by society?

It must be stated that all this is not about what is the best looking, which is a question about taste, but alone about the historical telling of buildings that, at the beginning, were seen as symbols of new trends. If the architectural history should be kept in the build environment it is necessary to keep the better and most significant examples of the different periods and that is precisely what this is all about. However, the chosen examples are just meant to illustrate the problem that requires more care from the building authorities. They need a better regulation

together with a qualified judgement. How that can be realised is what the following will concentrate on.

2. Appreciation of the individual building in its environment

In the above text, it is already indicated that the value of a building not only depends on the building itself. Normally the value depends first and foremost on how the building performs in its environment. Even buildings that are seen as architectural manifests by professionals and historians cannot keep their full original value if their appearance is not somehow supported by their surroundings. An example of this is the Schroder House by Gerrit Rietveld.

The Schroder house ignores its environment to the same extend as Rietveld's red and blue chair ignores the meeting with the human body. The house is most charming in its own right but first and foremost it can be said that the only thing that justifies the existence of the building at the chosen spot is its status as a manifest of the modern style. A trend that should break with the existing building culture and show the free and relaxed life of the future when it was built back in 1924-25 (Bacon, 1975; Frampton, 1980; Van Zijl, 2016).

At the chosen spot the building states that it is as different from the others as can be, and that might not have pleased the neighbours. It does not want to accept the existing order. This also indicates that it belongs to someone who wants to establish a distance to the rest of the local society (Van Zijl, 2016). A reflection on that might conclude that it is not a democratic behaviour – it is a mere revolution. But the one who wins in a revolution will afterwards govern and so did the modern style and its complex of new ideas (Gideon, 1967).

Figure 3. The Schroder House totally ignores the characteristics of its environment. The houses to the left existed when it was built. To the right Rietveld's Red and Blue Chair Google Earth, 2019

Ever since the time of the Schroder House, many architects have followed the principle of Rietveld and apparently ignored existing environments in their eager to express the ideas they, at the time, are most occupied with. All the old was no good. Thus, we have numerous of additions to buildings, infill new buildings, and refurbishments that do not fit into their environments (Barrett and Kruse, 2016). The result of this is fewer good "positions" as the real

estate agents would call it, and people are less attracted than they would have been had everything been better integrated (Barrett, 2019).

The most successful buildings when it comes to attractive value are those that appear the best within environments of high integrity. High integrity is established by a combination of several factors. Among those order and complexity are very important. Order, because it establishes a feeling of safety and complexity, because it establishes an entertaining environment. It is a pleasing order when not two buildings are the very same in an environment where a human scale is respected when it comes to the size of the buildings. This might not be the way of thinking of most professionals, but it is in line with the reaction of the common users of buildings and built environments (Barrett and Kruse, 2016).

Even if the terraced buildings to the left of the Schroder House are in a human scale, they are too much the very same to establish an entertaining level of complexity. It is obvious to all that they were all a result of the very same investment initiative, whereas the Schroder House obviously was made for an individual. The attempted order in the neighbourhood is that all buildings are the same and that is boring. Then the order was broken by the Schroder House, which was unpleasant simply because it established uncertainty. It had been much better if the established order had been that no two buildings were the very same even if they had all been of the same kind or if the differences had been within the same limits. That would have made "a good position" (Barrett, 2019).

Figure 4. Sluseholmen in Copenhagen shows the balance between order and complexity people in general tend to feel attracted to. Small individual looking buildings lining up in rows instead of the usual terraced buildings (Barrett, 2019). Google earth, 2018.

All this argumentation is meant to qualify identification of the characteristics that create value for society, which is also what create value for the individual owner. Such characteristics are what those professionals who are going to refurbish existing environments and individual buildings in general should pay respect to. One should normally not ignore the environment when planning a refurbishment of a building and when refurbishing a whole environment, one should not ignore any of the buildings that establishes it. One simply must "kill one's darlings" and pay respect to existing qualities in buildings and environments when refurbishing. Order is always a must and a certain entertaining complexity should also be it (Botton, 2014; Barrett and Kruse, 2016).

3. Identification of architectural historical characteristics

To identify the most important characteristics of a building and of an environment one is going to refurbish requires insight on periods and styles of the time of the establishment. How did the original designers see their designs and the messages they were giving by the help of their architectural language? Whether this question can be answered or not, it is relevant to ask and find answer to the question of what the style and period tended to stress and what was less important. This is necessary knowledge to maintain the historical telling of the items to refurbish.

The Schroeder House is historically a special building with a unique and interesting history. It is in three dimensions what Piet Mondrian's paintings are in two dimensions. Rietveld and Mondrian were both members of the De Stijl group of artistic pioneers for the modern movement. The house is their best-known architectural statement to show their way of thinking and the lifestyle they suggested (Frampton 1980; Gideon, 1967, Van Zijl, 2016). It is the significant architecture plus its fame and place in the history of architecture that makes the building important and worth maintaining - not its performance in the surrounding environment. It is also the modern artistic and very innovative architecture of the building that has caused the fame of the architect. In fact, he managed to tell a "fairytale" in architecture.

For other historical buildings like for example H. C. Andersen's house in Odense it is the fact that a famous person lived there that makes it important to keep and maintain it. This time it was the telling of real fairytales that created the fame. The great poet was so kind to be born and live his first years in the building but the building itself is very ordinary and in no way outstanding.

Thus, any refurbishment and maintenance of the building need to keep and maintain all that can testify about the period and life circumstances of the Andersen family when he was a wee boy. It is also important for the story that the environment around the building supports the experience of a provincial lower-class environment at that time. All this has to a certain extend been possible because Andersen became famous relatively early in life so that the city of Odense has been keen on keeping and maintaining the surrounding areas ever since, to be able to show the humble place of birth of the great man.

Figure 5. The yellow washed corner building is the humble dwelling where H. C. Andersen was born. When built it was more fashionable with regular brickwork than half-timbered constructions. Therefore, the timber is yellow washed like the rest of the wall in contrary to the building to the right where the timber frame is expressed. Google Earth 2019

However, in most buildings and environments to refurbish it is mainly the characteristics of the style and the period when they were established that needs attention. Sometimes there

might also be something a little unique and individual to recognize and to keep and stress. Normally, the original designers have had their own likings and habits a bit different from others and when emphasizing this, the story of the building or environment becomes more interesting. The users of the building might be able to tell stories about it and might appreciate the value more. Therefore, the refurbisher will try to notice and keep such personal characteristics.

3.1. COURSE OF ACTIONS TO PREPARE THE REFURBISHMENT

1. As a practical precaution a professional consultant appointed by the authorities could first note, in as simple terms as possible, the well-known main characteristics of the specific style or trend to which the building belongs.
2. Then the consultant should look at the building and see if any of the general well-known and individual characteristics can be noticed and then make a photographic documentation along with a description to explain what is identified.
3. Finally, it should be decided how the identified characteristics can be kept and maintained.

These three steps are always necessary to secure a decent version of refurbishment. This is because the identified characteristics are typically serious parts of the reason to refurbish instead of replacing the building with a new one. The good characteristics might be linked to the environment in which the building is placed and the extent to which it fits well into this environment (Barrett and Kruse 2016).

To the "architectural historical characteristics", which is the headline of this section, belongs also the structural solutions that are integrated parts of the architecture. They always go hand in hand with what can be seen at the outside and the inside surfaces of a building. Sometimes, the structure is a relatively hidden phenomenon and sometimes it is the basis of the main architectural story told (Frampton, 1980).

For example, went the above mentioned "brutalism" as a style more or less hand in hand with what was also called "structuralism". In that period the load bearing system of a building often was used as the main architectural narration like it was far back in time when the gothic cathedrals of Europe were made. A third Danish example is shown below (Faber, 1977).

Figure 6. Refurbishment work going on at a brutalism piece of architecture in Copenhagen - the Panum Institute (1974-1976) Will the whole upper concrete part be enveloped in glass for the sake of insulation, or what will happen? Google Earth, 2019

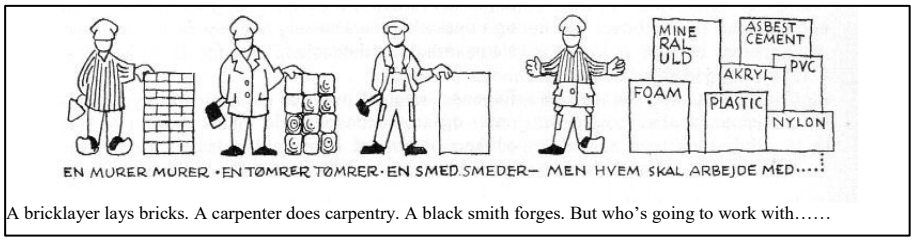
In this late example of brutalism, a delicate tension is established by the contrast between the covering plinth of brickwork and the displayed upper skeleton of concrete columns and beams. This is like when the contrast between a tweed jacket or knitwear and a silk shirt creates a desired tension by opening to a more intimate part of dressing. Of course, it is important to keep this effect if one is going to refurbish the building.

For practical reasons, the structural part of the architecture to refurbish is discussed separately in the next section of the article.

4. Identification of structural historical characteristics

The historic period we are concentrating on from around 1920 to 1990 is a period in which the development took the construction industry from building methods utilizing the traditional handicrafts to a situation where handicraft was totally replaced with montage of industrialized components. The "handicrafts" were not just handwork, but techniques developed and refined over a millennium. The industrial development where machines are used to replace works previously done by hands also resulted in works and results based on what only machines can do. But both in 1990 and today 30 years later the construction industry is far behind all other main industries. They have all totally left the idea of reaching handicraft-like results with products based on what only machines can do. Also, the key roles of the actors in the industry is still stuck in the tradition from before industrialization (Kristensen, 2015).

Around 1920, pioneers of the modern movement like Rietveld began to design buildings that looked as if they were fully industrialized and not results of traditional handicraft. Their aim was to meet the future as fast as possible and they designed their house structures of materials that did not belong to the traditional handicrafts. They used reinforced concrete and other new materials causing the problem visualized later in the Danish "Byggebogen" in 1969:



A bricklayer lays bricks. A carpenter does carpentry. A black smith forges. But who's going to work with……

Figure 7. The result of the use of new materials in the building industry (Byggebogen 1969).

Even if the pioneers of modernism aimed to use the newly invented industrially made materials, they often had to face the fact that only very few or nobody were used to handle them. Thus, they were often forced to accept that handicraft methods and materials were used to make their building look modern industrially made. Pretending to be of industrialized concrete elements even if it was traditional plastered brickwork. That constituted an ethical problem for the architects who normally aimed to make architecture structures of high integrity (Lawson, 2006).

Thus, we find structures pretending to be something they are not, which is never pleasant. This is also the case when later Danish architects aimed to use traditional materials in new, not traditional handicraft contexts. Thin brickwork screens placed outside insulation put on prefabricated loadbearing concrete elements became a common disposition. In such contexts the bricks are typically placed in ways that indicate traditional load bearing solid brick walls, and this discrepancy is barely any better. Assuming the architect is aware of what he or she is

doing and how it will be misinterpreted by people, it is again a deliberate attempt to mislead the spectator.

May be the professional who is going to refurbish a structure does not like such original dispositions, but does that mean that such implications should be altered? No, they should not! They are a part of the history to tell and any historian need to be honest and tell the truth, which is what society expects. In fact, the professional has the responsibility of a historian and/or an archaeologist when doing a refurbishment project.

If so, what is then the difference between refurbishment and restauration? In principle there is no difference except a degree difference since what we call restauration normally concerns very valuable historic listed buildings, whereas refurbishment is the term used in contexts that are less sensible. The premise of this paper is that also refurbishment projects should be handled with much care and sensibility in order to maintain the original story for the sake of the history of lifestyle and culture needed by society to get true pictures of its background.

Within refurbishment and restauration activities, traditions are different from country to country. Some places one can notice that it is accepted that only the façade of the building is kept while all the rest is broken down and replaced with a brand-new state of the art structure behind. Other places like in Denmark, such behaviour is against the traditional local "professional religion". In Denmark, if the main stabilizing and load carrying structure cannot be kept, the whole building will either be rebuilt if very valuable or it will be replaced with a brand-new building.

This is a question about moral and if aware that an untrue story is told and people in general will be misled to believe something untrue, the planner is deliberately telling a lie. Some might say that it doesn't matter because people either believe the untrue story and no harm is done or they realize the truth and then the same counts because they are not misled. No! in the latter situation there is a serious harm because then the building states that in this society it is not only legal but perhaps even smart to lie – and that is corruption.

4.1. ACTIONS BEFORE REFURBISHMENT OF THE STRUCTURE

a. As a practical precaution, a professional consultant appointed by the authorities could first collect all relevant original drawing material and study it well with a focus on both appearances and structures.
b. Then a photo documentation and comments on **what** the characteristics of the structure are and **what** specifically to maintain and take care of.
c. Finally, it should be decided **how** the above identified characteristics can be kept and to what extend they need maintenance.

5. Building survey procedure

In Denmark, there are special professionals who, after having passed specific courses and a test to secure that they on top of their educational- and prior professional background possesses the right qualifications to undertake specific surveys on behalf of society. It is suggested here that professionals with the right prior educational background after having passed a relevant course and a test are appointed to undertake refurbishment survey procedures on behalf of society and in cooperation with local authorities.

Since what to keep and maintain regards all what is involved in the idea of building culture, the procedure integrates both superficial and structural characteristics. What we called architectural characteristics was mainly focused on what can be seen, whereas the section about structural characteristics was mainly about what is mostly hidden – all that establishes the building as such. In the wider professional sense of the idea of architecture the two things are integrated to a whole that constitutes the idea of architecture. A piece of architecture is typically a building paying certain respect to emotional and aesthetic human requirements but there are buildings that lack such qualities. They are just buildings. Architecture requires buildings to articulate and make an impact whereas a bare building does not need architecture just to exist (Pevsner, 1973).

Here, the procedure to undertake by the official consultant is suggested as a five-step procedure with a documentation for each step:

1. First the consultant should require all relevant drawing material and written documentation of the building. Then he or she should visit the building and make documentation of the findings. The findings should be all important cultural building parts – both those establishing the style and the individual characteristics of the building and those belonging to the main structure of the building. Special and unusual characteristics should also be noticed and documented.
2. Then the importance of each of the recognized features and characteristics should be estimated, which could be done by giving it a priority and a mark for how well the original part meets an ideal requirement. It could be as shown in the following schedule:

TABLE 1. A value estimation to stress the relative importance – yellow = high

No	Item	priority	mark	value
1	Granite plinth with grove	9	7	63
2	Windows with special mullions	5	10	50
3	Visible purlins with nice resting pads	10	9	**90**
4	Etc.			

3. Then the more important parts from the list should be selected and carefully described.
4. Based on the selected important topics above, the consultant advises how the refurbishment of each should take place to secure the desired quality.
5. As a quality management, the consultant might require to be called to inspect the most sensible parts at critical points.

The person who is responsible for the refurbishment project is always the owner of the building who usually has a selected professional or a company to act on his or her behalf. The professional business or company will normally have an appointed individual staff member to act for them in the actual case and this member and the official refurbishment consultant will be cooperating to establish how the important original characteristics of the building can be kept or renewed for the sake of the historic narrative of the building.

6. The use of the survey report

The work of the officially appointed refurbishment consultant should be required by the owner of the property or his or her appointed representative. This request will, in words and rough

sketches, be followed by a description of the intended work and alterations to be done. The appointed consultant will then act independently to produce the official survey report, which will be the official guideline along with the ordinary building regulations for refurbishment projects.

- When the survey report is produced, it will be sent to the owner by the authorities.
- Then the owner will have a project and an application for building permit made. The application should include an account for how the project relate to the recommendations of the survey report.
- The building permit will in its conditions state the requirements from the survey report and the rest is all the usual formalities within a building project.
- The payment for the building permit will include the expense to the survey consultant who will get payed directly by the authorities.
- Extra money to pay for quality management inspection by the surveyor during the execution of the works will be required by the authorities when it is finished and accepted by them.

Thus, all the activities of the refurbishment survey consultant can be undertaken fully independent of other interests than those of society to keep and maintain valuable messages from the past.

7. Conclusive final comments

The considerations and precautions described above are those the author finds relevant and appropriate. Older buildings than those mentioned (1920 – 1990) will often have undergone certain refurbishments that could be experienced as interesting historical messages themselves. Such buildings will often be subject to refurbishment or restauration if they are listed.

Listed buildings might be restored and, depending on how historically interesting undertaken changes can be deemed to be, they might keep the changes or be brought back to the original situation. However, all precautions necessary to secure a continued use of the building like up to date installations need to be made to ensure its survival.

Not listed but recognised and published buildings needing refurbishment like The Høje Gladsaxe buildings should be carefully surveyed by professional consultants aiming to appoint what characteristics to keep and not alter in order to maintain their historical telling.

Not listed more anonymous buildings that have already been refurbished in ways making them look from another time than the time of establishment might in most situations be taken as they are. The refurbishment survey consultant will then identify what is of cultural value and require it kept. It is the more frequent and aggressive refurbishments we now see that result in that important architectural historical messages are erased. To meet this problem the suggested official survey consultant seems necessary.

For the benefit of society, it is the sincere hope of the author that more architectural qualities, including historically important messages, will be kept and maintained for the future instead of being destroyed by people who do not pay appropriate attention.

References

BACON, E. N., 1975. Design of Cities. London: Thames and Hudson Ltd.

BAKER, E., 1999. The Top 10 construction achievements of the 20th century. Wadhurst, England: KHL International

BALD, S., LA COUR, P., and LARSEN, S.N., 1996. Demokrati. Krogerup: Krogerup Højskole

BARRETT, N. 2019. Opgør med byggekulturen – hvad der skal til for at alle kan bo godt og rart i deres by. Gjern Denmark: Forlaget Hovedland

BARRETT, N., AND KRUSE, J, 2016. How Buildings Visualise Client and Architect. In: A. G. GARRIGOS and T. KOUIDER, ed. Healthy Buildings: Innovation, Design & Technology. University of Alicante May 2016, 139-158.

BARRETT, N., 2014. The Outstanding and the Ordinary. In: T. KOUIDER, ed. Architectural Technology, Towards Innovative Professional Practice, Aberdeen November 2014, the Robert Gordon University, Aberdeen, 128 – 150.

BARRETT, N., 2011. The Rise of a Profession within a Profession – The Development of the Architectural Technology Discipline within the Profession of Architecture, the Robert Gordon University, Aberdeen. Available: https://openair.rgu.ac.uk/10059/529/simple-search?query=niels+barrett

BARRETT, N., 2005. Design in a Human Scale, or How to Make Sitters, Walkers, Bikers and Drivers Meet and Feel Comfortable, In: D. KOZLOWSKI and W. WOJCIECH, ed. Public Space of Contemporary City, 17th - 18th November 2005, Instytut Projektowania Urbanistycznego Politechniki Krakowskiej, Kraków, pp. 45-46 - 50.

