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Could the inclusion of certain Building Information and Modelling aspects into the Leaving Certificate Engineering syllabus, aid the transition of students into third level education, when choosing a course within the construction industry

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Could the inclusion of certain Building Information and Modelling aspects into the Leaving Certificate Engineering syllabus, aid the transition of students into third level education, when choosing a course within the construction industry

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Abstract−The paper investigates the effects of implementing several Building Information and Modelling (BIM) aspects into the Leaving Certificate Engineering Syllabus and examines the impact this has on students choosing third level Architectural Engineering and Construction (AEC) industry courses with the desire of improving the shortage in the sector. The method and content of the study was based on academic research on second level education in other European countries through the lens of a Literature Review. A sixteen-week pilot program was trialed with over one hundred students at Senior Cycle. The outcomes of the study were critically evaluated through stakeholder interviews and thematic research. The project has raised serious discussion over the Leaving Certificate Engineering syllabus with research suggesting that an update in the curriculum is overdue. Findings suggest; (1) that the pilot BIM module could be adopted into the Engineering Syllabus; (2) students who took part in the course developed a better understanding of jobs available to them in the AEC industry leading to a higher caliber of student adopting DMT subjects and going down the industry career path; (3) the BIM module could be adopted through the vigorous CPD training through the different educational bodies; (4) a continuous classroom-based assessment would be implemented in the Leaving Certificate engineering; A holistic curriculum development at second level education would change the industries attitude on the standard of collaboration and modelling by providing students with 21st century skills which will benefit the AEC sector.

Keywords−Engineering Education, Technology in schools, BIMM Education

I INTRODUCTION

We are facing enormous difficulties - social, economic, and environmental as we become a globalised society, propelled by a faster rate of change. As technological advancements such as the digital era unfolds, society and business must adapt. But adaption of digital work methods is proving difficult. To tackle this concern the Construction of Architecture and Engineering (AEC) has implemented the widespread adoption of Building Information Modelling (BIM) as a standard across the construction industry. The application of this BIM process has been closely monitored and the effects have been analysed with in depth research across all fields.

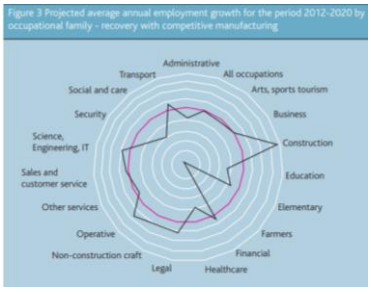


Figure 1 IRELAND'S NATIONAL SKILLS STRATEGY 2025

Furthermore, the rapid growth of technology in this AEC industry is projected to raise demand for qualified and skilled workers. Globally, to help

deal with this issue, intervention at second level education is becoming more popular. The implementation of many second level courses around Europe within schools aimed at students between 12 - 18 years has led to a sharper career focus amongst teenagers and improved the quality and standard of students entering the construction sector. For example, 'Project Lead the Way' is a great example of a successful initiative here in Ireland, also 'Architects in Schools', Ireland's STEP program and finally DEC (Design Engineer Construct). All courses ran by construction companies in conjunction with the syllabi and collaborate closely with schools focusing on the development of future skills and the creation of young engineers and awareness of the various job options available in the field of AEC.

In the UK, DEC runs as a second level subject which is seen as an EQF / QQI accredited teaching curriculum equivalent to a level 3, 4, and 5 here in Ireland. It is designed at secondary school students' and is in selected schools all around the United Kingdom. DEC is a project-based organisation, a subject that is finished by working through an exercise workbook available online and can be accessed by any teacher. Each school is supported by a foundation, by which the course can be funded, but also will give access to professionals in the field of AEC. The course has had a significant growth in recent years and an impact on the number of students choosing AEC courses in these schools at 3rd level entry has increased.

With many second level courses focused on the different processes carried out in the AEC industry such as architecture and engineering, a major topic which has not transitioned with the improvements in technology is BIM. With students at second level having access to new software's and 3D modelling tools such as Onshape or Minecraft. The introduction of BIM elements will show the relevance to students at a young age and give them more of an awareness of the AEC industry and the importance of design and problem solving in the world around us. Educating students at a young age could be the catalyst for future social change within the construction sector.

Aims and Objectives

Objective 1: To Critically review best practice in Science, Technology, Engineering and Maths (STEM) education

Research Method*:* The Research was carried out through a Literature Review, analysing all published research relevant to the objective.

Objective 2: To implement elements of a BIM project as a 16-week pilot program for 4th year engineering students.

