PREPARING ARCHITECTURAL TECHNOLOGY STUDENTS FOR BIM 2016 MANDATE

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Abstract. This paper presents a challenging stand for architectural technology (AT) students, and roles. What roles are AT graduates going to play before and after the 2016 Building Information Modelling (BIM) mandate and how academia is preparing them for such roles. All these questions and others have been debated since the mandate, speculation more than any other tangible knowledge or experience is the basis for most changes to the AT curriculum. AT student expectations have been explored and the different opportunities that a graduate might have, in the light of the suggested roles. A survey was designed and emailed to third year students in the second semester of their study. The purpose was to understand students perception on BIM within the context of professional practice (s) this included both; work placement and Simulated Professional Practice. The results suggest that BIM as a practice in context still lacking, however AT graduates feel confident for the mandate. But to overcome the current transitional stage academia needs both; contextual teaching and training of BIM, and stronger ties with the industry. Achieving that would provide well-trained and confident AT graduates to take up the transitional change competently and innovatively in AEC practices.

1. Background

With the government Building Information Modelling (BIM) 2016 mandate, the construction industry is faced with changes in practices, processes and roles. Consequently, Architectural Technology (AT) as a profession has the ability to gain versatile opportunities to complement the gap between the architect and other construction parties, but this can only be accomplished if AT graduates have the technical skills to support both, knowledge of building design and BIM workflow.

The BIM strategy has added another technological responsibility for AT - to bridge the different attitudes of interdisciplinarity. This responsibility comes mainly from Information Technology (IT) and its new ways of doing things. The current shortage of trained BIM personnel is a barrier to BIM implementation.

This study considers the effect of work placement on contextual learning possibilities for full-time curriculum of Architectural Technology education. It discusses the approaches adopted in the Scott Sutherland School of Architecture and Built Environment at Robert Gordon University, which we believe will be of interest to colleagues and educators in other schools who are concerned with a lack of opportunity to undertake practical training allied to the built environment.

The study employs a questionnaire survey to look at the effect of undertaking work placement and attendance at a professional practice studio on the participants' skills development. This survey examines the current position with regard to the balance between education and work in practice. A detailed account is provided with a focus on professional studies, where some issues and opportunities were highlighted for improvement.

2. BIM Current Messages for Education

Encouraging the development of Information Technology (IT) skills is a key part of the UK Government's strategy to improve the construction industry productivity and performance. Recently the Government's Construction Strategy complemented this with its mandate for *'fully collaborative 3D BIM as a minimum by 2016'*, and the need for efficiency and industry reform to realise a '*cost reduction of 20% during the term of the current parliament'* (National BIM Report, 2012 p.04). This has already encouraged many firms to revise their "*technology assessment and training programmes, to make sure that they can measure the skills of key personal*" or new graduates.

At the same time, it is necessary to understand the changing needs of the industry and these must be communicated to be able to develop governance that supports UK students to acquire the right skills in the field of Architecture Technology and Built Environment. This can be achieved through a centrally co-ordinated collaborative approach to monitor skills development of final year architecture technology students, and architecture design students.

Therefore, an investigation into the influence of placement from an industrial context on students' skills is required. Bearing in mind that until now there has been no consensus on how best to address this aspect of students' development (Salman, 2011), this research focuses on the practical skills of students in both AutoCAD (CAD) and Revit (BIM). Other studies focused on skills that are more generic and their impact on students' professional capacity. Taking into consideration the potential benefits for architectural technology programmes, this research will help set the agenda for professional training and BIM integration – areas that have to be set properly to maintain our educational role and impact for the 2016 BIM mandate.

The focus of this study is on one aspect of employability - that is graduate's confidence in using BIM (3D CAAD based design processes) within a placement as opposed to University (Salman, 2011). How would placement change students' engagement in learning and using CAAD (2D and 3D) while the context is different? How this might enhance their confidence and employability after graduation? Remarkably, this is an under-researched area and requires more efforts by scholars to understand how teaching programmes can bridge the technical/professional aspects of students' development: that is, how undergraduates are using BIM principles and 3D skills rather than learning new skills and other attributes through the higher education process. This will have a positive impact on student's professional preparation.

2.1 TERMINOLOGY

One aspect of our teaching is the terminology that we use to express concepts and relations. Adopting new technologies brings new terminology, when BIM is mentioned the wording used implies that all parties are present in one way or another.