BOTTON, A., 2014. The architecture of Happiness. London: Penguin Books.

BRAND, S., 1995. How Buildings Learn – What happens after they´ are built. New York: Penguin Books

BROCHMANN, O., 1969. Huse. Copenhagen: Nyt Nordisk Forlag Arnold Busk.

CULLEN, G., 2000. The Concise Townscape. Oxford: Architectural Press

DAMGÅRD-SØRENSEN, T. 2001 Vikingeskibsmuseet In Den store Danske Encyklopædi volume 20, p. 160. Copenhagen. Forlaget Gyldendal

FABER, T., 1977. Dansk Arkitektur. 2 edn. Copenhagen: Arkitektens Forlag.

FRAMPTON, K., 1980. Modern Architecture: a Critical History. London: Thames and Hudson.

GEHL, J., 2006. Life between Buildings, Copenhagen: Arkitektens Forlag

GEHL, J. and GEMSØE, L., 2001. New City Spaces. Copenhagen: Arkitektens Forlag

GIDEON, S., 1967. Space, Time and Architecture. 5 edn. Cambridge, Massachusetts: Harvard University Press, pp. 211-217.

GOOGLE EARTH, 2019, Images from Denmark and Holland. Downloaded by the author.

GRAFE, C., 1960. Architecture is a social art. In: HUNCH: The Berlage Institute report, (6), pp. 222-224.

GRAHAM, J., LINFORD, D. and LOBBAN, P., 2007. Traditional Building Craft Skills - Skills Needs Analysis of the built Heritage Sector in Scotland 2007. London: The National Heritage Training Group.

HANSEN, J. P., 2012. Guidelines on Building regulations 2010. 2 ed. Danish Building Research Institute (SBI), Aalborg University.

ILLIES, C. and RAY, N., 2014. Philosophy of Architecture. Cambridge, UK: Cambridge Architectural Press.

KOSTOF, S., 2004. The City Assembled. London: Thames & Hudson

KRISTENSEN, E. K., 2015. Byggeriets industrialisering: Mere byggeri for mindre. Aarhus: Forlaget Hovedland

KÜHN-NIELSEN, P. 2000. Sørensen, Erik Christian In Den store Danske Encyklopædi volume 18, p. 504. Copenhagen Forlaget Gyldendal

LAWSON, B., 2006. How Designers Think - The Design Process Demystified. 4 edn. Oxford: Architectural Press, Elsevier Ltd.

LESAGE, D., 1966. The task of the architect (a remix). In: HUNCH: The Berlage Institute report, (6), pp. 305-306.

LLEWELLYN DAVIES, R., 1957. Deeper knowledge: better design. Architects' Journal, 125, pp. 3247.

MOLLERUP, J., BARRETT, N., BARSLEV, M., BENGTSSON, L., HØWISCH, J., SELCK, P. and SØNDERLUND, M., 1991. Husbygnings Materialer. 5 edn. Copenhagen: Nyt Nordisk Forlag Arnold Busck.

MOELLER, V. A. 1996. Arkitektur In Den store Danske Encyklopædi volume 4, p. 500. Copenhagen Forlaget Gyldendal

PEVSNER, N. 1973. Europas Arkitektur Historie. Copenhagen: Politikens Forlag

RASMUSSEN, S. E., 1949. Byer og Bygninger. Aarhus: reprinted 1985 by Arkitektskolen i Aarhus

SITTE, C., 1945. The art of building Cities. New York: Reinold Publishing Corporation

SØRENSEN, A., 1933. Funktionalisme og Samfund. Copenhagen: Forlaget Fremad.

VADSTRUP, S., 2005. Huse med sjæl – Om nænsom istandsættelse og bevaringsmæssig forbedring af ældre bygninger. Copenhagen: Gyldendal Fakta

VAN ZIJL, I., 2016. Gerrit Rietveld. London: Phaidon Press.

TEACHING AND LEARNING ONLINE USING VISUAL BUILDING REGULATIONS

A single case study experiment trialling visual building regulation pedagogy in a freely available multidisciplinary three hour continuing professional development course

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Abstract. This research is situated in the field of building regulation pedagogy and educational research design. It builds on previous research conducted by the author which identified a research gap in the areas of visual building regulation pedagogy and building regulation online learning tools. **Visual building regulation pedagogy** is defined as a systematic delivery, assessment and award process using visual literacy skills, along with digital, media and foundation literacy skills. Relevant literature was explored outlining professional development competencies in construction and equivalent professions, visual pedagogy for effective online course design, and a critical analysis of online versus traditional learning models. A three-hour freely available multidisciplinary online Continuing Professional Development (CPD) course was designed using the Irish building regulations to evaluate the use of a visual building regulation pedagogy. The topic area chosen was domestic stairs. Voluntary Industry Professional (IPs) experts were approached to seek technical guidance and input during the course design. Professional Bodies (PBs) were approached to advertise the freely available pilot online course to their members for research purposes. Elements of the course were created using a selection of reusable learning objects and assessments named Applied Visual Interactive Building Regulations (AviBRs) designed specifically for this course and delivered using a scaffolded approach. Voluntary Online Participants (OPs) were recruited from architecture, architectural technology, engineering and building surveying. Two research questions were posed, firstly, to evaluate how OPs reported their experience of teaching and learning using visual building regulations online. This was broken into five sub-questions to evaluate the course and curriculum design, the course management, teaching and learning, assessment and award. The second research question explored whether the experience changed, or did not change, the OPs perceptions or beliefs of teaching and learning using visual building regulations online. Twelve themes were found from empirical data analysis, namely validation, improvement, time-starvation, accountability, suggestions for more courses, gratitude, perceived expectations, apologetic, online learning is not suitable for everyone, technical difficulty, complementary and positivity. The findings reveal that visual building regulation pedagogy is reported as useful. Also reported were that flexible delivery, online learning, competency assessment and a multidisciplinary cohort were useful. Virtual immersive interactive competence assessment could be a natural progression for this research. Discussion of results concludes that a consistent, standardized regime of CPD training with specific emphasis on an appropriate, authentic and fit-for-purpose competence assessment process is warranted for professional development in Architecture, Engineering and Construction (AEC) and the Built Environment (BE). The legal vulnerability of PBs and professional members of these bodies and the safety and protection of members of the public, clients and building regulation practitioners are the drivers for this change.

Keywords: Online learning; CPD; pedagogy; interactive: Visual; VR assessment.

1. Introduction

1.1 CONTEXT

Central to this research is the desire to create innovative, challenging and rewarding teaching and learning practice in building regulation education. The author is convinced that there is a place for visual building regulations within and alongside existing pedagogical practices. When one understands building regulations, combined with authentic assessment to demonstrate ones understanding and critical thinking in an applied, contextualised manner, a merited qualification which validates such competencies is warranted. That is the premise of this research.

This study is situated in the field of building regulation pedagogy and educational research design. It builds on the previous research conducted by the author (Hayden, 2019). To put into context, this ties in with findings by Simpson et al (2019, p2) who report that lifelong learning offerings in the BE need to be tied to competency evolution. They identify an opportunity for a digitally-enabled infrastructure to host CPDs to situate competency requirements based on demand in the United Kingdom (UK) and note that the definition of pedagogy which best suits the upskilling required is still being defined (Simpson et al., 2019, p3).

This research investigates teaching and learning online using visual building regulations. The author designed and developed a free three-hour online CPD course which was taken on a voluntary basis by multidisciplinary professionals and educators in the AEC and the BE, but principally from the disciplines of architecture, architectural technology, building surveying and engineering. The course design developed a novel pedagogy into a working experiment, thereby adding value. The author developed a systematic delivery, assessment and award process with visual literacy at is core to represent visual building regulation pedagogy for online learning. Not only was visual literacy used but also digital, media and foundation literacy skills. The author designed a selection of reusable applied visual interactive teaching and learning objects, assessments, quizzes and forums as AviBRs specifically for this course.

Domestic stairs were chosen as an area of the building regulations which was not contentious so that OPs would not become preoccupied with discipline-specific arguments and discussions, but instead focus on their online learning experience. The teaching, learning and assessments on the course covered domestic stairs requirements in Part K (DoHPCLG, 2014b, 2014a), Part M (DoHPCLG, 2010) and Part B (DoHPCLG, 2017). The online CPD course outlined the design, construction, occupation, maintenance and deconstruction of domestic stairs both within and outside of the building regulation requirements.

1.2 RESEARCH QUESTIONS

The research aimed to address two Research Questions (RQ):

RQ1 How do participants report their experience of teaching and learning online using visual building regulations?

RQ1.1 How do participants report their experience of the course and curriculum design?
RQ1.2 How do participants report their experience of the course management?
RQ1.3 How do participants report their experience of teaching and learning?
RQ1.4 How do participants report their experience of assessment?

RQ1.5 How do participants report their experience of the award?
RQ2 How has this experience changed or not changed participants' perceptions or beliefs of teaching and learning online using visual building regulations?

If one were to prioritise the order of significance of each of the sub-questions in RQ1 to the visual building regulation pedagogy being tested, it would take the order indicated in Figure 1.

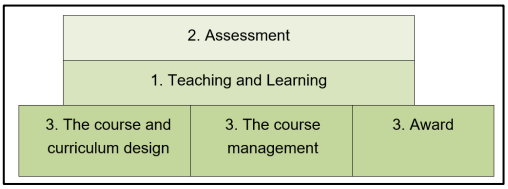


Figure 1. Order of significance for the evaluation of the visual building regulation pedagogy in an online course

To use a construction analogy, for a single case study which was an experimental online course, this would not have been executable without the foundation, or third row, first being in place. It facilitated teaching and learning to happen, reflecting an upwards build-order hierarchy. Teaching and learning were singularly the most important factors in the execution of the visual building regulation pedagogy. Assessment of competence was the end goal, but nothing would have been assessable without some teaching and learning occurring first, hence the numerical hierarchy indicated in Figure 1.

2. Literature Review

2.1 VENN DIAGRAM

A thorough literature review for a doctoral thesis was conducted in three areas illustrated in the Venn diagram in Figure 2. Choices which influenced the course were underpinned by this process. The extensive literature review findings were retained by the author and concluded below, firstly, to reduce the word-count of this conference paper and secondly because it was felt that they were adequately represented in an applied format in the final course design.

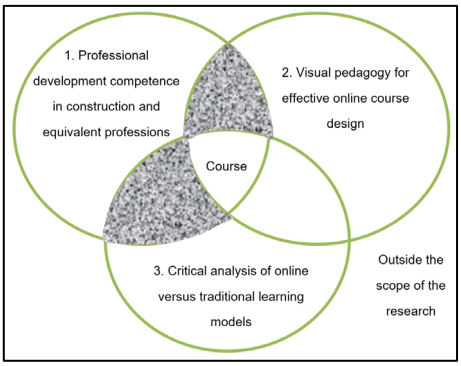


Figure 2. Literature review

2.2 CONCLUSION- PROFESSIONAL DEVELOPMENT COMPETENCE IN CONSTRUCTION AND EQUIVALENT PROFESSIONS

The concept of an online CPD course was acceptable in the current landscape because the PB culture requires members to achieve CPD hours annually to maintain chartered status. A scarcity of peer-reviewed publications, case studies or guidelines were available to truly inform the online course design, assessment design or to outline the pedagogical options available to course designers of professional development CPD offerings outlining the building regulations.

There is a great need to develop a robust professional development landscape and to provide supports for building regulation practitioners. This requires input and buy-in from key stakeholders and a holistic societal change or paradigm shift in the construction industry to voluntarily and / or legislatively enforce a transparent, accountable building regulation competency maintenance plan, structure, educational offerings and supports for practitioners in the field and for the betterment of a safer society and BE.

2.3 CONCLUSION– VISUAL PEDAGOGY FOR EFFECTIVE ONLINE COURSE DESIGN

This outlines a summary of the instructional strategies selected from the literature review. It links the literature in answer to RQ1, its sub-questions and RQ2. A CPD course descriptor was required for the online course. It should clearly state the aim and competencies of the course. It should clearly state the course learning outcomes expected from a successful participant. Clear expectations and grading criteria should be expressly stated. A formative and competency-based assessment protocol was chosen for the course. A pass grade was set at 80%. Grading rubrics should be used for the final 3D assessment.

Visual sign posting should be used on the online Learning Management System (LMS) in keeping with the novel pedagogy employed. Where possible, these should be broken into twenty-minute segments of new learning. The design of the course material and the assessments should seek input from industry partners as experts in the field. The author felt that digital badges tied to competencies were a worthwhile inclusion in this course as part of the overall experiment. Difficulties will be expected implementing new Information Learning Technologies in a wholly online course as this has not been done before. Personalising a flexible learning journey is essential for effective teaching and learning. Adult learning theory should be employed when conveying the course.

Assessments should be incorporated in all activities. Assessments should be designed for learning by facilitating active learning initiatives. Assessments should allow for repetition until they are successfully passed. Assessments should be competency-based and authentic and facilitate the demonstration of professional competencies in domestic stairs required in the building regulations. Authentic problem-based assessments such as a 3D visual, immersive assessment scenario with building regulations incorrectly presented should be utilised as it is in keeping with the pedagogy being tested. Assessments should use Bloom's (Bloom and Krathwohl, 1956) taxonomy stages of analysis, synthesis and evaluation where possible in combination with discipline-informed taxonomy to encourage higher-order thinking and critical analysis. Formative feedback on assessments should be used to encourage OPs to become involved in the assessment process while stimulating the development of higher order thinking, critical analysis and taking ownership and direction of their learning.

Learning object interactions and opinion polls should be used for learner-focussed teaching practice and active learning. Forums should be used to encourage higher order thinking by

facilitating discussions circumventing the concrete interpretation of the building regulations in Technical Guidance Documents (TGDs) and to accommodate best practice discussions. They should be used by OPs to showcase exemplars of their professional practice. Discussion forum participation should be assessed as part of the overall experiment, in keeping with Gilly Salmons' (Salmon, 2013a) recommendations for e-tivity design. Asynchronous videos should be used at the beginning of topic areas on Moodle to demonstrate authentic teaching practice for adult learners.

2.4 CONCLUSION– CRITICAL ANALYSIS OF ONLINE VERSUS TRADITIONAL LEARNING MODELS

Supplementary effective instructional strategies have been extracted from this literature review in addition to those summarised above. E-tivity instructions (Salmon, 2013a) should be used in the course. The author chose to include these multimodally by asynchronous video upload subtitled for inclusion purposes in keeping with the visual pedagogy employed. Influence can be drawn from Gilly Salmon's (2013b) five stage model and Universal Design for Learning (Alberta Education, 2015) graduated scaffolds as principal ideologies for an online learning model from which to follow, once higher order skill sets and student centred learning requirements are included. Scaffolding should be used on the course to break tasks down into more manageable learning sizes while using a visual framework of breadcrumbs to navigate new information and to support student achievement. The course should contain a slow start and a soft landing visually on the LMS while adding an expressly stated course evaluation process inspired from the Analysis Design Development Implementation Evaluation (Taylor, 2017) and Kirkpatrick (*The Kirkpatrick model*, 2019) models.

3. Methodology

A single case study methodology was chosen for this research as it represented meaningful small scale research (Tight, 2017). Because this was a pilot course, it was an experiment which evaluated the teaching and learning practice in an objective way. This combined research design merged the strength of both, thereby enhancing the generalisability, validity and credibility of the research findings (Tight, 2017, p95). The research design also embedded a nested single loop developmental evaluation process (Bornstein, 2007; Patton, 2011, p11) when the course was live, which allowed the author to make adjustments to the course when warranted (Chelimskey, 1997; Saunders, 2006, p205; referred to by Hayden, 2019, p166).

A curriculum critical theory (Cohen, Manion and Morrison, 2011, pp. 35-36) was used to support the research design. A pragmatist paradigm was used to analyse mixed-mode findings (Greene, Caracelli and Graham, 1989; Creswell, 2007 pp. 10, 14-15; referred to by Hayden, 2019, p166). These choices support the authors ontological critical realist and constructionist epistemological positions (Moon and Blackman, 2017).

4. Methods

4.1 TOOLS AND SURVEY DESIGN

4.1.1 Course recruitment

Voluntary OPs were recruited from architecture, architectural technology, engineering and building surveying. This was conducted by advertising on Twitter and LinkedIn and by sending 852 emails to architects, architectural technologists, engineers and building surveyors. The email addresses were sourced from freely available Irish PB websites and could be contacted under the Irish and United Kingdom General Data Protection Regulations. The Chartered Institute of Architectural Technology (CIAT) also agreed to include the course in their events calendar online.

4.1.2 Course enrolment

Enrolments began on the 8th of March 2019. The online CPD course slowly wound down nine weeks later from Tuesday 7th May 2019. A cut-off date for CPD certificate completion was set to the 20th June 2019.

4.1.3 Survey design

Empirical data was collected from OPs from seven sources including 1. Moodle statistics (n=34), 2. Questionnaire in the introduction section on Moodle (n=34), 3. Questionnaire in the evaluation section on Moodle (n=9, which provided mixed-mode data), 4. and 5. two discussion forums in the evaluation section on Moodle (n=1 in each forum), 6. semi-structured interviews conducted by telephone (n=1) and face-to-face (n=2) and 7. by relevant email correspondence (n=20).

4.2 ETHICS

An email was received from the Irish Government giving permission to refer to the building regulations. A disclaimer was added to the Moodle page to explain that the course was not a substitute for the legally binding building regulations and that the course was based on the Irish building regulations alone. An ethical pack was submitted and approved to collect empirical data for this research. Informed consent was sought from voluntary IPs by email or using hard copies. Informed consent was sought from voluntary OPs using a Moodle questionnaire. A consent form and a participant information sheet were directly downloadable from Moodle. All data was anonymised and will be securely retained for ten years.

4.3 SCOPE AND LIMITATIONS

A single case study has many variables operating within it (Cohen, Manion and Morrison, 2011, p289). As a single case, it could be argued that it aligns with Creswell's definition (1994, p10; referred to in Cohen, Manion and Morrison, 2011, p289) and is limited and bounded by the online CPD course and its participants. However, as the second RQ sought to look outward to seek whether this had an impact outside of this boundary, the scope is more akin to that described by Yin (2009, p18; referred to in Cohen, Manion and Morrison, 2011, p289), where the extent of the phenomenon and its context is blurred.