Research Method: Action research carried out with a 16-week pilot program implemented to six different Transition Year (TY) classes.

Objective 3: Critically evaluate the pilot program including it's potential to be incorporated into the engineering syllabus

Research Method: Quantitative data was analysed using basic statistics, while qualitative data is analysed using anonymous surveys and thematic analysis.

Objective 4: Evaluate the current issues with the DMT subjects and the inclusion of the pilot study

Research Method: The qualitative method of a semi-structured interview approach was used across five personnel.

II LITERATURE REVIEW

The literature analysed for this research assessed current practice in Engineering and Design Communication Graphics (DCG) at second level within Ireland. This document critically appraises current practices and traditions at present within these subjects with the intention of exploring effects of student uptake in this field and following on into 3rd Level education. Investigating the types of students that choose a STEM course and exploring the roots of the construction industry. The Engineering and DCG syllabus have a limited scope for research, but research from subjects within the STEM category will allow a more in-depth analysis across the literature. With STEM jobs providing the most exciting, diverse, and fulfilling careers available and with STEM skills crucial to the modern world and are vital to Ireland's innovative capability and global competitiveness [8]. The importance of adolescent career choice has never been as significant with the growth of the construction industry in Ireland [14].

With the first Leaving cert engineering exam commencing in 1994, the syllabus has been very much written in a vague model so that it can be updated by the teacher in the classroom depending on the developments in Technology and Industry

[23]. With the curriculum heavily reliant on the autonomy of the teacher it can cause many discrepancies within the syllabi across schools with many teachers failing to up-skill or develop their subjects. With the Implementation of CAD into many STEM subjects in the last ten years the chief examiners still reported that there was very poor uptake in the use of CAD to complete projects within STEM subjects [29]. With technology at the forefront of education and living in the digital age these tools must be used to invite students of this generation to engage in STEM subjects and not become passive learners [12]. According to the OECD's Teaching and Learning International Survey [24], 40% of instructors lacked professional development in technology use, and nearly 20% recognized a significant need for additional training [35]. The lack of incorporation of technology into the classroom through the ignorance of continued professional development (CPD) has affected the student subject choice by failing to modernise the content and future proof STEM subjects. According to [6], BIM is the process of digitally representing the physical and functional components of a building. By not incorporating these appealing aspects of AEC at second level, students do not get the full experience of working in the construction sector.

With regards to the construction sector, a major problem facing it at present is a lack of 'skilled workers' entering the industry. If the industry is to continue to grow there must be an influx of skilled employees [18]. Problem solving and data management are sought as being the main characteristics of most AEC jobs, however the chief examiners report on STEMs subjects reported that students lack the ability 'to interpret, analyse and evaluate' given data. Many of the candidates studying a STEM subject also struggled at the testing and evaluation stage of the design process, in many instances, the evaluation lacked depth and focus [29]. This shows the key skills needed in the construction sector are not achieved by students in STEM subjects at a young age, this has been caried right through into 3rd level education and into future employment. The lack of skilled workers entering AEC jobs is a knock-on effect resulting from the second level syllabi.

With the engineering curriculum built around mechanical engineering, processes and technological applications integrated and techniques necessary for practical resourcefulness, creativity, and design realisation in the execution of work [23], it is clear from the chief examiners report that this is not happening. The STEM reports that ''levels of performance in STEM subjects are not good enough if we aim to provide the best for our nation's children and if we wish to sustain our economic ambitions for the future'' [31]. The engineering curriculum may not be reaching the needs of students who enter at college level 7 courses; however, it does facilitate the needs for many students of level 4, 5 and 6 courses such as apprenticeships [13]. With much of the curriculum build around benchwork and machining [23], involving students in such skills at a young age can really ameliorate their career choice.

Data collected from students who studied STEM subjects in 3rd level education shows staggering figures, with the completion rate in DIT, now known as TUD, only at 67%. [33], showing a dropout rate of 33% / 1/3 of students. It is clear that there is a severe lack of understanding and engagement from candidates in these technology subjects. [19] believes that engineering, computer science, and construction industry courses have the greatest non-progression rates. Where these courses are provided in technological institutes, drop-out rates are higher. The chance of advancing successfully to the completion of a degree at third level is strongly correlated with the student's achievement at the Leaving Cert level. Dropout rates are higher for Leaving Cert students who do poorly. Students at Leaving Cert level are unsure of their chosen career paths and are inevitably set up for failure.