"*It makes designing fun again. We are not drawing lines, we are building a building*" (Downs, 2009).

Active and experiential learning of BIM have changed terminology in two ways. The language has become more active in the sense that it carries with it collaborative meanings and shared values. Table 1 shows some of the differences between the terms of yesterday (then) and tomorrow (now or tomorrow).

Table 1. Terminology and BIM.

THEN	NOW and TOMORROW
Disconnected	Integrated
They	We are..
2D drafting	3D, 4D, nD
Sketching ideas	Building ideas
Print	Digital
CAD skills	Modelling
Drawing	Prototype

While they differ, they share similar aims and qualities. The adapted terms aim at placing emphasis on the exploration of 3D qualities and information extraction whilst also emphasising information transmission in an integrated approach.

2.2 CAAD VS BIM

When BIM is mentioned CAD also mentioned, even if implicitly, and the question of whether BIM is CAD or CAD is BIM comes to the forefront. Based on teaching BIM, Eastman et al. (2008) recognised clearly that "*students are able to grasp the concepts and become productive using BIM tools more quickly than they were with CAD tools". BIM appears fairly intuitive to students, and it more closely resembles their perception of the world*." Because BIM requires different ways of thinking about how to develop designs and manage construction of buildings, the industry sought to retrain those employees who are more familiar with CAAD (Eastman, et al., 2008). This training needs to balance old ways of thinking (primarily 2D-based) and working habits with different processes and work flow. New graduates, who are influenced by their familiarity with BIM and use it for a full range of undergraduate projects, are likely to have a profound effect on the way that companies will deploy BIM.

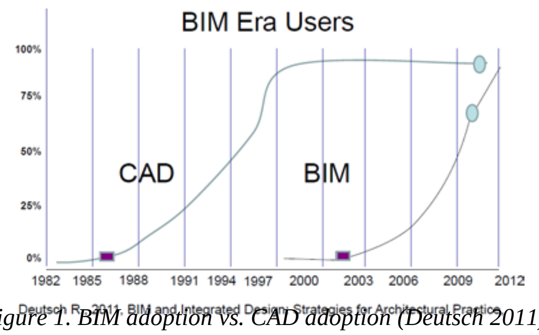

Figure 1. BIM adoption vs. CAD adoption (Deutsch 2011)

In the literature, the term CAAD is treated as an inclusive term of all CAAD systems that may be used for the architectural design process (Salman, 2011). However, it is not inclusive or generic from students' point of view. In Salman's (2011) study, all participants agreed that when CAAD is mentioned they associate it with the most used CAAD package AutoCAD (no mention of ArchiCAD, although it has been taught in parallel, and it is a CAD compound term). Briefly, the study suggests three things: 1 - defining the term CAD or CAAD as a meaning was based on a practical context in relation to the way it was used by students during their university education; 2 - introducing CAAD in a detached manner from its historical evolvement and philosophies, and 3 - to reflect on the differences between different

CAAD software programs such as AutoCAD and SketchUp, which are totally different in the way they work.

BIM implementation does not mean employing another CAAD software program, or a particular software program, even if that software program is 3D based. Implementing BIM involves both technology and process, as the existing processes will evolve with the implementation of BIM technology (Deutsch, 2011).

2.3. BIM IN THE EDUCATIONAL CONTEXT

Most schools consider the integration of computer literacy and CAAD as one concept (Mark, Martens and Oxman, 2003), which involves the teaching of two types of computer systems: social and professional. In recent years, Garcia et al. (2007) challenged professional (commercial) systems by proposing an educational system that has the same aspects of AutoCAD commercial software, but with an easier learning curve. The results showed that students preferred to learn and use AutoCAD even though it is more difficult than the new system. This preference was based on two reasons: CAAD's advanced *technical* aspects, and its role in their future career (Garcia, et al., 2007). This also reflects the common perspective of why these systems are important in design schools and design teaching.

AEC industry requirements change with time, e.g. the BIM 2016 mandate, and all careers are subject to such changes (Soltani-Tafreshi, Twigg, and Dickens, 2009). It is imperative that students are able to handle the uncertainty that comes with such changes. Academia tries to highlight potential roles and the accompanied changes as these requirements are not always aligned with the curriculum.