While all four professions of architecture, architectural technology, engineering and building surveying were represented by OPs who completed the online course, only those who

provided informed consent have been included in the research findings. Therefore, this research is limited to a small case study with representation from architecture, architectural technology and building surveying alone. It is also limited to feedback from professionals working in the Republic of Ireland and has limited educator feedback.

5. Data Analysis and Discussion of Results

5.1 COMPLETION STATISTICS

Data referring to the findings from IPs, PBs and the single loop developmental evaluation process have been retained by the author and are not reported in this conference paper for clarity purposes. The OP profile on the course is illustrated in Figure 3.

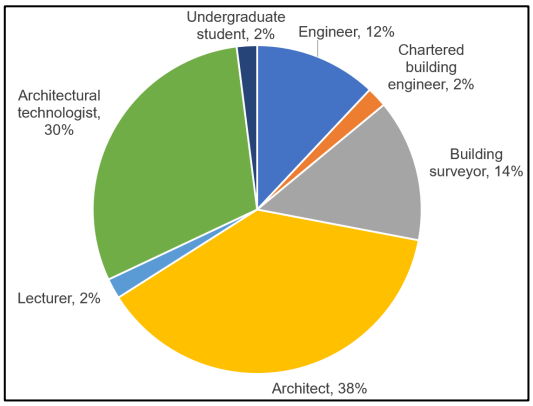


Figure 3. OP profile

This reflects a 40% cohort of architects, 32% architectural technologists, 14% engineers and 14% building surveyors. The online CPD course completion statistics are profiled in Table 1.

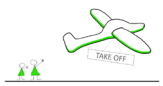
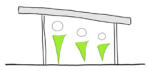
TABLE 1. Course completion statistics, June 2019

Course enquiries	110
Initial OPs enrolled on course	70
OPs who left the course	8
OPs who remained on the course	62
OPs who did not engage in the course assessments	32
OPs who started the course assessments	n = 30
OPs who completed all course assessment requirements and received a 3-hour CPD certificate	13 CPD certificates were issued
Percentage completion	43%
'Introduction to visual building regulation' digital badge	2 issued
'Domestic stairs using visual building regulations' digital badge	1 issued
Consent to use anonymous data from Moodle	35 consented; 1 OP did not consent; 1 subsequently withdrew consent – they were not available to do the course

Informed consent	35 OPs gave informed consent; 1 subsequently withdrew consent – they were not available to do the course

A 43% completion rate for a pilot online course was considered acceptable, particularly when compared to some Massive Open Online Courses (MOOCS) which report a 15% average completion rate (Franceschin, no date). If this had been a fee-paying course, the completion rates would be expected to be much higher. If it had been delivered synchronously at a set date and time, it may have had a higher completion rate but smaller uptake. Table 2 outlines a breakdown of the completion rates in the four stages of the online CPD course, each of which contained assessments.

TABLE 2. Breakdown of completion rates, June 2019

				
Introduction to visual building regulations quiz	Domestic stairs using visual building regulations	Scorm file split into seven stages	Teaching and learning forums	Online CPD course assessment
30 OPs (100%)	23 OPs (77%)	12 OPs (40%)	19 OPs (63%)	14 OPs (47%)
Pass rate 40%	Pass rate 80%	Pass rate 80%	Read all discussion forums to pass	Pass rate 80%
30 passed (100%)	6 passed (26%)	12 passed (100%)	15 passed (79%)	13 passed (93%)
92% average grade	56% average grade	93% average grade	-	89% average grade

As the topics on the course progressed, engagement became an issue, although the percentage passing was still high for those who wished to complete the required tasks. A high pass grade of 80% was set for the critical competency assessments in the second and fourth topics on Moodle, namely the teaching and learning topic and the final assessment. This was not a deterrent once the Scorm files were simplified to one for each of the seven stages, rather than being all contained in one Scorm file, illustrated in Figure 4.

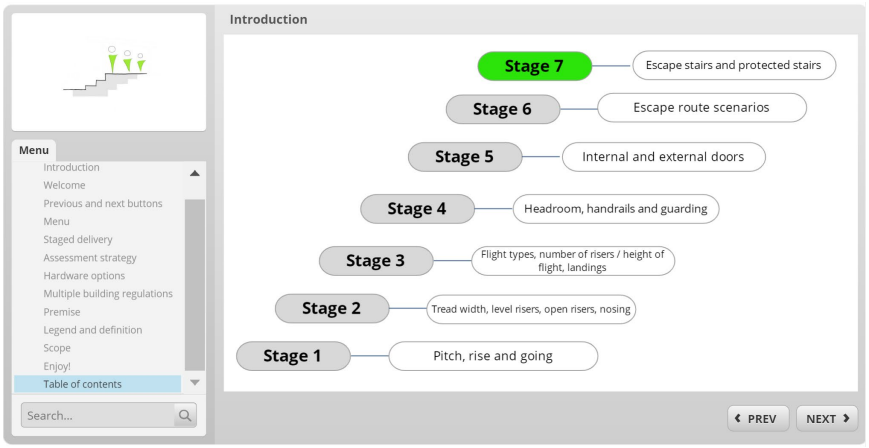


Figure 4. Articulate Storyline 3. Table of contents with seven interactive buttons bringing OPs to the seven incremental stages within the AviBR learning object

This change was conducted as part of the single loop developmental evaluation process early in the course roll-out. Figure 5 illustrates the OP profile for course completion.

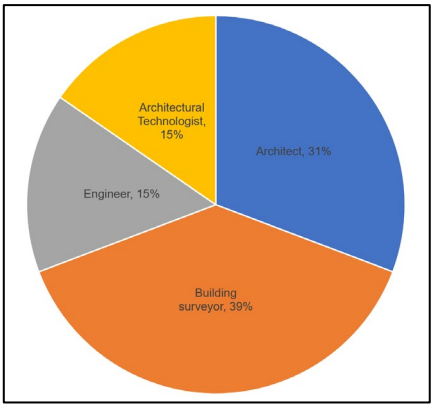


Figure 5 CPD certificate professional demographic, June 2019

5.2 RQ 1.1 - THE COURSE AND CURRICULUM DESIGN

5.2.1 The purpose of the course and influence of higher education best practice

OPs strongly agreed that the purpose of the course was situated clearly at the start and that the influence of higher education teaching, learning and assessment best practices was clearly stated. For example, an illustration of the course scope can be seen in Figure 6 below.

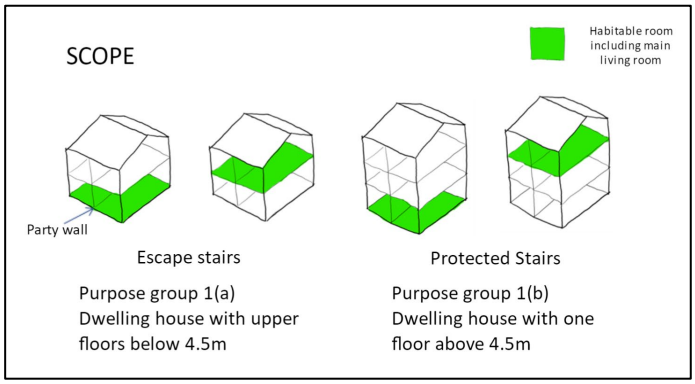


Figure 6. Sketch created using Surface Pro and Autodesk Sketchbook

This is reinforced in a 92% average grade in the ice-breaker quiz in the introduction section. OPs somewhat agreed that combining research with the course design was useful. An OP reported in the evaluation discussion forums that they *'felt that the course design was good'.* Another stated in the questionnaire comments that the *'course was good, enjoyed it'.*

5.2.2 The staged structure

OPs somewhat agreed that the staged structure of the course was appropriate. This finding was reiterated by one OP who reported '*the staged structure of the course was helpful and enabled me to come back to complete items as my work commitments allowed'.* Similar sentiment was reported by the educator interviewee, who stated *'that's a really good way to do it for students, if they have to learn little pieces… splitting up into smaller pieces helps.'*

5.2.3 The timing and duration

The timing of the CPD course was somewhat agreeable as was the course duration. Three OPs suggested that more time was spend on the course than three hours. The educator interviewee suggested that it could have been *'6 hours or maybe 5, but it would be harder to get more volunteers then.'* Another OP commented in the questionnaire that '*3 hours CPD is far, far too little for the amount of time that had to be given to this course'* and a further stated that '*personally, I found navigation through the course material confusing and the time spent does not relate to the awarded CPD accreditation. Having said that, the content was most useful*'. The course design should be more generous in the time afforded to complete a technical online course, to allow time for OPs to enrol on the course, to get familiar with the Moodle platform and using Articulate Storyline, and to allow time to digest, read and download documents. The educator OP suggested that *'if you need to repeat stuff'* or want to re-read it, to allow more time.

5.2.4 Online, flexible delivery of a free course

Time-starvation was noted as the author received six emails from different OPs having personal or work issues. One stated '*I think the only impediment to completion is getting the time. I enjoyed the little bit I did to date'.* Flexible delivery and extension of deadlines was essential for professional adult online learners. A summary of the relevant questionnaire findings is outlined in Table 3.

TABLE 3. Questionnaire findings for online, flexible delivery of a free course, June 2019.

Question	Likert score	Predominant opinion
The fact that this was an online course was useful i.e. it allowed for mobile, distance learning	1.1	Strongly agree
The fact that this had flexible delivery built into its design was useful	1.0	Strongly agree
The fact that the course was free was useful	1.1	Strongly agree

One OP stated that '*the mobile learning platform was extremely useful for me, full time employed with other commitments and an inability to attend courses regularly'.* Another reported that *'the online delivery of the course was particularly useful for me as I am self-employed. The majority of relevant CPD for my profession is offered in larger population centres such as Dublin and Galway, which are a four-hour round trip from my location. The flexible delivery was also a significant help as my current work commitments do not allow me set times to dedicate to CPD'.* An interviewee reported that '*an online course like that… it is a good way to do things… because you can do it in your own time. I can do it at home, I don't have to go somewhere to do the course. I can do it in my own time'.*

One OP commented that '*the quality of the course is of a very high standard and it clearly took considerable work to put the course together. A course of this quality would usually present a significant expense for me and I greatly appreciate that it was offered free of charge'.* Accountability for the implications of building regulation course design is something worth considering. The author believes that financial issues should not be a hindrance when considering competence standards for building regulations. What price would society put on the welfare and wellbeing of professionals working in the BE and on the occupants living and working within the BE if valuable training provision is missed because of financial, location or time-starvation related issues? Or if they are unaware of training provisions because their professional body chooses not to let them know of alternatives? This finding is supported by curriculum critical theory.

5.2.5 International and multidisciplinary cohort

The international reach of the course was reported as somewhat agreeable. As very few OPs were international, this is perhaps a suggestion to take on board when considering the design of new courses. The multidisciplinary cohort was found to be strongly agreeable, triangulated by comments received on the final assessment feedback and from email correspondence indicating new take-aways resulting from participation on the course.

5.2.6 Conclusion - RQ 1.1

The course design was generally well received. The purpose of the course and the influence of higher education teaching and learning were clearly understood at the beginning of the course. The staged structure of the course was well received but improvements were advised, that is, naming the titles on the Scorm files to reflect their content. The timing of the course was reported as somewhat agreeable. To make allowances for and to accommodate all learners, for future reference, the course duration should be extended from three to six hours. The online, flexible, free CPD course was reported as strongly agreeable on all counts. The international reach was somewhat agreeable, whereas the multidisciplinary cohort was reported as strongly agreeable. The research themes of validation, improvement, time-starvation, accountability

and suggestions for new courses were derived from the course and curriculum design data analysis.

5.3 rq 1.2 - The course management

5.3.1 Conveyor-to-peer interactions

The conveyor contributed to 47% of the discussion forum posts to encourage engagement on the course and appease a sense of isolation which might have otherwise been perceived. Most conveyor to peer interactions were by email correspondence. Engagement in discussion forums would be an area for improvement in new course offerings. Relevant questionnaire findings are included in Table 4.

TABLE 4. Questionnaire findings for conveyor to peer interactions, June 2019.

Question	**Likert score**	**Predominant opinion**
The interaction with the conveyor of the course was appropriate	1.1	Strongly agreed

The email correspondence yielded a sixth theme of gratitude. Twenty-two OPs emailed *'thank you'* to the course conveyor for things such as enrolment, emails, reminders, instructions and CPD certificates. One OP emailed '*thank you for your response on queries and personalised approach regarding reminders, update and modification'.* Gratitude was communicated by email to the conveyor for the course itself by two OPs, with one reporting '*you have put a massive amount of effort into getting the course up and running so thank you for that'.* Another OP stated on the comments section of the questionnaire that '*the conveyor was very approachable, supportive and keen to ensure my experience was positive and the course effective'.* A further OP reported in the same comments section that '*the regular updates and reminders from the course management were particularly useful'.*

A seventh theme related to the perceived expectations of the course prior to its commencement. One OP emailed requesting to *'know dates / times.'* As it was flexible delivery, dates and times were not set so this persons' expectations of the course were different to how it was delivered. Another OP emailed '*I'd be interested in partaking of the course and possible research as I've always had questions over the regulations for stairs and the possibilities for different types of designs of them'.* This alluded to a point mentioned by the educator interviewee, saying that for our profession, visuals are '*the right way to do it because… you transform the text into an image in your head and that might be different to what is really there. So, I think it would help if* (we) *can see it'.*

This concurred with the recurring theme of validation. A comment received through the evaluation questionnaire by another OP suggested that *'maybe… deeper knowledge in stairs'* would be useful. This suggested that their expectation of what the course would deliver and what it did deliver were different. It was a suggestion for improvement, so added to that theme also.

An eighth theme noted was an apologetic theme. Six apologies were received by the conveyor by email. Some were more mannerly than anything whereas others related to the time-starved situation OPs found themselves in, between work and other commitments. It may have reflected their unsureness or insecurities when participating in an online course. Three

OPs, through interview and evaluation discussion forums on Moodle alluded to this being their first experience of a course like this.

This reflected an issue which has not been addressed fairly in the AEC and BE professions to-date, namely, to take account of the time and financial commitments required to complete structured training. This finding is supported by the curriculum critical theory and adds to the accountability and time-starvation themes found in this research. In the authors' opinion, no professional who is an expert in their line of work should be time-starved or apologetic when conducting their duties. And their duties must include continuing upskilling and learning for the betterment of their professional development throughout their entire careers.

5.3.2 Peer-to-peer interactions

Peer-to-peer interactions were reported as somewhat agreeable, which is not surprising given that forums were only engaged with by a few OPs and that peer-to-peer discussions accounted for ten posts, or 18% of the entirety of the discussion forums. Only nineteen OPs (63%) clicked in to read any of the discussion forums and even less, fifteen OPs (50%), did this for all thirteen teaching and learning discussion forums. OPs may not have been ready for online learning or that their perceived expectation (to reiterate this recurrent theme) was different to the course requirements. This also reflects a ninth additional theme that online learning is not suitable for everybody as well as adding to the improvement theme.

5.3.3 Technical support

Technical support was reported as strongly agreeable, reflecting changes made during the single loop developmental evaluation to the Scorm file and reflecting extensive email correspondence. Some OPs did have technical difficulty in enrolment, understanding the assessment requirements and understanding how to navigate the online course, which contribute to a tenth theme of technical difficulty.

5.3.4 Conclusion – RQ 1.2

Overall, the course management was well received. Conveyor-to-peer interactions were reported positively. Peer-to-peer interactions did not flourish in this course. Many OPs avoided posting to discussion forums and peer-to-peer interactions were reported in only 18% of cases. Technical support on the course was reported as appropriate. Analysis of the course management data yielded additional examples of recurrent themes of validation, improvement, time-starvation and accountability. Five new research themes were collected, namely gratitude, perceived expectations, apologetic, online learning is not suitable for everybody and technical difficulty.

5.4 RQ 1.3 – TEACHING AND LEARNING

5.4.1 The appropriateness and comprehensiveness of the teaching and learning activities

An eleventh theme, complementary, was noted in a significant amount of data collected. One OP reported that *'the content was most useful'* on the questionnaire comments. A different OP emailed that *'the course was very well put together and clearly took a lot of time and work'*. Another OP emailed that *'yes, I found the course very useful'*, with a further emailing *'great work'*. Relevant questionnaire findings are included in Table 5.

TABLE 5. Questionnaire findings for the appropriateness and comprehensiveness of the teaching and learning activities, June 2019.

Question	**Likert score**	**Predominant opinion**
The visual building regulation teaching and learning activities were appropriate in the context of the aspects of the building regulations covered	1.2	Strongly agree
The teaching and learning activities were sufficiently comprehensive for a CPD course of this size and nature	1.2	Strongly agree

In a telephone interview, an OP reported that *'it was okay'* and in a face-to-face interview the OP reported *'well, I had a good experience, yeah'*. In keeping with the complementary theme, one OP reported by email that '*the sections reviewing fire compliance were really beneficial and how they affect stairs and their requirements'.* This further reinforces the continuing validation theme reflected in the research findings.

5.4.2 The applied and visual nature of the learning objects

The applied nature of learning objects was somewhat agreeable. One interviewee commented that they *'found it surprisingly accessible… I found it very, very relevant and usable'*, because of the contextualised nature of the teaching and learning objects. This contributed to the validation theme in this research. The visual nature of learning objects was reported as strongly agreeable, an example of which can be seen in Figure 7.

Figure 7. Photo edited using Adobe Photoshop

An OP emailed *'I really enjoyed the initial stages and the visual images used to illustrate (it)'*. In the telephone interview, a different OP stated, *'it was good for me because I have a photographic memory'*. On an evaluation discussion forum, another OP stated '*the visual approach is helpful in augmenting the text contained with the TGD and does help explain what can be a fairly dry read. The text is still necessary for day to day use at work'.* A different OP similarly commented in a face-to-face interview that *'the visual thing helps learning for me… I like looking at visual stuff*'. This contributed to the recurrent validation and complementary themes. An interviewee suggested improvement by including images from the TGDs in the Scorm files, thus reusing their visual literacy skills when referring to the building regulations once the course was complete.