Previous years in England, similar shortfalls have been occurring but studies to date show that just 16 per cent of students at universities, colleges and technical training institutions in the UK leave their courses before finishing [9]. With Many AEC workers behaviour influenced by a variety of circumstances, including relationships with co-workers and management intervention [37]. The UK believe that the introduction of School Partnerships can have significant benefits that can be extracted by students to overcome changes in work practises and innovations in technology used in the industry today. Design, engineer & construct, an English education programme, has set up a digital built environment programme designed to enable students to gain the skills required to perform a particular job, or qualifications that may be taken as part of a wider study programme or apprenticeship. The purpose of the programme is to develop awareness of the career opportunities for professionals who work in AEC sectors and bring real-world applications in core subjects to students at a young age [34].

We must provide students with the necessary resources and offer them the STEM education to which they are legally entitled if we want them to be ready to face the challenges of tomorrow [21]. According to [20] he believes that the youth could be targeted for industry intervention, they are mature enough to comprehend ideas and impressionable enough to follow advice. The youth are at stage in

their development where they start to distinguish themselves intellectually, making this a fantastic opportunity to showcase careers that are unique to each person. Currently in London for children aged 4 to 14, KidZania has been set up. KidZania is a realistic role-playing experience that combines education and fun. Children get the chance to try out more than 60 real-world role-playing games that are designed to teach them important life lessons [15]. Unfortunately, the construction sector career role play is not offered here which is a great opportunity to miss out on inspiring kids with some of the virtual reality (VR) BIM tools have to offer.

There is long-standing idea that K–12 education in the United States is to prepare children for college and higher education however this concept is starting to give way to a new emphasis on getting kids "college-and–career ready" [4]. There are even claims that college graduates will discover they are not immediately qualified for the jobs they had hoped to seek despite having a degree [5]. It should go without saying that students should have the necessary information and skills to pursue a college degree, but more importantly, they should be able to use the technical knowledge and abilities they have learned in a job that demands an increasingly high level of expertise [28]. Many believe that student's STEM education, particularly in secondary schools, may not be at a level that prepares them to meet both present and future labour market demands.

It is clear that there is a gap in students understanding of AEC careers and courses. The level of detail and skills studied in STEM subjects in Ireland does not prepare students for future career choice or furthermore prepare students to meet industry needs. Following review of the literature, it can be said that students' needs in STEM subjects are not met as an outdated curricula has continuously been force fed to them at second level education.

The findings from this study will dictate how a simplified collaborative BIM project could be introduced into the Irish engineering curriculum in conjunction with a college partnership to provide a greater understanding of everyday AEC STEM projects and skills needed and support students with their career choices.

III Pilot Study

Research for this section of the study was carried out through an action research methodology as outlined below. An action research cycle was implemented on a 16-week pilot program within a secondary school. The action research was deliberate, methodical, organized, and systematic, in order to provide reliable and significant results [27]. Using a pilot study for this type of research makes perfect sense to us because the pilot research will offer the clearest proof of the viability and potential efficacy of the intervention [32]. However, with this pilot study based in only one school and one social area, the depth and range of the results could be questioned and cannot be classed as generalised results. As pilot study findings may offer some indication of the likely size of the response rate in the main survey, they cannot guarantee this because they do not have a statistical foundation and are nearly always based on small numbers [10]. Action research is also discovered to be a highly time-consuming method of gathering empirical data, and there is a substantial danger that the project will not go as intended [30].

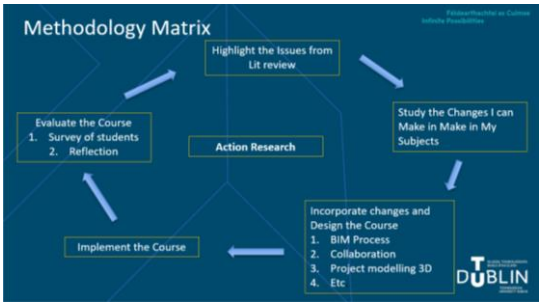


Figure 2 Action Research Matrix

For the purpose of this research a 16-week pilot study was implemented. It involved the execution of 16-week course aimed at TY students, aged between 15-17 years of age. The school was based in North County Dublin with over 1,400 with a pupil population of over 1400. The course was offered to students as a choice subject and was examined across two academic years with 4 classes of which 30 students participated. Each class was a mixed group with a small percentage of students in each class having studied a DMT subject for junior cycle. The students entering the study were at random and aligned with school class system.