Figure 2. BIM transferrable change

With a mandate from the UK government, BIM adoption is inevitable. However, its implementation may manifest in two opposite directions suggesting that change needs a wider base; this wider base may be presented by new graduates coming BIM ready to industry, or by industry technological reformation. The most likely is that graduates will take the lead to bridge the identified gap between industry and academia, between technology and multidisciplinary teams.

2.4. EFFECT OF THE WORKSPACE

The term design workspace refers to the tools that are available to designers in a shared workspace; either studio or practice, such as CAAD software programs and paper-based, and the designers' interpersonal communication channels (Maziloglou, Scrivener and Clark, 1996). In the workspace, one can observe both interpersonal interactions between designers and other construction specialists, and their interaction with the various workspace tools and media. These two interactions are responsible for giving the design workspace its richness and complexity. The flow of work may change to accommodate a new technology or approach to design processes. Workflow has changed in the industry to suggest new experiences and problems. However, collaboration and cooperation are the most appraised by employers and professional practices.

The interaction between students and tools and their ability to be critical of the used tool also depends on the level of skill in using this tool and, to a certain extent, how confident they feel interacting with a tool in the academic context of the studio. If the skill is available, then interaction will take place and as a result, the student's ability to be critical will mature.

Universities in the UK promote the merits of vocational degree programmes that combine academic rigour with periods of placement within industry. At Scott Sutherland School third year AT students have to select one option from the following professional contexts: Industrial Placement, Simulated Professional Practice, or Exchange Programme.

2.5. NEW ROLES

BIM means different things to different professionals, working with BIM means a profession has more specific roles that an AT, CAD manager or IT coordinator. Some of the research on BIM comes from a particular discipline or professional perspective. Specific literature has been written to help professionals and graduates to understand the benefits of BIM and the changes in roles. This change can be categorised under new emergent professions as outlined below (Oxman, 2008; Salman, 2011; Simpson, 2012):

- *The Technology Manager:* An AT who is responsible for setting up information, communication and modelling strategies for the whole project team (s), from start to operation.
- *The Modeller:* An AT who is responsible for creating geometry based models, and any detailed components required for the BIM model.
- *The Toolmaker:* An AT who is responsible for tailoring tools, apps and interfaces to allow exchange of ideas, information and data between different project team members and software programs.
- *The Researcher:* Anyone who wants to bridge the gap between theory and practice to speed up implementation and solve problems.

3. Data Collection

The interaction between research, practice and education is important in producing and revealing necessary knowledge. Through this interaction, the applicability of CAAD from one context to another can be observed and applied through design practices. Thus, the investigative (physical) setting is a significant factor in the overall research approach to design processes, which affect the research methods used. For example, work placement as a setting provides a reliable indication of the applicability of student's transferable skills.

This study methodology aims to monitor the effects of professional context (under simulated or real conditions) on undergraduates' skill development, which also supports the "process" point of view of research methodology as an explorative methodology. Consequently, the current research involves a questionnaire survey to monitor students' development during their second semester professional practice.

The research started with a literature review focusing mainly on the following keywords; work placement and skills acquisition, employability and attributes, professional context and BIM adaption. The search included both literature on general employment skills and literature specific to architecture technology and architecture disciplines. The goal of the literature review was to find out the main skills of the discipline and develop a questionnaire that is explorative in nature. The questionnaire focuses on how undergraduates comprehend their generic skills, specifically CAAD skills development, through work placement and simulated professional practices, and how their CAAD/ Revit skills were perceived by the employer.

3.1. SURVEY

The questionnaire survey was exploratory in nature, but also evaluative, which was critical in two respects. Firstly, it describes the contemporary student from the student's perspective by reflecting on their experiences and the application of CAAD and BIM (if any), in order to support the study with contextual propositions. In addition, it further informs what needs to be changed or modified in subsequent year(s) of study.

Data from the targeted sample was collected for the following research objectives:

- To describe the targeted sample in terms of their skills, knowledge and contextual learning in the professional context, and
- To know how students measure their learning preferences and needs.

3.2. METHOD

A questionnaire survey was designed and circulated using an online tool (dotsurvey.com) to gain an understanding of the professional context within which students operate and interact. This study was able to clarify the effects (if any) of their professional practices on skills acquirement and employability expectations and helped to gain understanding of how context would affect CAAD's future integration in the architectural technology curriculum.