5.4.3 Navigating the Scorm files and the interactive nature of the learning objects

The recurrent theme of technical difficulty was noted in the context of the Scorm file created using Articulate Storyline 3. The Scorm file drew criticism on its interactions because of its difficult navigation when embedded as one major Scorm file and its lack of user-friendliness when it came to saving answers and accessing grades on Moodle. One OP through the comments section of the questionnaire reported *'personally, I found navigation through the course material confusing'*. Another reported *'I had some minor issues navigating through the course. This may be due to my inadequacy and if further modules were available then this would be easier'.* A further reported in the telephone interview that the course *'needs easier navigation'.*

In the Moodle evaluation discussion forum, one OP commented '*the only negative point is that smoothness of transfer between slides is lost when getting back to the main slides from one of the secondary slides (which are accessed from clicking on a prompt on a main slide)'.* The educator was asked in their face-to-face interview if they had similar issues with the Scorm file, which they did. After further probing, it was the interactions on slides which were not favoured. They commented *'maybe for younger people that's more interesting, people who do video games.'* The author noted that during beta testing, which was conducted with first year undergraduate architectural technology students, they did not report any difficulty navigating the course or using its interactive elements. Perhaps they were more used to these kinds of interactions? The educator interviewee suggested *'you could just make* (it) *so it's more linear and* (you are) *not missing something'.* The single-loop developmental evaluation designed some of these issues out early in the course roll-out, so this aspect of the methodological choice was invaluable. This is an area earmarked for improvement if a course such as this were rolled-out again. Relevant questionnaire findings are included in Table 6.

TABLE 6. Questionnaire findings for navigating the Scorm files and the interactive nature of the learning objects, June 2019.

Question	**Likert score**	**Predominant opinion**
The usefulness of the interactivity of the learning objects	1.6	Somewhat agree
The course was easy to navigate	2.6	Neutral

5.4.4 The amalgamation of the relevant TGDs, linking general construction details, site-based practices, health and safety and universal design to the building regulations and including expert input in specialist areas

Relevant questionnaire findings are included in Table 7. These findings were reiterated by one OP in the comments section of the questionnaire. *'I felt that the amalgamation of building regulations and health and safety regulations was helpful. There is a danger of assessing regulatory compliance of elements of a building in silos and the manner in which the course addressed these issues was well considered'*. Expert input was used in the creation of content used in the discussion forums. These findings further contributed to the themes of validation, gratitude and complement.

TABLE 7. Questionnaire findings for 5.4.4, June 2019.

Question	Likert score	Predominant opinion
The amalgamation of the relevant TGDs was useful	1.6	Somewhat agree
Linking general construction details to the building regulations was useful	1.1	Strongly agree
Linking site-based practices to the building regulations was useful	1.4	Strongly agree
Linking other regulations, such as health and safety regulations, to the building regulations was useful	1.3	Strongly agree
Linking additional information such as universal design to the building regulations was useful	1.2	Strongly agree
Including expert input in specialist areas was useful	1.3	Strongly agree

5.4.5 The reduced language interpretation of the building regulations and universal accessibility including those whose first language was not English

The reduced language interpretation of the building regulations was reported as strongly agreeable. Universal accessibility, including those whose first language was not English, was reported as somewhat agreeable. The findings are in keeping with the complementary and validation themes. They were mirrored by one OP on the comments section of the questionnaire who stated, '*if I am finding the learning more accessible using visual learning, I can only imagine it would be of even more benefit for…* (non) *English speakers.'*

5.4.6 Conclusion – RQ 1.3

Four of the five sub-areas within the evaluation of the teaching and learning of this online course were found to be appropriate and well received. Navigating the course and the design of the Scorm files are areas noted for improvement. Data analysis revealed an eleventh theme, complementary, and reinforced multiple findings of validation, improvement, technical difficulty and gratitude. As previously indicated in Figure 1, this is significant because findings reflect principally but not exclusively a positive outcome and a successful use of a visual building regulation pedagogy for online learning.

5.5 RQ 1.4 – ASSESSMENTS

5.5.1 The scope, breadth and depth of assessments

One OP in the comments section of the questionnaire reported that '*the course assessments were suitably challenging and required participants to consider all relevant regulatory requirements.'* A comment from another OP in the questionnaire stated, *'the assessments were a bit challenging but not too much just the right balance'.* This corroborates the Likert question findings in Table 8 and adds to the theme of validation found in this research.

TABLE 8. Questionnaire findings for scope, breadth and depth of assessments, June 2019.

Question	Likert score	Predominant opinion
The assessment of knowledge-based competencies was appropriate for a CPD course of this size and nature	1.4	Strongly agree
The assessments were appropriate in the context of the aspects of the building regulations covered	1.4	Strongly agree

The assessments adequately explored the new learning acquired	1.3	Strongly agree
The assessments adequately explored an understanding of the new learning acquired	1.3	Strongly agree

5.5.2 The assessment adjudication

It was reported as somewhat agreeable as to whether the assessments were challenging. It was also reported as somewhat agreeable that the assessments avoided surface learning and rote learning. The integrity of the assessments was reported as somewhat agreeable in terms of being easily compromised. Finally, the assessments were reported as somewhat agreeable in how they tested a deeper understanding of why the building regulations have been written the way they have.

Eighteen questions were included in the staged Scorm files, with a 100% pass rate and an average grade of 93% summarised in Table 2. The quiz in the introduction section also used four multiple choice questions and had a 100% pass rate with an average grade of 92%. The somewhat agreeable answers reported would seem to the author to reflect these assessments and not the final 3D immersive assessment. This corroboration of findings contributes to the improvement theme found in this research. The final 3D immersive assessment could not be cheated nor readily compromised. It avoided surface learning and rote learning. Every submission for the 3D assessment was checked by the author / conveyor using a rubric and returned to all OPs with suggestions for improvement on their submission. Every submission was checked by the author for uniqueness and originality.

The language in one of the assessments was noted by three OPs. Those who could not pass this stage mistakenly included a comment in relation to vertical railings, which comes down to their understanding of language rather than visuals. Surely a finding like this could help justify a visual assessment strategy and validate its use in this context? This was one of three assessment questions in stage four and can be seen in Figure 8.

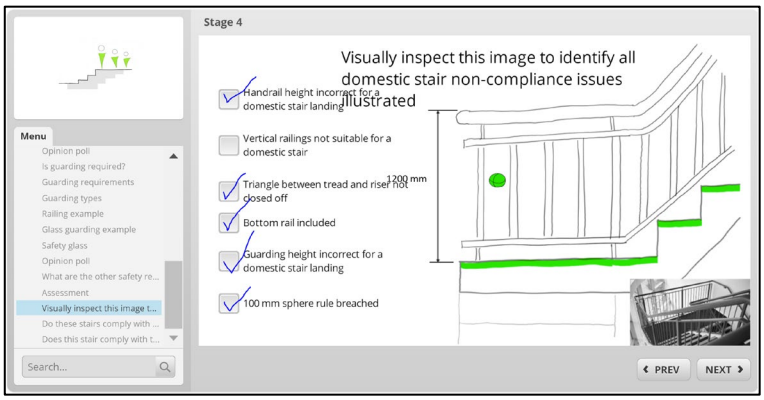


Figure 8. Stage four multiple choice assessment with visual cue – correct answers indicated

5.5.3 The applied visual interactive design of assessments

Interactivity was included in the introduction quiz and the Scorm assessments. All Scorm assessments with visual cues were illustrating the context of the building regulations applied to a scenario. Visual cues were used for some but not all these assessments. The principal visual assessment was the 3D immersive final assessment discussed below. A 100% pass rate

corroborates findings in Table 9 below, contributing to the recurring theme of validation gleaned from this research.

TABLE 9. Questionnaire findings on the applied, visual, interactive design of assessments, June 2019.

Question	Likert score	Predominant opinion
The interactivity of some of the assessments was useful	1.3	Strongly agree
The applied or contextualised nature of the assessments was useful	1.4	Strongly agree
The visual nature of some of the assessments was useful	1.6	Somewhat agree

5.5.4 The amalgamation of the relevant TGDs and universal accessibility including those whose first language was not English

One OP reported in the questionnaire in relation to the 3D immersive final assessment, '*I like how the system was combining more than one set of regulations to give it a more authentic experience and it may have contributed to a subliminal learning experience that would enhance the quality of teaching re: the overt regulation intended.'* Combined with Likert findings indicated in Table 10, this contributes to the validation and complementary themes derived from this research.

TABLE 10. Questionnaire findings for 5.5.4, June 2019.

Question	Likert score	Predominant opinion
The amalgamation of relevant technical guidance documents and / or approved documents in assessments was useful	1.3	Strongly agree
The visual building regulation pedagogy used in assessments made assessing building regulations more universally accessible	1.3	Strongly agree
The visual building regulation pedagogy used in assessments made assessing building regulations more universally accessible, for example, to those whose first language is not English	1.6	Somewhat agree

5.5.5 The 3D immersive final assessment

The correction rubric for the 3D assessment was updated resulting from the single-loop developmental evaluation cycle. In the authors' research searches, building regulations have never been assessed in a visual way before. An OP reported in the evaluation discussion forum that '*the assessment was good. The visual nature of the 3D images replicated, as much as possible, a survey situation'.* Another OP reported in the questionnaire '*the 3D walkaround model was a very realistic / authentic and immersive test that was as close to a real-world exam as you are likely to get electronically / online'.*

The author had designed it as an authentic assessment. This contributes to the validation and complementary theme found in this research. The Likert findings somewhat agreed that the integration of some gamified, motivational or immersive assessment strategies was useful. An OP commented in the evaluation discussion forum that *'the feedback was also helpful, and essential, to this process'*. Formative and summative feedback was given to OPs who completed the final assessment, seen in Figure 9 and 10.

Figure 9. Final visual immersive authentic assessment created using Revit

Figure 10. Final assessment Quick Response (QR) codes

One OP inadvertently thought that one QR code was answerable and not two in the final assessment. A suggestion for improvement would be to have only one 3D image per assessment on Moodle.

5.5.6 Competency assessment

Three unique OPs commented favourably in the questionnaire to complement the lack of commercial bias in the course. One reported '*an absence of commercial bias in the course delivery was good. Some commercial CPD events can have the approach of a sales pitch, which is natural, but does not always benefit or improve the knowledge of participants.'* Another reported

'a lack of commercial bias makes me feel that the course is an almost "altruistic" educational achievement rather than an agenda or a sponsor/business driven enterprise. This sort of training can be seen as more "honest" and accessible to a wider range of groups'. A further OP stated that *'it is a good course without a specific brand selling its product'*. The Likert findings concur with these statements, thus adding to the recurrent validation and complementary themes. Relevant questionnaire findings are included in Table 11.

TABLE 11. Questionnaire findings on competency assessment, June 2019.

Question	Likert score	Predominant opinion
The fact that higher education teaching-learning practices have been used in this online learning environment is beneficial to the course	1.8	Somewhat agree
The fact that higher education assessment practices have been used in this online learning environment is beneficial to the course	1.9	Somewhat agree
The fact that the course was designed without commercial bias was useful	1.2	Strongly agree
The fact that the course assessed an understanding and applied knowledge of building regulation competence requirements was useful	1.1	Strongly agree

The last question in Table 12 warrants discussion. The average finding from the questionnaire strongly agreed that the course assessed an understanding and applied knowledge of building regulation competence requirements. The authors' opinion is that this is reflected in all the assessments but primarily in the discussion forums and in the 3D immersive final assessment. It is a strong validation that the purpose of the course has been achieved through its' assessment processes and it validates the assessment data analysis findings and the competence assessments' position in Figure 1.

5.5.7 Conclusion – RQ 1.4

The assessments used in the online CPD course contributed to the recurrent validation, improvement and complementary themes found in this research. The 3D assessment was a unique way to visually assess an understanding and applied knowledge of building regulations relating to domestic stairs up to a professionally competent level. Its' authentic assessment visual immersive scenario using amalgamated building regulations combined with other regulations was well received.

5.6 RQ 1.5 – AWARD

5.6.1 CPD certificate

Members from all four professions of architecture, architectural technology, engineering and building surveying, seen in Figure 5, completed the course and received a three-hour CPD certificate by email. Relevant questionnaire findings are included in Table 12.

TABLE 12. Questionnaire findings on competency assessment, June 2019.

Question	Likert score	Predominant opinion
The fact that a CPD certificate was awarded upon completion of the course was useful	1.1	Strongly agree
The fact that a CPD certificate was awarded by email was useful	1.1	Strongly agree

Of the twenty-two OPs who emailed *'thank you'* to the course conveyor, three thanked the conveyor for their certificate, with one stating *'many thanks for the prompt confirmation and CPD certificate'*. One OP commented in the questionnaire
'the provision of a CPD certificate on completion is important and helps to satisfy CPD audit requirements from professional bodies.' The Likert findings concur with these findings, thus

contributing to the recurrent research themes of validation and gratitude. One OP stated that *'I have not get a certificate yet so I cannot comment on that.'* They had completed the course and questionnaire rapidly but received their certificate by email later that same day.

5.6.2 Digital badges

Only three digital badges were issued on this course, whereas twenty-eight additional introduction badges and twelve course badges could have been issued from this course. Their appropriate use on the course and multilingual availability were reported as somewhat agreeable. One OP who received a digital badge commented by email that they were *'new to this digital learning'*. One OP commented in the questionnaire '*I don't see the point of the badges, but I believe it is part of the course'.* From course findings, it seems that the construction industry does not yet have an understanding, role or place for digital badges. The finding ties in with the research theme of perceived expectations. The author took inspiration from the digital badge content to include the course CPD descriptor when issuing CPD certificates.

5.6.3 Rigour of awards offered

One OP commented in the questionnaire that '*limiting the validity of digital badges and CPD certificates is important in ensuring participants maintain and update their knowledge'.* This concurs with the Likert findings in the first and last row in Table 13, validating this finding.

TABLE 13. Questionnaire findings on the rigour of awards offered, June 2019.

Question	**Likert score**	**Predominant opinion**
The fact that the three hours spent on the course can be used as CPD for professional bodies was useful	1.6	Somewhat agree
The fact that GMIT will hold a record of candidates who have passed this CPD course for a period of 10 years is useful to verify professional development pathways of if being audited	2.1	Somewhat agree
The fact that GMIT will hold a record of CPD training for a period of 10 years may be useful to track the frequency of systematic building regulation upskilling or refresher training undertaken by an individual or a company should they wish to do so and if more CPD courses such as this were offered	2.1	Somewhat agree
The fact that the CPD badges and CPD certificate are only valid for 12 months is useful	2.3	Somewhat agree

The author wanted to limit the guarantee of competence when issuing a certificate or digital badge. Twelve months was assumed. The educator interviewee suggested a longer duration but embed revision practices (Kos, 2016).

Another OP commented in the questionnaire '*I would have liked a longer validation for the awards. If the refresher courses are free or charged a minimal amount while retaining this sort of quality, I would fully support them and put my relevant staff forward for them as part of their employment contract.'*

5.6.4 Conclusion – RQ 1.5

The CPD certificate was reported as strongly agreeable and its issue by email equally so. The option of receiving a digital badge was not taken up by most OPs and the author suspects that digital badges have yet to find a role in the construction industry. The rigour of awards was reported in general as being somewhat agreeable, with suggestions to consider lengthening the duration of the validity of these awards while embedding revision practices into the design of the course. A suggestion for refresher courses was also made. The research themes of validation, gratitude, improvement and perceived expectations were further contributed to.

5.7 SUMMARY RQ1

Eleven recurrent research themes were found in answer to the sub-questions relating to RQ1, namely 1. validation, 2. improvement, 3. time-starvation, 4. accountability, 5. suggestions for more courses, 6. gratitude, 7. perceived expectations, 8. apologetic, 9. online learning is not suitable for everyone, 10. technical difficulty and 11. complementary. Gilly Salmons' e-tivities (2013) suggested to grade forum posts. This was found to be inappropriate and not aligned with the requirements of OPs on this course, whereas adult learning theory was found to be much more appropriate. Adult learners want to participate in their learning design, be safe to make mistakes and to expect to do so as part of their continued learning (Pappas, 2018). Digital badges were not used by many OPs on this course. The twenty-minute timing for a classroom activity was naive when applied in an online course with flexible delivery, because timing becomes less significant and varies from person to person. Breaking up online activities and assessments into smaller sections did prove to be significant, however, and clear visual signposting, instruction and direction were important. The course duration was recommended to be doubled from three to six hours.

Although the data set was small, OPs reported generally in favour of the course. The use of IP experts was appropriate, and a research finding was that OP expert input was also appropriate. All key stakeholders are jointly accountable for the elimination of negative issues associated with professional development offerings. Financial, location, time-starvation and apologetic issues should not be occurring for professionals who are experts in their fields. This is supported by curriculum critical theory.

Multidisciplinary building regulation CPD offerings reap greater rewards for professional OPs and could be offered similar to the National Forum All Aboard initiative (National Forum, no date). As noted by Simpson et al (2019), a platform for such offerings is warranted. While online building regulation educational offerings have their place alongside other types of CPD delivery models, the role of competence and its assessment is significant and warrants further investigation. The author suggests that a virtual immersive interactive competence assessment would be a natural progression for research using a Steam platform such as VR Chat (no date).

5.8 RQ2

Emailed correspondence received from some OPs reflected the twelfth and final theme of positivity. Three OPs commented *'if you have any more (courses), please let me know', 'wish*(ing) *you well with your ongoing research'* and *'thank you and best wishes for success with your research'*. Their perceptions or beliefs were positive resulting from participation in this course. Another OP, as previously reported, suggested that they would encourage all their staff to do refresher courses like this as part of their employment contract if it were reasonably priced or free of charge. A different OP reported in the questionnaire that they *'look forward to the natural progression of this form of education and testing.'* This is a very positive

comment, framing the visual building regulation pedagogy illustrated in Figure 1 as both teaching and assessment.

Suggestions for more courses theme was added to in answer to RQ2. An OP within the evaluation discussion forums stated '*most professionals are committed, and mandated, to ongoing CPD but the time and cost of getting to Dublin or further afield for quality CPD is sometimes prohibitive. Whilst physical attendance at some CPD courses remains essential, development of visual based online CPD courses would be a very useful and positive way to help satisfy ongoing CPD requirements.'* Another positive suggestion for a follow-on course was made by email '*as suggested by one of the other participants, if* (your Institute) *considered a continuation for other TGDs (especially Part B), I could see same being well received by professionals and authorities such as'* an Irish PB for Architects.

A further reported suggestion was made in the comments section of the questionnaire, stating that *'commercial stairs would be a good topic for another course'* and a different OP suggested a *'deeper knowledge in stairs'*. This was reinforced by another OP in the questionnaire who wrote *'would like to do more CPDs of this nature'*. An additional comment was suggested by a further OP that '*it is a good course without specific brand selling its products. One for each building regulation could be useful'*. These are very positive and complementary findings from this research in answer to RQ2.

Another OP emailed '*from a building surveyors' perspective… the real take-aways are what do we need to pick up during an inspection and its very much safety first'*. This reflects another positive change to an OPs perception or beliefs having completed the online course. It is interesting how the melting pot of a multidisciplinary cohort was beneficial.