Figure 3 CIF Home For Everyone

The aim of the 16-week pilot course was to incorporate many of the main features and characteristics of the BIM process into the TY syllabus. The students were put into groups of 5 at random. Each group designed a future "house of their own" with

the criteria set out in Figure 3-1. The house was designed following the BIM process. The Main characteristics seen in the Figure 3-2 were implemented into the course in order to give students the experience of working in the AEC industry today. The students researched the different jobs involved in the process and engaged in whatever roles they felt was most relative to them. Each student played their part in the execution of the BIM process on the house and the steps were documented on a Learning Log (A sample learning log can be found in appendices). The teacher played the part of 'client' in the module and used an active project-based learning method that focused on the needs of a customer. The curriculum provided students with information on a variety of employment options in the AEC sector as well as on how the sector is digitising. The students completed their models both on software and physical model's depending on the student's abilities. On completion of the 16-week course the students completed a survey under the supervision of the principal, where the students were asked to critique the module. All anonymised data was then handed over to the researcher, all data collected was examined and analysed as part of Objective 2.

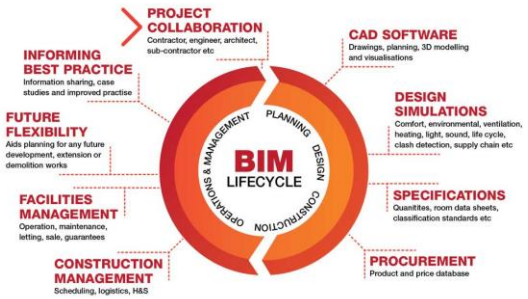
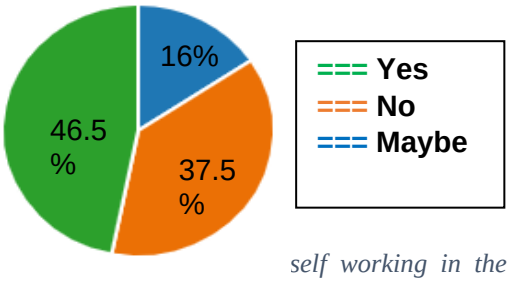


Figure 4 BIM Today

Findings of Survey

For this objective a quantitative questionnaire and fundamental statistics were used to perform the inquiry. When dealing with the data it is first important to determine if results from the sample can be extrapolated to the full population or if they are merely the product of chance using inferential statistics [16]. A piece of research is considered to have strong generalisability if the findings are generally relevant to several different sorts of persons or circumstances [1]. With over 100 students surveyed in the study the results can be presented as a percentage as survey percentages consider the proportion of affirmative replies to all other responses [7].

The first element of data analysed in the survey was the number of students who did junior cycle DMT subjects and their attitudes towards the DMT department for Leaving Cert. The data showed 72% of the students who took the course had done a DMT subject at Junior Cycle, only 34% of these students have chosen to study DMT subject for Leaving Cert, with only 9% of these were girls. However, 50% of students in TY said that the BIM course was their favourite project in the year, however 16% of these choose not to continue to study it. When the students were asked why they did not choose to do a DMT subject, one answer that continued to show was no interest in the theory element, a theory element which hasn't been updated since the 70's. The Figure below showed the percentages of students who would like to work in the AEC industry as a career after school. The students who would like to work in the industry is marginally greater than the students studying it in level 2. These figures align with the national average where 39% of students sat a DMT subject in 2018 but only 4% of these were female [2].



I self working in the construction industry

There are many skills associated with working in the AEC industry such as management, punctuality, etc. In retrospect of the Leaving Certificate syllabus some of these skills were analysed during the pilot course. With BIM being at the fore front of change in the AEC industry there were 4 main characteristics that crossed over into the DMT syllabus *Collaboration, Visualisation, Sketching/communication and Problem Solving.* The students were asked to give their rating of how difficult they found each of these tasks during the course. The ratings were form 1-10, 10 being difficult, 1 being easy, the results can be seen in the table 1 below.

Table 1 Average Difficult Levels of skills

Topic	Avg.	M	F	Students Doing DMT in LC
Collaboration	**5.4**	**5.1**	**5.9**	**5**
Visualisation	**4.8**	**4.6**	**5**	**4.7**
Sketching/ communication	**5.2**	**4.44**	**5.96**	**4.9**
Problem Solving	**5.9**	**6.3**	**5.5**	**6.5**

During the course many of the students found it hard working in teams and delegating out work depending on the tasks or jobs that they were in. With an average difficulty level of 5.4 it seems to align with general perception of teamwork but on taking a closer look at the data recorded it showed over 40% of the students gave a difficult score of 5 and over. This statistic does not sit right with the NCCA where teamwork is one of the major fundamentals of secondary education but still a large sum of students is finding it difficult [24].