The targeted sample consisted mainly of third year students who have been studying Architecture Technology at the Scott Sutherland School of Architecture and Built Environment for at least two years, with an average of one-year industry experience (taking a placement).

4. Results

Twenty-five responses (representing a 50% sample of the cohort 2012-2013) were received. The questionnaire took approximately 3 minutes to complete. Results are presented in the same sequence as the main survey.

Descriptive analysis was carried out to provide a general overview of the sample to be presented in percentages. Survey responses were analysed using an Excel spreadsheet. Survey responses were analysed using the MS Excel package by performing descriptive statistics, and presented in percentages.

4.1. PROFESSIONAL CONTEXT

In response to what the participating students (third year) had to do in their semester-two studies, work placement and professional practice simulation were cited equally, with a percentage of 43%. This is shown in Figure 3. Only 14% cited none of the two options.

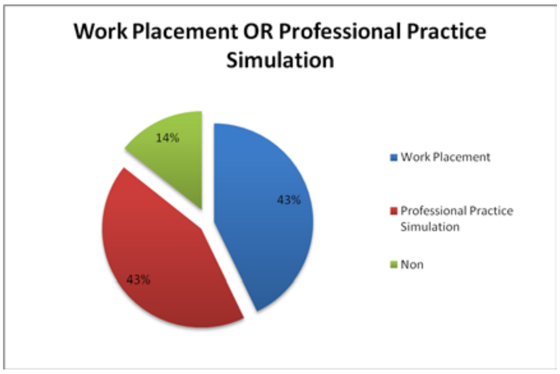

Figure 3. The survey participants

4.2. DESIGN SKILLS

Students' self-assessment of their design skills (architectural design, and CAAD) was highlighted in the following manner. Students' skill "self-assessment" was measured on a five–level scale from poor (1) to excellent (5). The results are shown in Figure 6. The results showed that students ranked their design skills as follows: architectural design skills mean score is good (mean score of 3.4 out of a possible 5), and CAAD skills mean score is good (3.8); slightly higher compared to their design skill.

The chart in Figure 4 provides a visual indication of the students' self-assessment scores showing the lowest and the highest score.

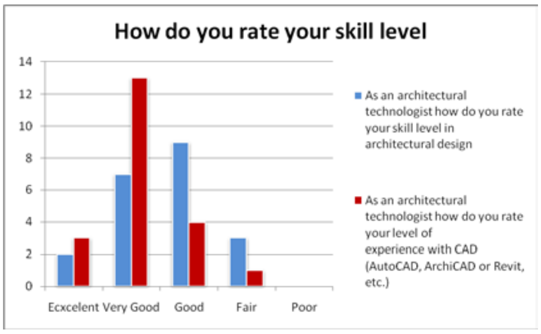

Figure 4. Participants' skills Self-assessment

It is obvious that third year students were consistent in assessing their design skill and extremely inconsistent in assessing their CAAD skill by scoring various levels of CAAD experience within the same studying stage. This should be taken into consideration when designing any CAAD related modules. Normally, students at earlier stages of education have various levels of skill, something that is less likely to be noticed when they are in the final stages of their education. Therefore, access to various levels of CAAD tutorials is essential for AT students.

4.3. THE USE OF 2D AND 3D

Figure 5 shows the differences between the main two contexts in terms of CAAD use in relation to work placement and professional simulation. In the workplace context, more than half of the students (53%) tend to use CAAD for 2D drawings with a lower percentage (29%) of them using it for simple 3D drawings (without rendering). Only 18% of them use it for 3D modelling (with rendering).

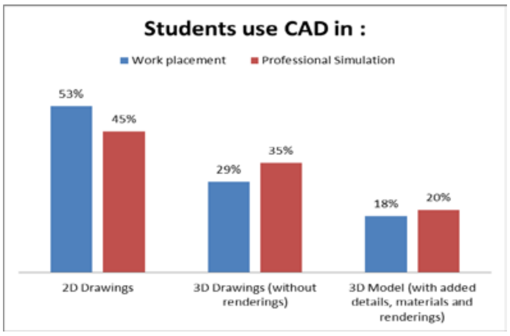

Figure 5. Participants' use of 2D and 3D

On the other hand, the results in relation to professional practice showed a different trend, CAAD use in a professional simulation studio. Figure 5 shows that less than half of the participating students tend to use CAAD for 2D drawings with a lower percentage (35%) of them using it for 3D drawings. Only 20% of them use it for 3D modelling (detailed and rendered).