Three OPs reported that this was their first time completing a course like this, so they had no prior perception. In the evaluation discussion forums, an OP stated *'I was not aware of such methods previously… I now see them as a useful method of learning'*. This positive and complementary finding was reiterated and reinforced in an interview, where the OP stated '*I haven't done much like this before… an online course like that … it is a good way to do things because you can do it in your own time… the visuals help… and splitting up into smaller pieces helps'*.

Another OP who had previous experience participating in online CPD courses reported at interview that the visual building regulation pedagogy affirmed their opinion that it was useful as an alternative learning option, even though it was their *'first time experiencing a course like this'*.

A further OP reported by telephone interview that it did not change their opinion and that they will *'always prefer going to classes, not e-learning'*. There is something to be said for this statement. When one attends a class, one has designated time and finances set aside for the course and they allow themselves to cut ties from work and personal commitments for its duration. They can ask questions at the time and alleviate any worries they may have on assignments, for example. The time-starvation reported in the experience of this online course is not as much of an issue when someone attends a class. Online learning is not for everyone. This is reinforced in the course findings, with 110 enquiries made about the course but only 13 completing it. This contributes to the recurrent theme that online learning is not for everyone.

5.9 SUMMARY RQ2

A twelfth and final theme of positivity was found in relation to findings from RQ2. Six positive suggestions for future courses were put forward resulting from this research. In general, OPs perceptions or beliefs relating to a visual building regulation pedagogy were positive having participated in this course with three OPs reporting not having experienced a course like this before. The course was an experiment using a visual building regulation pedagogy. Four recurrent research themes were contributed to, namely 1. validation, 2. suggestions for more courses, 3. online learning is not for everybody and 4. complementary. Benefit from the multidisciplinary cohort and universal design was also noted.

6. Conclusion

From a small data set, visual building regulation pedagogy in an online course was generally validated with suggestions for improvement. From those who wished to give feedback, most reported it had a positive impact on their perceptions or beliefs about visual building regulation pedagogy having participated in the online course. Suggestions for further offerings including refresher courses and design improvements have been noted which, if they materialise, would continue the case study beyond a single case. Key stakeholders have a responsibility to progress professional development and building regulation competence assessment. This will facilitate a safer BE and protect practitioners in their professional duties. Online learning using an evolving visual building regulation pedagogy has its place among such offerings.

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References

Alberta Education (2015) Scaffolding for Students Success, You Tube. Available at: https://youtu.be/CTR_snb-0nQ (Accessed: 1 April 2017).

Bloom, B. S. and Krathwohl, D. R. (1956) ‘Taxonomy of educational objectives: The classification of educationa goals, by a committee of college and university examiners’, in Handbook 1: Congnitive domain. New York: Longmans.

Bornstein, D. (2007) How to Change the World: Social Entrepreneurs and the Power of New Ideas. Oxford: University Press.

Chelimskey, E. (1997) ‘Thoughts for a new evaluation society’, Evaluation, 3(1), pp. 97–109.

Cohen, L., Manion, L. and Morrison, K. (2011) Research Methods in Education. 7th edn. London: Routledge.

Creswell, J. W. (1994) Research Design: Qualitative and Quantative Approaches. CA: Sage.

Creswell, J. W. (2007) ‘Understanding mixed methods research’, Qualitative Inquiry and Research Design: Choosing Among Five Approaches, 11(2), pp. 1–19. Available at: http://www.amazon.com/dp/1412916070.

DoHPCLG (2010) ‘Building Control Officer Part M 2010 Workshop’. Dublin: The Stationery Office, pp. 1–135.

DoHPCLG (2014a) Supplementary guidance on the design of stairs to help achieve compliance with the Building Regulations. Dublin: The Stationery Office.

DoHPCLG (2014b) 'Technical Guidance Document K Stairways, Ladders, Ramps and Guards'. Dublin: The Stationery Office, pp. 1–16.

DoHPCLG (2017) 'Technical Guidance Document B Fire Safety Dwellings 2017'. Dublin: The Stationery Office, pp. 1–92.

Franceschin, T. (no date) Completion rates are the greatest challenge for MOOCS. Available at: http://edu4.me/en/completion-rates-are-the-greatest-challenge-for-moocs/ (Accessed: 10 June 2019).

Greene, J., Caracelli, V. and Graham, W. (1989) 'Toward a conceptual framework for mixed-method evaluation designs', Educational Evaluation and Policy Analysis, 11(3), pp. 255–274.

Hayden, I. (2019) 'An evaluation of the design and use of applied visual interactive resources for teaching building regulations in higher education built environment programmes', Architectural Engineering and Design Management, 15(3), pp. 159–180.

Kos, B. (2016) How to study, learn and master things faster than people with the highest IQs, Brainpower & Skills, Free Guides. Available at: https://agileleanlife.com/how-to-study-and-learn/ (Accessed: 24 May 2019).

Moon, K. and Blackman, D. (2017) A guide to ontology, epistemology, and philosophical perspectives for interdisciplinary researchers. Available at: https://i2insights.org/2017/05/02/philosophy-for-interdisciplinarity/ (Accessed: 17 January 2019).

National Forum (no date) ALL ABOARD, Digital skills in higher education. Available at: http://www.allaboardhe.ie/ (Accessed: 17 June 2019).

Pappas, C. (2018) 7 Top Facts About The Adult Learning Theory (2018 Update). Available at: https://elearningindustry.com/6-top-facts-about-adult-learning-theory-every-educator-should-know (Accessed: 17 June 2019).

Patton, M. Q. (2011) 'Developmental Evaluation Defined and Positioned', in Developmental Evaluation: Applying Complexity Concepts to Enhance Innovation and Use. New York: The Guilford Press, pp. 1–27.

Salmon, G. (2013a) E_tivities, The Key to Active Online Learning. 2nd edn. New York: Routledge.

Salmon, G. (2013b) Gilly Salmon's Five Stage Model of E -learning. Available at: https://www.acu.edu.au/__data/assets/pdf_file/0014/411035/Salmon_Five_Stage_Model_of_ELearning.pdf.

Saunders, M. (2006) 'The "presence" of evaluation theory and practice in educational and social development: toward an inclusive approach', London Review of Education, 4(2), pp. 197–215.

Simpson, M. et al. (2019) 'Evolve or Die', pp. 1–56. Available at: https://ciat.org.uk/uploads/assets/uploaded/101f628c-061d-445d-817368422197b626.pdf.

Taylor, D. (2017) The ADDIE model for online course design, E-learning in education. Available at: https://elearningmasters.blogspot.com/2013/08/the-addie-model-for-online-course-design.html (Accessed: 22 August 2019).

The Kirkpatrick model (2019) Kirkpatrick Partners. Available at: https://www.kirkpatrickpartners.com (Accessed: 26 August 2019).

Tight, M. (2017) Understanding Case Study Research, Small-scale Research with Meaning. London: SAGE.

VR Chat (no date). Available at: https://www.vrchat.net/ (Accessed: 17 January 2019).

Yin, R. K. (2009) Case Study Research: Design and Methods. 4th edn. CA: SAGE.

THE BIRTH AND LEGACY OF AN ARCHITECTURAL DESIGN STUDIO WITHIN ARCHITECTURAL TECHNOLOGY

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Abstract. Design and architectural bachelor degree programs across the world commonly use the design studio approach to improve their pedagogic approach. Architectural Technology bachelor degree programs in the United Kingdom have a mixed approach to the teaching and pedagogic approach, partly due to the department or school expertise in which they sit. Some are associated with architecture, others sit in the built environment sphere and some in interior or product design disciplines. This leads to a wide skill variety of architectural technology graduates with different experiences and philosophies to their practice.

The Architectural Technology course within Coventry University has been established for over twenty years. The original course was born from the Building Surveying course within the department to coincide with the growth of Architectural Technology within the higher education sector. This course over the past five-six years has gone through a process of change, evolving from a complete mixed balance of joint taught modules with fellow construction disciplines with building services engineering, building surveying, construction management and quantity surveying to a more unique, purpose driven, course caring, studio environment.

In order to advance these levels and expectation of technical architectural skills a whole new pedagogic approach needed to be introduced. These changes led away from very little dedicated design content into a new fully explorative and cultured environment that created an award-winning course with true design and technical solution skills at the core.

This paper explores the pedagogical shift in emphasis within the course, from the very beginning and examines the difficulties and perceived change within the year groups, benefits and drawbacks and the overall feedback in forms of interview and questionnaire from each year until there was an essence of not knowing any different pedagogy ever existed. We will look at the rationale and difficulties staff encountered and how these can be used to avoid similar problems for other future transitions and ways of incorporating best practices.

Keywords: Architectural Technology, Education, pedagogy, studio learning, design based problems.

1. Introduction

Design and architectural bachelor degree programs across the world commonly use the design studio approach to improve their pedagogic approach. Architectural Technology bachelor degree programs in the United Kingdom have a mixed approach to the teaching and pedagogic approach, partly due to the department or school expertise in which they sit. Some are associated with architecture, others sit in the built environment sphere and some in interior or

product design disciplines. This leads to a wide skill variety of architectural technology graduates with different experiences and philosophies to their practice.

The Architectural Technology course has been established within Coventry University since 1996. The original Architectural Design Technology course was established from the Building Surveying course within the department to coincide with the growth of Architectural Technology within the higher education sector.

The Architectural Technology degree at Coventry University has gone through a process of change over the past few years, evolving from a complete mixed balance of joint taught modules with fellow construction disciplines (building surveying, construction management, etc.) with very little dedicated design content in years one (typically two hours a week) and two (typically four hours a week, including software training), the third year provided sufficient content time (eight hours), however, the design skills leading into this year were typically poor.

An important factor to note here is that the level and expectation of technical architectural skills was also increased in line with the additional workload. Students were traditionally given some specific design teaching but as many modules were joint with the building courses, the standard time allowance focused the outputs very much on the specific task of detailing rather than the holistic view of the industry that the students were typically entering into.

This paper explores the pedagogical shift in emphasis within the course, together with developments that were needed as well as reasoning and reactions to these changes from students and staff alike.

2. Literature review

There has been extensive writing about the benefits of studio teaching and learning. The idea of architectural studio was set up from the Ecole de Beaux Arts movement that continued into the Bauhaus School movement (Salama, 1995). Dizdar (2014) states that “One sees that the teaching method gained importance through the Bauhaus student-teacher (master-apprentice) interaction. An educational method was used that recognized the possibility of the student being active and developing freely and the possibility of learning while doing, discovering the fundamental characteristics of the means being used and free of moulds.” This recognizes the importance of student-lecturer interaction in a setting where real-life simulated projects were used as a vehicle for checking learning and understanding.

‘Activity Led Learning’ (Wilson-Medhurst and Glenning, 2009) and ‘Problem Based Learning’ (Roberts, 2007) both discuss the importance of learning by doing and using real life simulated projects as coursework.

CEBE explains how the process of learning to become a teacher of architecture has traditionally been one of ‘learning on the job’, where the necessary skills are gleaned through experience and rely on how they were taught as a model of how to teach. Our key staff are both experienced architectural practitioners but from two different directions, Carl Mills being a chartered Architectural Technologist and Heather Bibbings being a chartered Architect. This lay the foundation and blending of different taught backgrounds and industry expectations within the direction deemed best for the course based on industry experience and research done on leading universities in this subject area.

The amount of time needed to be introduced to implement the desired changes were a key challenge, Ibrahim & Utaberta (2011) states that it is normal for design studio to take up 6-8 hours per week and that the design studio is the most dominant subject. This is what would

become the norm across the course with each year receiving 8 hours of studio taught content a week. This was a key timetabling and practicality shift from previous years.

3. Methodology and development of pedagogical initiative

During the process of understanding best practice and what can be judged to be leading courses (based on student awards, centre of excellences, outside perceived quality, student numbers and research outputs), newly appointed course director Carl Mills undertook visiting and interaction activities to feedback best practices and incorporate these within our structure where possible, a clear advantage many other universities had was a dedicated space to be used freely solely for Architectural Technology. This was not a new discovery as for many years the course had been requesting their own space, backed up yearly by our external examiner; Robert Mason of Edinburgh Napier University from 2010 to 2014. Although with this determined approach for improvement and clear support to achieve this, in 2014 we were given permission to explore the potential of adapting a suitable space to be used as a space for informal group working where a series of computers would be removed from a computer laboratory and this space would be used to hold presentations and tutorials essential to the studio pedagogical culture.

However, purely altering the space would not have been enough to achieve the desired shift in culture and outcome. As part of the newly approved design studio philosophy, we needed a new member of staff to help develop and lead with implanting the culture and different pedagogic teaching that we desired. We needed an experienced Architectural practitioner, a person who had been through their education process in this manner and someone who has preferably taught in this manner. At interview stage there was a wide variety of candidates but the person deemed most suitable being Heather Bibbings (HB), who had all the requirements needed for the changes to have a chance of success.

Once the creation of the studio in the first instance took place then interviews and questionnaires were used to gauge the impact of the changed philosophy and studio approach, each year the feedback would help shape the future developments and direction required as the students are deemed the key stakeholder in this process.

This ‘big bang’ of studio learning has an impact on the current direction of each year, the first year students would know no different, the second year students would be in an adjustment period, knowing what will be to come in year three, but the largest impact would be on current and returning year three students, whom would have never experienced this type of teaching method but would need to adapt in an extremely important year. The feedback from this year will be vital to understanding how a changed approach effects them and will be the key output to this paper. The impact of this 2013 starting year cohort will be assessed in this paper whilst 2014 & 2015 cohort starts will be reviewed in future papers.

4. Staff viewpoint

4.1. KEY STAFF MEMBER 1 – HEATHER BIBBINGS

Initially upon joining the course in September 2015, I was very surprised of the style of teaching and previous lack of individual space for the studios. Coming from an architectural background it was standard practice to have dedicated studio space and enough time and contact hours to verbally and visually present work rather than the traditional AT method of a typical two-hour lecture and one formal hand in at the very end of the modules. I felt that by changing the project delivery and assessment to a more frequent presentation format it would encourage the student to look at their own and each other's works and increase their awareness. The project briefs needed to be re-written and timetabling adjusted to suit the new format, for instance, taking a 2 hour a week first year module into an 8 hour a week contact time which took extensive time and effort however I felt that the benefits to the students would be exponential.

The development of the studio space allowed the appropriate time and emphasis on not only computer based design but learning from hand sketching and physical model making which would not have been possible in the old style format. The studio space at the rear allowed group tutorials and increased peer-to-peer exposure and social interaction bound the group from appeared to be a non-cohesive cohort previously.

4.2. KEY STAFF MEMBER 2 – CARL MILLS

The studio process had already begun upon appointing HB but the execution of studio culture and philosophy would be vital. Initially the studio would become an exclusive space for AT students that may not best resemble the typical architectural studio but is the first step in establishing the desired studio space that we eventually hoped to achieve. A new critique/model making area was created to assist in the new approach.

Immediately HB changed the thinking and approach to pedagogy within the course, which is exactly what was hoped to achieve. The next steps is to establish this new approach as a bedrock and underpinning nature of the new delivery and assessment format.

4.3. KEY INFLUENCE – ANN VANNER

Ann Vanner 2014-18 external examiner commented that the studio culture has created a much better output quality. Her external examining report in 2014-15 prior to studio set up was as follows: "A dedicated studio for the Architectural Technology students is very important - it was intimated that this was in the pipeline. The next stage is to ensure a vibrant and dynamic studio culture – and this is often the more difficult aspect to achieve. Students should be given ownership of the space; previous work should be available for the students and a range of activates should be timetabled to demonstrate the scope and flexibility of the space".
She commented positively about the changes noticed that year following set up of studio and seeing teaching and learning outputs in practice.

5. Student viewpoint

Students also appear to have learnt from this experience. Interviews were held to ascertain the following learning points.

5.1. MOTIVATION

All students who were in third year when the change began noted that they spent minimal time in studio in their first and second year. As they were in year 3 when the studio was set up, they were direct witness to the changes in year 1 and the encouragement to use the studio themselves. All students noted that in year 3 they felt the benefit of working in studio once they had realized that it was a safe place for them to work.

5.2. INTERACTION

All those questioned mentioned that once they started to work in studio they increased interaction with others on their course both from their own year group and of others. Their exposure to work of their peers enabled peer to peer learning to take place on a regular basis.

5.3. INVOLVEMENT

Students felt that they were part of a wider AT community in turn this resulted in them creating their own university society- the technical architecture society. This spurned a completely new use for the studio as it was seen as a meeting place, social gathering place as well as somewhere to work. Further benefits of the students' involvement included self-driven study trips for groups and other unintended consequences.

6. Conclusion

Students and staff alike learnt a considerable amount from the incorporation of these changes both pedagogical and practical into the course structure, and student feedback has been essential to the development of this initiative. Responses gathered will be examined in the full paper, however, the conclusion would be that the impact had a positive effect overall, peer to peer learning vastly improved, it increased third year students time in university (studio environment) from previous years (with same contact time as before studio) and seen as a first point of study. The critique process although brand new helped them improve at each review stage more effectively than previous tutorial or seminar process. The new layout was deemed a better working environment and a much better place to work in and was not 'just a computer suite' anymore. Some issues such as the review process deadlines were to be overcome, and some students found it a little difficult with a new teaching style with but problems were seen to be solved with additional individual teaching support that was deemed acceptable to the students. The approach is one that we are continuing and will investigate the impact further in future research papers.

References

BIBBINGS, H, BIELUGA, P., MILLS, C. 2018. Enhancing Creativity and Independent Learning of Architectural Technology Students through the use of a Real Life Design Competition Module. Archnet-IJAR, 12(1): 376-387

CEBE ,2010. Guide for new teachers in architecture. CEBE Briefing Guide Series 11.

DIZDAR.2014. Architectural education, project design course and education process using examples. In Procedia - Social and Behavioural Sciences Volume 176, 20 February 2015, 276-283

IBRAHIM & UTABERTA, 2011, Learning in architecture design studio. In Procedia - Social and Behavioural Sciences Volume 60, 17 October 2012, 30-35

ROBERTS, A ,2007. 'Problem Based Learning in Architecture' CEBE Briefing Guide Series 11, p1-4.

SALAMA, A, 1995. New Trends in Architectural Education: Designing the Design Studio. Available online from: https://www.researchgate.net/publication/30874574_New_Trends_in_Architectural_Education_Designing_the_Design_Studio

ULUENGIN & KOCA 2014. An examination of reflections of mainstream and architectural approaches in architectural design studios. In Procedia - Social and Behavioural Sciences

Volume 152, 7 October 2014, Pages 19-24

WILSON-MEDHURST, S. AND GLENDINNING, I. ,2011. Winning hearts and minds: Implementing activity led learning (ALL). In: Kallioinen, O. (ed) Proceedings of The Learning by Developing – New Ways to Learn 2009 Conference, Feb. 12-13 2009, Laurea Publications, Vantaa, Finland, pp304-323.