In general, the results show that the use of CAAD for 2D drawings is significantly higher than 3D use in the workplace context. The use of CAAD for 3D drawings is significantly higher than 2D use in the professional simulation studio. This could suggest that academia has enhanced the use of 3D within its curriculum compared to industry, and potentially demonstrates how academia might be quicker to adapt BIM practices/principles.

4.4. 3D MODELLING SKILLS

The responses of students to whether knowing that you are skilful in 3D modelling is an important aspect to your work placement are shown in Figure 6. More than half (56%) of the sample found it very important that their employers knew that they were skilful in 3D modelling. Forty four percent of the sample reported that having 3D modelling skills is not important for their employers.

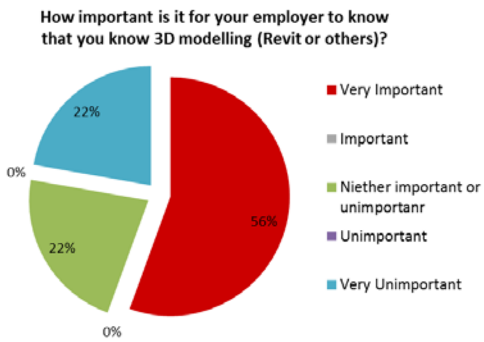

Figure 6. 3D modelling and employers

Based on the sample's background and skills, Figure 7 shows that less than half of them (45%) believe that using 3D modelling in the workplace has influenced their working capability in general, and 44% neither agree nor disagree with the same statement, with 11% disagreeing. This suggests that the sample's views regarding 3D modelling impact on design related issues and capabilities are divided, although they share the same level of knowledge as they are at the same stage of education.

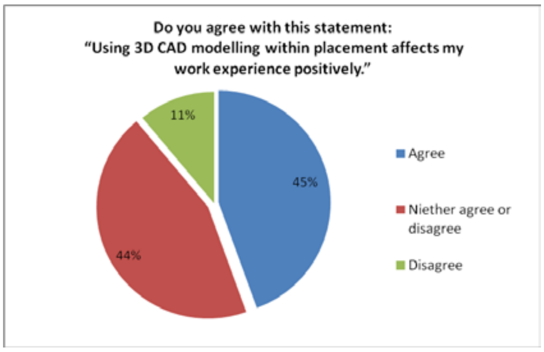

Figure 7. 3D modelling and experience gained.

4.5. WORK PLACEMENT

The students were asked if either their placement or professional simulation have validated the skills and knowledge of their undergraduate studies. The majority (89%) of the sample completely agreed that work placement validated their studies, and 11% neither agreed nor disagreed. This data is shown in Figure 8.

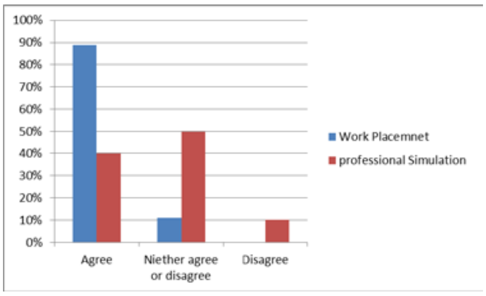

Figure 8. Work placement and Knowledge validation

In the context of professional simulation, 40% percent felt that professional simulation practice has validated their knowledge. Fifty percent of students neither agreed nor disagreed with the statement, while 10% of the sample disagreed. These differences suggest that students relate knowledge validation with work placement rather than a professional simulation studio. Students still believe that work placement acts as a real industrial context and as such would validate their skills in a tangible way.

4.6. OTHER SKILLS

Results also showed that while students recognise the contribution that the course had offered them so far, they still feel that there is a lot to learn from a professional context. The importance of teamwork, being given responsibility, and collaborative learning emerged as the most important factors for effective learning in the two professional contexts under consideration. They also felt that they needed to learn about other principles and relations in their final year taking into consideration integration of the following skills (Figure 9):

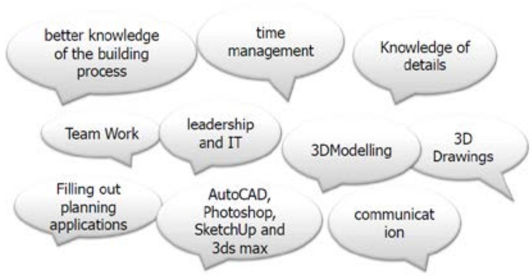

Figure 9 Skills Development

All participating students involved in the survey had experienced work placement or professional simulated practice as a formal part of their undergraduate studies. Results showed that while graduates recognised the contribution university had made to their generic skills development, they greatly valued the experience of learning in the workplace during placement and, subsequently, in employment.