THE ROLE OF THE ARCHITECTURAL TECHNOLOGIST IN BIM ENVIRONMENTS

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Abstract. Built environment professionals are expected to work in Building Information Modelling (BIM)-enabled environments. (BIM)-enabled design is examined within the context of interdisciplinary architectural practices from a professionalism perspective. A substantial part of the literature on BIM focuses on its implementation or effect on communication and collaboration. Less research has investigated the challenges facing the architectural technologist and their role in interdisciplinary architectural practices that have implemented BIM. The effective transition to BIM-enabled design will be subject to its role in shaping the architectural practices norms. BIM is considered as a way of working that is changing the design process as well as the identities and structures of the built environment professions. The professionalism lens challenges the prevailing technical perspective that is dominating the literature. Case study work conducted in international architectural firms using BIM-enabled design is presented. The research shows aspects of both traditional and new professionalism.

Keywords: Architectural Technologist, BIM, Role, Interdisciplinary, Practice.

1. Introduction

The transition to Building Information Modelling (BIM)-enabled design has been the centre of a growing literature for a number of years in both the national policy (BIM Task Group, 2011) and architectural design (e.g. Sebastian, 2011; Nelson, 2017). BIM has also been examined in a wide range construction firms (Jaradat and Sexton, 2016; Dainty, Leiringer, Fernie and Harty, 2017; Li et al., 2019). BIM has been defined in a number of ways over the years. In this paper BIM is defined as the process and practices of architecture that are supported by large integrated digital systems (Bilal; Succar, Sher, & Williams, 2012), used to design, deliver and maintain buildings and infrastructure. An important development in these literatures is that the movement to BIM-enabled design is increasingly seen as not only been driven by shifts in national government policy, but also as a reorientation of structures and processes (Arayici et al., 2011) involving a redefinition of procurement and design (Taylor & Bernstein, 2009). Most of the research in this direction has so far focused on the translation of BIM requirements by governments into structured levels to guide and co-ordinate sector-wide change and development of technical infrastructure. An underlying policy agenda in the UK, for example, envisioned the implementation of BIM Level 2 (Managed 3D environment held in separate discipline 'BIM' tools with attached data) from 2016 on all publicly procured built assets (BIM Task Group, 2011: p. 16). UK Government policies privilege technocratic perspectives which argue that the successful transition to BIM depends on firms' ability to implement new technologies, structures and processes. The same technocratic emphasis is

evident in the prevailing BIM-enabled design literatures (Jaradat et al., 2013). Recent research has attempted to criticize and inform policy makers (e.g. Dainty, Leiringer, Fernie and Harty, 2017; Dowsett & Harty, 2018). Policy-makers and scholars, though, do not make transparent the generative role that the architectural profession must play to construct a supportive, mutually-constituted narrative of BIM and the profession itself. This research therefore argues that the successful transition to BIM-enabled design will depend on its conforming to (or shaping) the architectural profession's norms and expectations, rather than BIM simply supporting procurement and design operations with greater technocratic efficiency.

To better understand BIM-enabled design and the architectural professions, the framing perspective in the professions' literature is used in this study. This framing emphasises a shift to a 'new professionalism' in the built environment (Bordass and Leaman, 2013; Samuel, 2019). Professionalism is perceived as a set of values, knowledge and actions applied in institutionalized ways (Abbott, 1988; Elliott, 1972; Freidson, 1994). Professionalism in this paper is considered broadly - across a range of roles within and outside architecture – in the context of BIM-enabled environments. 'New professionalism' in this research refers to emerging aspects of professionalism that have not been traditionally associated with classic professions such as medicine and law. In other words, new professionalism refers to a collection of concepts and engagements that are contradictory to typical features of professionalism. By using the concept of 'new professionalism' this research examines how BIM-enabled design has been understood and practiced in interdisciplinary architectural practices, and how the purpose and role of the architectural and architectural technology professions and BIM-enabled design have been mutually redefined.

2. The Technocratic View of BIM and Professionalism

The technological element of BIM, i.e. the digital technologies and associated tools used for adoption and implementation, forms a central core of the prevailing BIM research (e.g. Arayici et al., 2011; Davies & Harty, 2013). Implementing BIM involves using a variety of digital technologies and tools as well as data interfacing and adoption concerns (Tse, Wong, & Wong, 2005) which create interoperability issues and technical complexities in adopting BIM (Jardim-Goncalves & Grilo, 2010). A number of emerging traditions of research within this technical perspective focus on integration, interoperability and standardization (Laakso & Kiviniemi, 2012), to solve issues of integrating project information amongst several disciplines (Wu & Hsieh, 2012). Similarly, many researchers studied data capture using laser scanning techniques and visualization web-based tools (Manferdini & Remondino, 2012). Other studies paid attention to the modelling concepts of BIM (Nederveen, Beheshti, & Gielingh, 2010) to clarify conceptions and present practical approaches to implementation and use (Jung & Joo, 2011; Bilal Succar (2009). However, a growing body of research brings attention to the limitations in emphasizing a technological perspective only (e.g. Dainty, Leiringer, Fernie and Harty, 2017s), and considers technical as well as non-technical issues including processes, people (e.g. Gu & London, 2010) and the socio-cultural environment (Arayici, et al., 2011). Earlier research also addressed the integration of BIM and collaborative working in terms of how BIM interrelates with construction processes (Grilo & Jardim-Goncalves, 2010). Less research has considered the instrumental role of the architectural or architectural technology professions in shaping the articulation and implementation of BIM in interdisciplinary architectural practices.

2.1. TRADITIONAL VERSUS NEW PROFESSIONALISM

Earlier definitions of professionalism mostly referred to the 'institutionalization of expertise', e.g. by establishing professional associations to regulate practice (e.g. Abbott, 1988: p. 324-5; Elliott, 1972). Similarly, Freidson (2001) focused on the professionalization of occupational groups within a wider system of professions. Researchers also made a distinction between organizational professionalism, with its focus on control used by managers, and occupational professionalism that has an interest in the self-regulation of occupational groups (Evetts, 2005, 2010). A form of hybridized professionalism in public domains was suggested by Noordegraaf (2007) which includes: 1) linkages between work and organized action, 2) mechanisms for legitimating work, and 3) searches for occupational identities. Noordegraaf (2007) investigated the contradictory attempts of managers who were trying to weaken professional control in service delivery, but at the same time seeking to become professionals themselves by imitating classic professions.

The concept of professionalism was traditionally based on generic characteristics which can be gleaned from the literature. Key elements of traditional professionalism include bodies of knowledge (Elliott, 1972; Larson, 1977; Sharma, 1997), with professionals as experts who have a body of technical and tacit knowledge (Evetts, 2003; Sharma, 1997). The codification of professional knowledge makes a profession distinctive (Larson, 1977) and legitimates professional work (Abbott, 1988). Professionals, including doctors and lawyers, apply extremely specialized rather than tedious manual labour (Noordegraaf, 2007). Another classic defining aspect of professionalism is barriers to entry to a profession (Elliott, 1972; Freidson, 2001). A profession refers to the group as well as the professional work of that group. Professionals form professional institutions to legalize occupational practice (Noordegraaf, 2007), and specify professional ethics (Larson, 1977; Sharma, 1997). Professional institutions organize professional work by requiring an academic degree and professional license; they also supervise professional conduct and discipline members who do not adhere to these codes of ethics (Noordegraaf, 2007). Ethical codes are described as individual obligations that serve to create trust, as expert services cannot be easily judged by the client (Bowen, Pearl, & Akintoye, 2007). Other relevant aspects of professionalism also include serving the public good or a wider perspective of the long-term public interest (Elliott, 1972; Evetts, 2003).

A great deal of autonomy, or independence and control over work, is also a typical aspect of professionalism (Evetts, 2003; Sharma, 1997). Professional autonomy is connected with skill and refers to the attempts of professionals to perform their jobs as they see appropriate (Freidson, 1994), and on the basis of professional judgement in defining problems and control over solutions (Abbott, 1988; Evetts, 2003). Despite the diverse range of definitions of professionalism in the literature, key features of traditional professionalism include: a distinct body of knowledge, service orientation and sense of identity, barriers of entry to a profession, a supportive professional community, ethical codes and public interest, autonomy and prestige.

Professionalism has been described as 'a social construct that changes over time. At its core lie two key notions: trust and the exercise of judgment based on specialist knowledge' (Duffy & Rabeneck, 2013: p. 1-2). Some researchers have reinterpreted professionalism in a broader fashion beyond the classic professionals only, such as medical doctors, but also included occupational groups such as managers and engineers (Evetts, 2003; Fournier, 1999). Similarly, Sharma (1997) argues that architecture, amongst other occupations, meet the requirements of professions as their practitioners are experts in the modern economy, and have specific service character and ethics, in addition to autonomy and prestige (Sharma, 1997).

The redefinition of professionalism has inevitable consequences including changes in the work and in relations between practitioners, their employers and clients, as well as in the work priorities and processes (Evetts, 2011).

A growing body of literature is considering professionalism in the built environment (e.g. Bordass & Leaman, 2013; Hill & Lorenz, 2011). Built environment professionals are ethically obliged to protect society and the built environment (Hill & Lorenz, 2011) by providing fair services and avoiding dishonest activities. Professions need a high level of conduct to ensure that the public have confidence in the quality of the services they provide (Poon & Hoxley, 2010). The concept of public good symbolized in values of trust and judgement is called for, to address the demands of sustainability in the built environment (Duffy & Rabeneck, 2013). The concept of professionalism remains valid despite a diminishing role of professional institutions (Hughes & Hughes, 2013). The professional institutions in the built environment enabled architects, surveyors, and engineers to hold significant positions of esteem and influence, within the domain of the built environment as well as broader society (Hughes & Hughes, 2013). Ethical codes specified by professional institutions are considered to govern the use of specialized knowledge, exercised by professionals in the built environment. Sadri (2012) argues that professional codes for architects appear to protect professional interests and ignore responsibilities towards humanity. These wide-ranging obligations at times compel professionals to challenge or confront what the 'client' or the 'market' needs (Hill & Lorenz, 2011; Hill, Lorenz, Dent, & Lützkendorf, 2013). Ethical obligations of the built environment professional involve thoughtful judgements case by case within the world, rather than direct observance to pre-defined codes (Farmer & Radford, 2010; Till, 2009).

A new professionalism in the built environment was recommended as a response for a need to examine the evolving nature of professionalism, and its role in the wider society (Bordass & Leaman, 2013). A shared vision and the common good are suggested as the heart of a new professionalism, which unifies all built environment professionals along with their institutions and educational systems. However, the conception of a 'new professionalism' that crosses the existing boundaries amongst building professions is seen to be challenging, in terms of the intertwining of processes of professionalization and institutionalisation on the one hand, and the influence of practice on the other hand (Bresnen, 2013). Despite the increased interest in examining professionalism in the built environment, the broader concerns associated with how professionalism is enacted in interdisciplinary practices and the role of the architecture profession have not been sufficiently studied.

The defining attributes of traditional professionalism, classically associated with professions such as medicine and law, are examined against concepts of new professionalism in the general literature as well as in the context of the built environment. Key characteristics of traditional and new professionalism are summarised in Table 1.

TABLE 1. Key Characteristics of Traditional and New Professionalism based on the Literature

Traditional professionalism	New professionalism
1. Based on the professionalization of occupational groups (Abbott, 1988; Freidson, 2001; Larson, 1977)	A shift of focus to an increased use of the discourse of professionalism in a wide range of occupations and organizational work places (Evetts, 2003; Fournier, 1999; Sharma, 1997)

2. Typical professional groups include classic professions such as medicine and law (Abbott, 1988; Elliott, 1972; Freidson, 2001)	Occupational groups outside health and law and include, for example, managers and engineers (Evetts, 2005; Fournier, 1999; Sharma, 1997)
3. Distinct bodies of knowledge, service orientation and sense of identity (Elliott, 1972; Larson, 1977; Sharma, 1997)	Suggested shared vision and unity in some educational systems such as in the built environment (Bordass & Leaman, 2013)
4. Barriers of entry to a profession, significant role of professional institutions (Abbott, 1988; Elliott, 1972; Freidson, 2001)	A diminishing role of professional institutions (Hughes & Hughes, 2013)
5. Ethical codes and public interest (Abbott, 1983; Larson, 1977; Sharma, 1997)	Strong emphasis on the common good, by for example making an interdisciplinary body of knowledge about buildings and their use (Duffy & Rabeneck, 2013)
6. A great deal of autonomy and prestige (Abbott, 1988; Freidson, 1994; Sharma, 1997)	Managerial control and decreased autonomy (Evetts, 2005, 2010, 2011)

2.1.1. Summary and Research Question

The technocratic view has dominated most of the literatures on BIM. Using a professionalism lens to understand BIM contests the prevailing technocratic perspective. Scholars take various views to define professionalism, as the notion of professionalism varies over time and involves several dimensions. Despite the numerous viewpoints taken to interpret professionalism, major defining characteristics are frequently mentioned. Yet new forms of professionalism continue to emerge in different domains within and outside classic professions. This paper considers professionalism within and outside classic professions, as the empirical work focuses on BIM-enabled design in interdisciplinary architectural practices, and is guided by the following research question:

How is the role of the architectural technologist played out within the contexts of BIM-enabled design?

3. Research Approach and Methods

The fieldwork discussed in this paper represents one aspect (professionalism in BIM environments and the role of the architectural technologist) of a larger research study investigating BIM-enabled design in interdisciplinary architectural practices in the UK and USA. The research approach is based on interpretations of qualitative data. Professionalism in BIM-enabled design is the unit of analysis within the context of interdisciplinary architectural practices. Data were collected from semi-structured interviews as well as other complementary materials, including pre-interview questionnaires, observations, documents, and web-based research to help interpret the interview data. The participants were mostly design professionals who have architectural and architectural technology backgrounds.

Thematic coding was used to analyse interview transcripts while other materials collected were read thoroughly to help interpret the interview data. All the interviews were transcribed verbatim and qualitative analysis software, NVivo, was used to facilitate the systematic analysis of large volumes of data. Key aspects of professionalism, gleaned from the literature are compared and contrasted against the case study findings. The analysis was structured around: 1) concepts of professionalization; 2) typical professional groups; 3) bodies of knowledge; 4) entry to a profession and the role of professional institutions; 5) professional codes of conduct and public interest; and finally, 6) autonomy and prestige.

4. Findings: Changing roles of built environment professionals

Using advanced BIM technologies enabled people who are not qualified architects for example, as well as others who do not have architectural backgrounds, to find a route to architecture and take control of BIM projects in some cases. These non-architects also took over certain tasks that used to be assigned to architects only, as this interviewee indicated:
'The tools available open up building design to a lot more people who are not architect… A lot of people in the design team who are not architects are able to take control of a project and do things that maybe historically only the architect would be given responsibility for.', Design Applications Manager "Firm 3 (London)".

Qualified architects, who are members of professional institutions such as the Royal Institute of British Architects (RIBA) and the American Institute of Architects (AIA), will still be needed in architecture practices and may not be required to get involved in BIM projects as architects are trained to design space that extends beyond buildings and their use. However, there seemed to be a sceptical view by some BIM practitioners regarding the significance of becoming a registered professional or a member of a professional institution in architecture or architectural technology. Some BIM practitioners argue that they may not need to become chartered if a desired role can be secured in leading architecture practices, by developing specialized BIM skills and becoming experts in certain tools:
'I'm very specialised in at least one programme, my specialty is the programme Revit. I've been working in it since 2004 approximately… I probably will not become an architect', BIM Coordinator and Specialist "Firm 2 (London)".

The title "architect" used to have a considerable position many years ago. Architects invest a lot to become licensed professionals in the hope that architecture would be a rewarding profession. Questions arise regarding the distinctiveness and future of built environment professions, and some traditional roles as leaders of project teams. The anticipation is that architecture practices will become part of a larger team that is providing design-build services:
'Well I hope we're still around. I hope we still have a role. This is pessimistic but I'm one of those who think we will go to more integrated companies that are design- build', Senior Vice President and Operational Manager "Firm 5 (Dallas)".

BIM was seen as one of so many other influences that are leading the move towards more integrated companies, in which architects and architectural technologists might not necessarily play leading roles. There is also a shift of focus away from concepts of profession and professionalization in the context of BIM-enabled design in interdisciplinary architectural practices which is in contrast to traditional professionalism.

5. Discussion and Conclusions

Key aspects of professionalism, extracted from the literature are compared and contrasted against the case study findings. A number of new professionalism features, which are inconsistent with traditional aspects of professionalism arise in interdisciplinary architectural practices using BIM-enabled design. The case study findings show that there is a shift to 'loosely-linked professionalism'. In loosely-linked systems BIM-related roles were taken up by those who either have architectural background but not qualified architects or architectural technologists yet, or who do not have architectural background. Those who had no architectural background but have developed an expertise in using BIM tools and processes played major roles in BIM projects. Integrated cross-training in educational systems was suggested by practitioners to enable fresh graduates including architectural technologists to work on interdisciplinary BIM projects. In BIM-enabled design the emphasis became on a broader perspective of collaborative work rather than individual autonomous professionals.

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References

ABBOTT, A. (1983). Professional Ethics. American Journal of Sociology, 88 (5), 855-885.

ABBOTT, A. (1988). The System of Professions: An Essay on the Division of Expert Labour. Chicago The University of Chicago Press.

ARAYICI, Y., COATES, P., KOSKELA, L., KAGIOGLOU, M., USHER, C., & O'REILLY, K. (2011). BIM Adoption and Implementation for Architectural Practices. Emerald, 29 (1), 7-25.

ARAYICI, Y., COATES, P., KOSKELA, L., KAGIOGLOU , M., USHER , C., & O'REILLY , K. (2011). Technology adoption in the BIM implementation for lean architectural practice. Automation in Construction, 20 (2), 189–195.

BIM TASK GROUP. (2011). BIS BIM Strategy Report. http://www.bimtaskgroup.org/wp-content/uploads/2012/03/BIS-BIM-strategy-Report.pdf.

BORDASS, B., & LEAMAN, A. (2013). Special Issue on New Professionalism. Building Research and Information, 41 (1).

BOWEN, P., PEARL, R., & AKINTOYE, A. (2007). Professional Ethics in the South African Construction Industry. Building Research and Information, 35 (2), 189-205.

BRESNEN, M. (2013). Advancing a 'New Professionalism': Professionalization, Practice and Institutionalization. Building Research and Information, 41 (6), 735-741.

DAINTY, A., LEIRINGER, R., FERNIE, S., A HARTY, C. (2017). BIM and the small construction firm: A critical perspective. Building Research & Information, 45(6), 696-709.

DAVIES, R., & HARTY, C. (2013). Implementing 'Site BIM': A case study of ICT innovation on a large hospital project. Automation in Construction, 30, 15-24.

DOWSETT, R., & HARTY, C. (2018). Assessing the implementation of BIM - an information systems approach. Construction Management and Economics, 37(10), 551-566.

DUFFY, F., & RABENECK, A. (2013). Professionalism and Architects in the 21st Century. Building Research and Information, 41 (1), 115-122.

ELLIOTT, P. (1972). The Sociology of the Professions London: Macmillan.

EVETTS, J. (2003). The Sociological Analysis of Professionalism: Occupational Change in the Modern World. International Sociology, 18 (12), 395-415.

EVETTS, J. (2005). The Management of Professionalism: A Contemporary Paradox. Paper presented at the Changing Teacher Roles, Identities and Professionalism, King's College London.

EVETTS, J. (2010). Organizational Professionalism: Changes, Challenges and Opportunities Paper presented at the DPU Conference: Organizational Learning and Beyond, Copenhagen, Denmark

EVETTS, J. (2011). A New Professionalism? Challenges and Opportunities. Current Sociology, 59 (4), 406-422.

FARMER, G., & RADFORD, A. (2010). Building with Uncertain Ethics. Building Research and Information, 38 (4), 363-367.

FOURNIER, V. (1999). The Appeal to 'Professionalism' as a Disciplinary Mechanism. The Sociological Review, 47 (2), 280–307.

FREIDSON, E. (1994). Professionalism Reborn: Theory, Prophecy and Policy. Cambridge: Polity Press.

FREIDSON, E. (2001). Professionalism: the Third Logic. Cambridge: Polity

GRILO, A., & JARDIM-GONCALVES, R. (2010). Special Issue on Building Information Modelling and Collaborative Working Environments. Automation in Construction, 19 (5), 521-664.

GU, N., & LONDON, K. (2010). Understanding and facilitating BIM adoption in the AEC industry. Automation in Construction, 19 (8), 988-999.

HILL, S., & LORENZ, D. (2011). Rethinking Professionalism: Guardianship of Land and Resources. Building Research and Information, 39 (3), 314-319.

HILL, S., LORENZ, D., DENT, P., & LÜTZKENDORF, T. (2013). Professionalism and Ethics in a Changing Economy. Building Research and Information, 41 (1), 8-27.

HUGHES, W., & HUGHES, C. (2013). Professionalism and Professional Institutions in Times of Change. Building Research and Information, 41 (1), 28-38.

ISABELLA, L. A. (1990). Evolving Interpretations as a Change Unfolds: How Managers Construe Key Organizational Events. The Academy of Management Journal, 33 (1), 7-41.

JARADAT, S. & SEXTON, M. (2016) BIM articulation and implementation in different-sized architectural firms, in the Association of Researchers in Construction Management (ARCOM) 32nd Annual Conference – Manchester, UK September 5-7th.

JARADAT, S., WHYTE, J., & LUCK, R. (2013). Professionalism in digitally mediated project work. Building Research & Information, 41(1), 51-59.

JARDIM-GONCALVES, R., & GRILO, A. (2010). Special Issue on Building Information Modelling and Interoperability. Automation in Construction, 19 (4), 387-520.

JUNG, Y., & JOO, M. (2011). Building information modelling (BIM) framework for practical implementation. Automation in Construction, 20 (2), 126–133.

LAAKSO, M., & KIVINIEMI, A. (2012). The IFC standard - a Review of History, Development and Standardization. Journal of Information Technology in Construction, 17, 134-161.

LARSON, M. S. (1977). Rise of Professionalism. Berkeley: University of California Press.

LI, P., ZHENG, S., SI, H., XU, K., & VILUTIENE, TATJANA. (2019). Critical Challenges for BIM Adoption in Small and Medium-Sized Enterprises: Evidence from China. Advances in Civil Engineering, 2019, 1-14.

MANFERDINI, A. M., & REMONDINO, F. (2012). A Review of Reality-Based 3D Model Generation, Segmentation and Web-Based Visualization Methods. International Journal of Heritage in the Digital Era, 1 (1), 103-124.

NEDERVEEN, S. V., BEHESHTI, R., & GIELINGH, W. (2010). Modelling Concepts for BIM. In J. Underwood & U. Isikdag (Eds.), Handbook of Research on Building Information Modelling and Construction Informatics: Concepts and Technologies. Harshey, PA: IGI Global.

NELSON, C. (2017) Managing Quality in Architecture: Integrating BIM, Risk and Design Process, London Routledge.

NOORDEGRAAF, M. (2007). From "Pure" to "Hybrid" Professionalism: Present-Day Professionalism in Ambiguous Public Domains. Administration and Society, 39 (6), 761-785.

POON, J., & HOXLEY, M. (2010). Use of moral theory to analyse the ethical codes of built environment professional organisations: A case study of the Royal Institution of Chartered Surveyors. International Journal of Law in the Built Environment, 2 (3), 260 - 275.

SADRI, H. (2012). Professional Ethics in Architecture and Responsibilities of Architects Towards Humanity. Turkish Journal of Business Ethics, 5 (9), 86-96.

SAMUEL, F. (2019) Professionalism: past, present and future, Building

Research & Information, 47:2, 248-250, DOI: 10.1080/09613218.2018.1502982

SEBASTIAN, R. (2011). Changing Roles of the Clients, Architects and Contractors through BIM. Engineering, Construction and Architectural Management, 18 (2), 176 - 187.

SHARMA, A. (1997). Professional as Agent: Knowledge Asymmetry in Agency Exchange. The Academy of Management Review, 22 (3), 758-798.

SUCCAR, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. Automation in Construction, 18 (3), 357–375.

SUCCAR, B., SHER, W., & WILLIAMS, A. (2012). Measuring BIM performance: Five metrics. Architectural Engineering and Design Management, Procurement and Law, 8 (2), 120-142.

TAYLOR, J., & BERNSTEIN, P. (2009). Paradigm Trajectories of Building Information Modelling Practice in Project Networks. Journal of Management in Engineering, 25 (2), 69-76.

TILL, J. (2009). Architecture Depends. Cambridge, Massachusetts: The MIT Press.

TSE, T. K., WONG, K. A., & WONG, K. F. (2005). The utilisation of building information models in nD modelling: A study of data interfacing and adoption barriers. ITcon, Special Issue From 3D to nD modelling, 10, 85-110.

WU, C., & HSIEH, S.-H. (2012). A framework for facilitating multi-dimensional information integration, management and visualization in engineering projects. Automation in Construction, 23, 71–86.

VIRTUAL REALITY IN THE ARCHITECTURAL TECHNOLOGY CURRICULUM IN THE U.K

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Abstract. This paper seeks to understand the climate for Virtual Reality (VR) within the Architectural Technology (AT)curriculum in the U.K. It seeks to assess through literature, focus groups and questionnaires VR's current place and seek to find a model to map an integration strategy of V.R. to the AT curriculum within the U.K. The paper uses focus groups, to highlight some of the problems that are still to be solved with the system and software. It also highlights for Architectural Technologists a new tool to communicate ideas with the three-dimensional world. We will assess virtual reality's current placement to see what steps have been achieved, therefore we can evaluate what is next for the technology for an A.T. This paper will query academics of other A.T. courses and their own implementation of V.R. within their curriculum and analyse what and why we should be using his type of technology in the education system. Looking back upon V.R.'s development we are able to see what progress has and is being made, to see if the time is right now to be implementing the technology with an appropriate method. The results show that it is a beneficial tool ready to be used by students to further their understanding of Architectural Technology. The paper was originally a dissertation by C. F. Wood in Robert Gordon University.

Keywords: BIM Manager, Role, competency, job descriptor.

1. Definition

Virtual reality definition according to Rheingold (1991) was the 'interactive computer technology' that simulates a space within the computer, able to be explored by the user. "Sometimes referred to as 'hybrid reality', mixed reality merges real and virtual worlds. This produces new environments and visualisations where physical and digital objects co-exist. The digital and physical objects can interact, in real time." (RIBA and Microsoft report 2018). Virtual reality has come a long way with its development and technology. The public now recognise it as a fully functioning technology available to the masses (Spaeth and Khali 2018)

1.1. RATIONALE

Architectural technologists' tools are changing. Technology is developing at a faster rate. V.R. is a relatively new tool to come to the curriculum; its opportunities were explored in the gaming industry and have come back to the construction industry as a more useful tool than previously (Spaeth and Khali 2018). Designers are now able to explore our models in a new dimension. This paper will seek to establish where virtual reality is placed within the Architectural Technology pedagogy in the U.K.

1.1. BACKGROUND

An Architectural technologist's role is to understand the concept given to them, see it through the stages to its completion and offer creative design solutions to an assignment (CIAT, 2018). Virtual Reality is helping to communicate these ideas from the mind of the technologist to the client. Three-dimensional representation is key for an A.T. to converse their ideas (Shujuan, Bo and Jie 2014). It is crucial in the early career of a student that they must concentrate on these new technologies such as V.R.

2. Introduction: Aim and Objectives

Two dimensional objects are only capable of showing the user a glimpse of the problem. By not being able to interact with it they are not able to make good decisions with a model that is probably for the most part a good model however to be able to understand it they must be able to relate to it in 3 dimensions (Kalisperis et al. 2002).

Horne, (2008) believes these are the reasons why students should learn V.R.:

- Rapid prototyping of models.
- Easy manipulation of objects and views.
- Makes the learning more exciting as they are exploring their own creation
- Scale models can be explored from the student's perception, i.e. they can walk through the model.

Bourdakis (2011) mentions the way designers are to represent their work is developing and is being analysed, with new technology such as virtual reality they must assess how to implement it to the pedagogy. By making the training process earlier on, the student will be more fluent with the technology in the later years. Baron and D'annunzio-green (2009) notes that students who are to cope at a higher level of education need to learn the skills as early as possible when they enter university. It is a new approach to learning compared to their previous years in education. It will aid the students and their way of learning as they are taught in a constructivist approach (Q.A.A. 2014). Thus, the aim of the paper is to understand through qualitative research and analysis, how V.R should be used in the Architectural Technology Curriculum in the U.K. To achieve this the paper investigates the reasons behind V.R.'s success in other industries, it analyses qualitative data from focus groups the authors have run on V.R application in the built environment and how people interact with the technology. It also analyses data from responses to a questionnaire, where the authors asked industry professionals and course leaders in A.T on their opinions on Virtual Reality in the curriculum, along with indicative quantitative data. The paper concludes with suggestions on how V.R. should be placed and exploited within the A.T. curriculum.

3. Methodology

The literature review will provide a basis for the topic in order to gain a true understanding of:

1) the current climate of how V.R and the extent to which it is being used in the curriculum,
2) who is best suited to undertake this field and teach the proceeding generations, making sure they can take this new technology into the industry,
3) And to predict where it is headed next.

Therefore, we must gather first-hand information from other universities and governing bodies of Architectural Technology within the U.K. To gather information, we must create a questionnaire to validate the literature review or challenge the review and provide new avenues for knowledge in the field.

The questionnaire will be released to programme directors of universities that teach Architectural Technology or of similar disciplines within the UK. The questionnaire will be limited to this particular group of people as having it online and open to all different groups of people will have cause for unreliable misinformed results.

Qualitative data in the form of observing the focus groups, should provide new questions. Whilst taking notes on how they interact with the given task. Denzin and Lincoln (1998) described qualitative data as information gathered from its source, this can be first-hand accounts of people's reactions and interactions with one another or a task. Creswell (1997) stated the fact that through the use of qualitative data, aids in creating 'open ended questions.' [Figure 1]

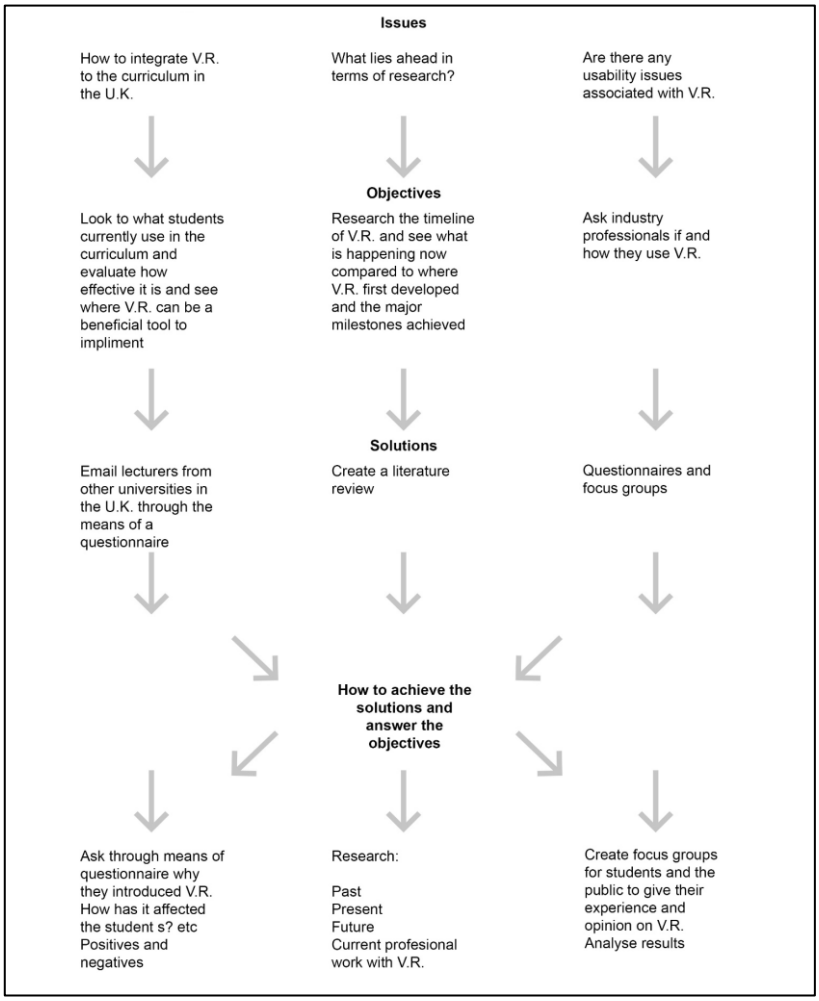

Figure 1: Methodology, diagram created by authors

4. Literature review

4.1. HOW IS ARCHITECTURAL TECHNOLOGY TAUGHT?

The Chartered Institute of Architectural Technologists (C.I.A.T) has outlined in the Subject Benchmark Statement by the Quality Assurance Agency (Q.A.A. 2014) that the course of Architectural Technology should be forward thinking in terms of technology. Hence the reason why we should adopt this new tool within the curriculum. Beetham (2013) mentions that students are more 'digitally connected' and the way they are learning must be geared towards this, for the future students benefit who are more digitally aware due to this new age of technology. Horne, M. states that new students entering the education system are expecting to be introduced to new technology and methods of learning.

4.2. VIRTUAL REALITY IN THE AT CURRICULUM

"Virtual Reality can be used when teaching using the real thing is dangerous, impossible, inconvenient, too time-consuming or too costly" (Pantelidis 1997).

A study was undertaken by Frank (2005) to ask students, "What do students' value in the Built Environment Education?" One aspect that students are only briefly shown and almost hidden from (not to the tutors' fault) is of the physical construction phase. Construction sites are hidden due to their potentially dangerous nature, this is where virtual reality can provide an insight to the construction phase.

Mujber, Szecsi and Hashmi (2004) described its uses and various fields. Showing us its rapid change and immersion in the industries such as prototyping and manufacturing. Designers need virtual reality to create, test, assess and repeat those steps until satisfied with the outcome. This ensures what we are designing as students is correct and fills the brief. Our principle as creators is to build, V.R. to us can be that building tool (Dvorák et al. 2005).

Advantages of virtual reality to the curriculum

- Assessment
- Learning
- Encourages collaboration

Milovanovic et al. (2016) stated that 'collaboration' is a key outcome with the future of V.R. and its effect within the groups using the technology. This only reinforces the fact that it is an additional tool that will add to the pedagogy of architectural technology.

4.3. HOW DO WE IMPLEMENT V.R. INTO THE CURRICULUM AND ITS FUTURE OPERATION IN THE EDUCATION SYSTEM?

"When people are asked to close their eyes and imagine a chair they don't think of the chair in section, elevation and plan, they picture it in 3 dimensions, people need to communicate their ideas in perspective" (Scott, J., personal communication by conversation. 2018). Technology and the nature of pedagogy work together and if one changes or develops, so does the other (Beetham 2013). With this in mind we cannot consider technology as a separate module within the curriculum, it must be integrated to every module (Bridges 1986). This can be transcribed to virtual reality also. Students whether they realise it or not are already exposed to virtual reality. The type of medium is the only difference. They may have experienced it in a video game or an advertisement on their mobile phone that uses V.R (Bourdakis 2011) V.R. is ready

now to be transcribed to the education system. If V.R is to be utilised and understood more readily by the user, it must be taught well throughout education programs.

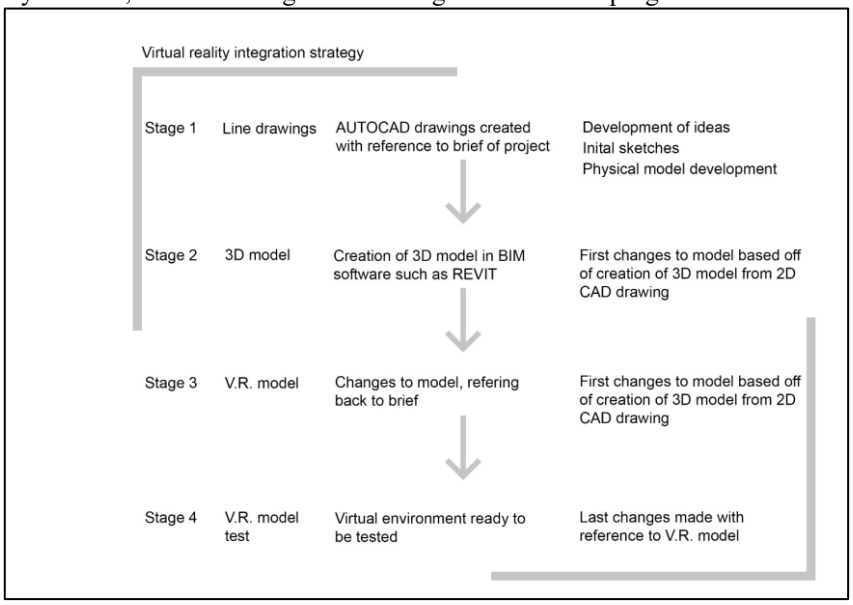

Figure 2: Process of generating a Virtual Reality Model, diagram created by Wood, with information from (Hamza 2006)

Figure 2 explains the process in which a V.R. project would be integrated to a student architectural technologists' role. We can see the first stage of how the AUTOCAD system begins to explain the design project through the use of line drawings, at this point the designer will begin to accumulate information regarding what the brief has specified, site analysis will be considered for the model. Then after, the 3D modelling stage (Stage 2) specific decisions regarding dimensions, orientation on the site and design will be finalised as regards to the brief. At stage 3 the virtual environment will be created on a PC, here we can improve the technical and design aspects.