4.7. BIM IMPLEMENTATION

Students who were in the workplace were asked if BIM was implemented yet or not. The results show that 22% of them indicated that they had not implemented BIM yet, and a similar percent indicated that their employers were planning it presently. More than half (56% percent) indicated that they have no plans for implementing BIM in the near future. On the other hand, 22% of them indicated that they are planning for implementation at present. Another 22% indicated that they have already implemented BIM, demonstrating that industry is providing students with little opportunity currently to gain full experience and benefits. How industry is going to deal with BIM and how these contextual experiences are conveyed to industry is still unclear as this loop is very weak at present.

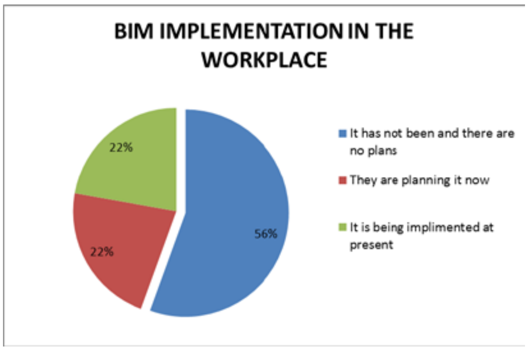

Figure 10 How has BIM implemented in your workplace?

4.8. CONFIDENT WITH BIM

Those students whose employers had implemented BIM were asked whether they had experienced BIM in the workplace context. The majority indicated that they had not. However, a low percentage (12%) had experienced BIM in the work place. This result is very dependent on the answer to the previous question relating to BIM implementation in the construction industry.

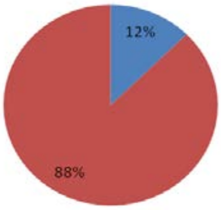

Figure 11 Had you experienced BIM at the workplace context?

Finally, third year students were asked if they feel confident that they have the skills required for the BIM 2016 mandate. More than half of them (57%) felt that they need practical experience with BIM to feel confident about the mandate.

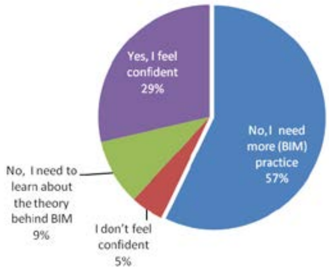

Figure 12 BIM Mandate

However, 29% felt confident that they already have the skills required for the mandate. Nine percent felt that they needed to learn about the theory and 5% felt that they were not confident in doing so.

5. Conclusion

All students involved in the survey had experienced either work Placement or Simulated Professional Practice as a formal part of their third year undergraduate studies. Results showed that while graduates recognised the contribution university had made to their generic and technical skills development, they greatly valued the experience of learning in the workplace during placement and, subsequently, in professional simulated. The importance of teamwork, being given responsibility, and collaborative learning emerged as the most important factors for effective learning in the two contexts under consideration.

BIM awareness should be raised to include the many facets of the emerging roles for AT graduates. The curriculum should be complemented by BIM through integration and contextual learning and teaching projects, which would enhance programs accreditation.

BIM practice is evolving rapidly in the industry; academia should be clear about defining graduates' role after 2016 to establish the confidence needed to start their career. On the other hand, the industry should push its opportunities by enhancing BIM practices for our graduates and the AEC industry.

In light of the 21st Century challenges for higher education, 3D CAAD and BIM principles become much more critical as a knowledge base. The professional context is the most vital medium for BIM learning and knowledge integration. Recent claims emphasised trans-disciplinary knowledge integration into the studio context (Salama, 2008), taking students' needs as the main criterion because it would be more effective to channel students' efforts toward their professional needs.

5.1. FUTURE RESEARCH

An extended study to emphasise and inform long-term (professional) development should be considered. Therefore, future studies should include how undergraduates' skills are developed through work placement, and to what capacity, and how their abilities and skills are enhanced or modified through professional work placement.

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