Once that has been completed, at stage 4 the project can be simulated and rendered into the virtual environment. It is ready to present with the use of an HMD or a projection room. A projection room is a space in which projectors are used to cast images of an environment on the walls to create a simulation. This eliminates the need for a head mounted display, it is another type of V.R. (Whyte et al. 2000)

Lentz et al. (2007) highlights the benefits and the function of having sound within a V.R. environment, giving a fully immersed experience for the user. The simulations may eventually be 4 dimensional, meaning that the user can be able to experience the acoustics, relative humidity and thermal comfort of the design, these can be adjusted within the program.

Student's generally only experience the construction phase post education. Chin and Chia (2003) mention that students may be fluent in understanding a problem and know the solution, but Gallagher et al. (2005) points out that it may not be correct in practice. On paper it is correct, but an actual physical construction may not. This is where V.R. can bridge that gap and help with the understanding of the construction phase.

4.4. TIME AND DETAIL

In terms of the educational aspect of V.R. and its immersion we can make models, and their environments, explore these and manipulate them rather than building a physical model that may take a longer period (Haque and Saherwala 2004). This requires time to make the model detailed enough to get to a certain level of intricacy. It is here where students need to make a key decision of which level of detail to take within their model. If they create a model with more time and detail then they will have a model that can be used as a collaborative tool, due to the depth.

4.5. FOUR DIMENSIONS AND BEYOND

To create a fully sealed off virtual space then we must design sound into the equation, as vision and handling of the V.R. model is standard. The primary intent of V.R. is to show a 3D model, acoustics in V.R. is not given the same time and attention to detail as models are (Lentz et al. 2007). Sound would increase the model and its complexity and immersion, being able to have sound in the model, for the user to be able to understand the virtual environment completely then the space must be complete with all senses (Serafin and Serafin 2004). This aspect of the model is called the 'soundscape'. Sound events and ambient sound are two different types of sounds which can be placed into a model.

4.6. VIRTUAL REALITY IN OTHER INDUSTRIES

Other sectors that have benefitted from the use of this technology are for example the medical industry. V.R. has enabled them to gain more knowledge and understanding of what to undertake in a real-life situation without causing unnecessary injury to patients (Gallagher et al. 2005). It gives them the chance to learn from their mistakes. The one issue that has been found is that of what quality and skill level is this simulation within the V.R. environment, giving these trainees and if so, what calibre are they getting from it and is it suitable to the standards required in the field. For example, is the training through the virtual environment of an operating room better than that of a real one? In order for it to be, then it must be fully immersive.

Figure 3: Virtual Reality Timeline, created by Wood

5. Questionnaire Analysis and reflection

The questionnaire was sent to all architectural technology course leaders in the UK, thus cannot be used to justify and answer the ideas of the entire UK, for that we would require more results. It is only an indicator of the way V.R is currently being used by the whole of the U.K. We use

the questionnaire to compare with the other aspects of the paper i.e. the focus groups and the literature to find the answer to the question of Virtual Reality in the Architectural Technology curriculum.

The initial findings from the questionnaire have shown that V.R. is being applied to the curriculum in some institutions within the UK. The results are consistent with that of what was discussed in the literature review with regards to V.R. being a great tool in collaboration, Milovanovic et al. (2016). The survey also echoed problems found within the focus group, the main issue was that setting up of the software to run the V.R. was difficult. On occasion upon initial start-up the computer did not recognise the HMD or that of the remotes, in the survey the general response was a medium difficulty in their experience of V.R. The focus groups provided more results with open ended questions and highlighted that even with today's advances in technology there will still be usability issues, which students might find. The responses were in some cases a little general to some of the questions, but I must highlight that it was not to the participants fault but since they didn't know the specific applications that they have at their institution. By constructing a general list of current and prominent applications on the market this may have solved this problem and able to give more clear results. Response to the questionnaires was less than 10% of the total emails sent out. This could have been higher if I had sent out the questionnaire over around June July of 2018. The responses overall shown that V.R. is being practiced in the education systems whether it is by the students or by the institution, it is up to the course leaders to work out where and how to assess if they see the need for it as part of their curriculum.

6. Focus Group Analysis and reflection

The focus groups aided in validating the statements brought up with the questionnaire as it gave a real-time simulation of how students would interact with the software and also helped to generate unforeseen questions to consider. The focus groups consisted of two Scottish Highers classrooms that visited the university and visitors during our open day that tested the VR equipment and software. The future use of these systems is to have one set up for students on every level of the school for them to test their models without the need for a lecturer to be present. This will mean live testing of models for students to work out whether their designs are going to work in an environment. This links back to the fact that the architectural technology curriculum is designed to encourage a constructivist approach amongst the students, virtual reality is encouraging this style of learning.

The focus groups gave us an understanding of the current systems, showed the benefits of the software as it encouraged teamwork amongst the 2nd year A.T.'s They discussed how parts of their design didn't work with relation to the height of windows needing to be higher, in order to let in more light. What is required to be adjusted will only be seen with the use of a V.R. model.

Overall the focus groups highlighted these key points:

- Students do not have a dedicated period for learning of this tool as time is given to other methods. Therefore, tutors must provide a means in which to give students the necessary starting blocks.
- New technology takes time, but they will benefit. In doing so and following those steps and guidelines students will gain a better understanding of 2D images and drawings, helping them to think more 3 dimensionally about their building.

- Students seeing their own work from Revit in V.R. gave them a new take on their work, opened new questions for colleges to help answer as they were able to see the project in 3D compared to 2D line drawings.

7. Conclusions

The ideas outlined and discussed have shown that the time is now for virtual reality to be introduced to the architectural technology curriculum, we have the affordable technology, applications such as Revit that run V.R., students have seen the need through the focus groups of the positive capabilities of the technology that can be seen in their own work.

The literature review helped to establish where the technology currently stands within the curriculum. With the help of examples where sectors that use V.R. technology have benefitted from the technology. Where it has gained traction in recent years with regards to its development, making it a more viable technology for more people to use and better understand its uses. Assessed whether it is an effective means in the pedagogy of the A.T. curriculum and that students would gain from its integration to their education.

The focus groups aided in the understanding of how the system is best set up within the curriculum and how students would benefit from V.R. It also helped eliminate issues before implementation of the tool, sorting out software problems and communication of data across applications that run V.R. The questionnaire results proved that institutions are aware of the benefits of the technology and identified its potential within the curriculum. This part of my research brought me back to Messner et al. (2003) paper which summarised that the space created in V.R. by students enriches them with a memorable atmosphere in which to learn and create. It is therefore key for course leaders to make the shift to integrate it to the curriculum for students to learn the technology from an early starting point so they can use it fluently throughout their years of study. A virtual model is able to be manipulated with ease (Arnowitz, Morse, Greenberg 2017). Overall if V.R. is to be mapped in an architectural technologists' role and the education system, there needs to be adequate software and a system that is readily available to the students in order to process the information into an interactive model. Giving them space and time required to learn the technology along with the set-out curriculum. As well as the students doing their own investigations to learn from mistakes at the educational level to be able to process the information. Starting this as soon as they begin their education is key to the development of this skill set.

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References

ACCELERATINGBIZ, 2018. Augmented and Virtual Reality Timeline. [Online]. Available from: https://acceleratingbiz.com/proof-point/augmented-and-virtual-reality-timeline/ [Accessed 8 November 2018].

ARASHPOUR, M. and ARANDA-MENA, G., 2017. Curriculum renewal in architecture, engineering, and construction education: Visualizing building information modelling via augmented reality, Volume (01), pg3.

ARNOWITZ, E., MORSE, C. and GREENBERG, D.P, 2017. Physical Design and the Perception of Scale in Virtual Reality, Volume (01), pg110-111.

ALVARADO, R.G. and MAVER T., 1999. Virtual reality in architectural education: Defining possibilities, Volume (18), pg7-8.

BARON, P. and D'ANNUNZIO-GREEN, N. 2009. Active learning in higher education. A smooth transition? Education and social expectations of direct entry students, Volume (10), pg7-10.

BEETHAM, H., 2013. Rethinking pedagogy for a digital age: designing for 21st Century Learning Edition (02). Oxford Brooks University, UK: Routledge

BOURDAKIS, V., 2011. Interactive spatial design course analysis. 10 years, 150 projects, Volume (01), pg647-652.

BRIDGES, A.H., 1986. Any progress in systematic design? Computer-aided Architectural Design Futures. CAAD Futures Conference Proceedings, Volume (01), pg10-13.

CHIN, C. and CHIA, L., 2003. Problem-Based Learning. Using Students' Questions to Drive Knowledge Construction, Volume (01), pg1-3.

CRESWELL, J.W., 2013. Qualitative inquiry and research design: choosing among five approaches. 3rd ed. Thousand Oaks, CA: Sage Publications.

DENZIN, N. and LINCOLN, Y., 1998. Strategies for qualitative inquiry. 3rd Edition. Thousand Oaks, CA: Sage Publications.

DUARTE, J., 2007. Inserting New Technologies in Undergraduate Architectural Curricula. A Case Study, Volume (09), pg423-429.

DVOˇRÁK, J. et al., 2005. Central European multimedia and virtual reality conference. Boosting up architectural design education with virtual reality, Volume (01) pg1-4.

FRANK, A. Dr., 2005. What do students' value in Built Environment education? Volume (02), pg21-27.

FOOD ALERT, 2017. Using virtual reality to enhance health and safety training. [online]. Food Alert. Available from: https://www.foodalert.com/news-views/using-virtual-reality- enhance-health-safety-training [Accessed 17 September 2018].

GALLAGHER, A. G. et al., 2005. Virtual Reality Simulation for the Operating Room, Volume (01), pg1-2, pg7-8.

GANAH, A.A., BOUCHLAGHEM, N.B. and ANUMBA, C.J., 2005. Viscon: Computer visualisation support for constructability, Volume (01), pg69-70.

GROAT, L. and WANG, D., 2013. Architectural research methods. 2nd ed. Hoboken, NJ: Wiley.

HARTS, M., 2012. Final year projects. [online]. Available from: http://final-year-projects.com/index.htm [Accessed 30 November 2018].

HAQUE, M., E., and SAHERWALA, S., 2004. American society for engineering education annual conference & exposition. 3-D Animation and walkthrough of design and constriction processes of concrete formworks, Volume (01), pg1-2.

HORNE, M. and THOMPSON, E.M., 2008 Journal for Education in the Built

Environment. The Role of Virtual Reality in Built Environment Education, Volume (03), pg6- 8, pg10-11.

HORNE, M. and HAMZA, N., 2006. Integration of virtual reality within the built environment curriculum, Volume (11), pg311-315, pg321-322.

KALISPERIS, L.N. et al., 2002. Design-education. Proceedings of the 20th Conference on Education in Computer Aided Architectural Design in Europe, Volume (2), pg64-70.

LENTZ, T. et al., 2007. Research Article. Virtual reality system with integrated sound field simulation and reproduction, Volume (2007), pg1-2.

LEVIN, P., 2011. Excellent dissertations! Edition (02). Berkshire UK: Open University press.

MESSNER, J.I. et al., 2003. Using virtual reality to improve construction engineering education, Volume (01), pg1-2, pg6-7.

MICROSOFT AND RIBA, 2018. Digital transformation in architecture. 1st ed. Available from: https://www.architecture.com/-/media/gathercontent/digital-transformation-in-architecture/additional- documents/microsoftribadigitaltransformationreportfinal180629pdf.pdf Microsoft and RIBA. [Accessed 28 November 2018]

MILOVANOVIC, J. et al., 2017. Virtual and augmented reality in architectural design and education, Volume (01), pg2-3.

MUJBER, T.S., SZECSI, T. and HASHMI, M.S.J., 2004. Journal of materials processing technology. Virtual reality applications in manufacturing process simulation, Volume (155- 156), pg1834-1835.

PAOLIS, L.T.D., 2003. Virtual and Augmented reality applications: Available from: https://libguides.rgu.ac.uk/harvard-referencing-templates [Accessed 4 November 2018].

POWELL, W. et al., 2016. Getting Around in Google Cardboard. Exploring Navigation Preferences with Low-Cost mobile VR, Volume (01), pg1-2.

Quality Assurance Agency for Higher Education, 2014. Subject benchmark statement UK quality code for higher education [online] UK: QAA. Available from: https://www.qaa.ac.uk/docs/qaa/subject-benchmark-statements/sbs-architectural- technology-14.pdf?sfvrsn=81ecf781_18 [Accessed 12 November 2018]

RHEINGOLD, H., 1991. Virtual reality Edition (01). University of Michigan: Summit Books.

SACKS, R. et al., 2015. Construction Management and Economics. Safety by design: dialogues between designers and builders using virtual reality, Volume (33), pg58-60, pg63, pg67.

SERAFIN, S. and SERAFIN, G., 2004. Sound design to enhance presence in photorealistic virtual reality, Volume (01), pg1.

SHUJUAN, L., BO, Y. AND JIE, Y., 2014. Landscape research record. 3D digital graphics in landscape architecture professional practice: current conditions in a nutshell, Volume (01), pg2.

SPAETH, A.B. and KHALI, R., 2018. The place of VR technologies in UK architectural practice, Volume (14).

STONE, R., 2001. International Journal of Human-Computer Studies. Virtual reality for interactive training: an industrial practitioner's viewpoint, Volume (55) Issue (04), pg700- 701.

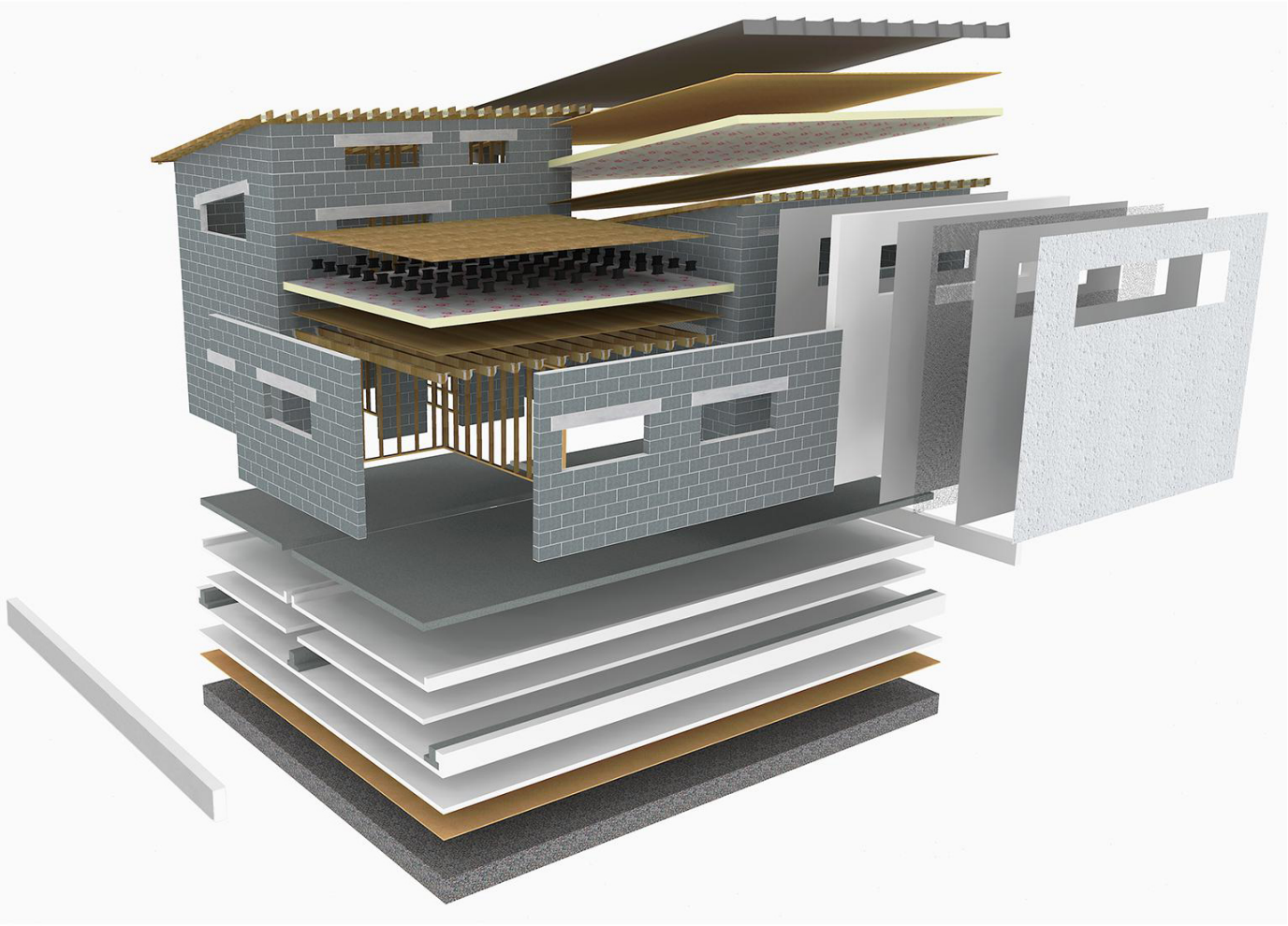
THE CHARTED INSTITUTE OF ARCHITECTURAL TECHNOLOGISTS, 2018. What is a Chartered Architectural Technologist? [online]. CIAT website: CIAT. Available from: https://ciat.org.uk/about-us/what-is-a-chartered-architectural-technologist.html [Accessed, 11 September 2018]

VANOVERBEKE, Z. 2017. Virtual reality. Volume (01), pg5,7 pg15-17.

WALLIMAN, N. S. R., 2004. Your undergraduate dissertation: the essential guide for

success. Edition (02). London: UK.

WHYTE, J. et al., 2000. Automation in construction. From CAD to virtual reality: modelling approaches, data exchange and interactive 3D building design tools, Volume 10 (01), pg43-44.



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