Looking at visualisation and sketching, the averages are quite low with females finding it slightly more challenging than males. With the use of technology in the classroom visualising can be aided through the use of 3D software and VR, similar to that of communication, students can access many different ways to transfer information in order to get their point across. These are two skills that are being processed by the students in day-to-day life and not just in the classroom.

Problem solving presented a curious result with males finding this most difficult throughout the course. Trying to stick to the project guidelines and complete each task proved difficult with a rating of 6.3. From this data it also found that students who chose a DMT subject for Leaving Cert found problem solving very difficult with a rating of 6.5.

The data from the survey exhibits that the majority of students doing DMT subjects at senior cycle are most likely to enter the AEC sector. It showed these students found the four fundamentals, mentioned above, very difficult in schools, which is a controlled environment, i.e., the syllabus. Other studies suggest that 50% of students who sit Leaving Cert engineering get over 60% in the exam [26]. If these students are struggling at this age and slip through the crack in the Leaving Cert syllabus, this will have a knock-on effect on the construction industry.

The pilot program reached its objective of improving students' knowledge and understanding of the construction industry. When students were asked, has the course giving them a better understanding of jobs in the construction industry 70% of them gave it rating between 8-10. With this question, students were then asked has their opinion of these jobs changed; 65% percent of students gave it a rating of 8-10. Figure 6 below shows the jobs scoring, with four main jobs students would consider working in a trade, an engineer, architect and interior designer. This finding relates to Figure 1 where students attitude of working in the AEC industry changed. Within the results 64% of girls said they would not change, however 36% said that they would like to consider architecture or interior designer. Although a small percentage, it is still 4 times more than the 9% of girls who study DMT subjects.

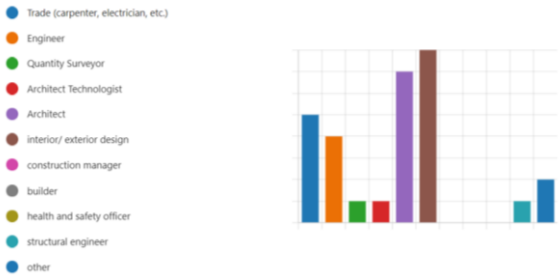


Figure 6 Jobs students would be interested in

The final finding investigates the type of course and what are the benefits of studying a course alike. With the course based of a real-life project giving an insight into real AEC work, 66% of students believed studying a course like this would help with career choice shown in Figure 7 below.

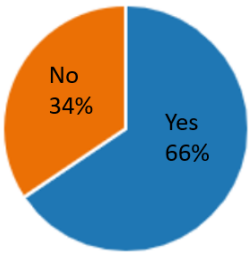


Figure 7 Realistic Course

With this, students rated a 6.9 out of 10, where they believed to be the gap between second level material and college. However, 65% of the students felt studying a course like this would help to breach that gap. Students felt taking a more realis-

tic approach to teaching and learning, which got a rating of 7.5, was the best way to help with their career choice. Furthermore, 88% of students said that they would like to see this course offered as a Leaving Cert subject and 96% of them proposed that they would recommend the following TYs to do the course.

The findings of the survey demonstrate that there are problems with the way DMT subjects are taught and portrayed in secondary schools in Ireland. When students got to experience an up-to-date curriculum within the pilot program it was evident that their opinion had changed and the appearance of a career in the AEC industry may not be what that thought at first. With the changes that are occurring in the AEC industry at present due to technology, e.g., BIM, it is very important to display and present these exciting advances to young students, such as VR or the 3D animation software, and indeed give them a taste of the career and trying to provoke a better brand to entering the industry.

IV Objective 4 Semi Structured Interviews

To determine if the results of the pilot research may have an influence shaping the curriculum, a semi-structured interview procedure through fourth-generation analysis was used. A change of management and curriculum model was used to analyse the data gathered from the interviews.

In order to promote organizational performance and results, we need change management, which is the discipline that directs how we prepare, equip, and assist people to effectively adapt change [36]. Thus, in order to change or adopt a new set of principals or meanings it is important to first understand how change occurs and what are the factors that influence change and how can it be managed and processed. In order to see if the change has been successful a process must be followed so that it can be analysed and evaluated in order to improve overall.

In the context of this study a change management process from Elchin Zeynalov paper has been adopted in order to analysis the data taken from the interviews. The data was looked through the lens of the Figure 8 below under the 5 headings; 1. Content, 2. Process, 3. Purpose, 4. People, and 5. Context. By using this strategy, the barriers and enablers have been analysed with regards to the possibilities of change within the DMT subjects.

The study looked at two phases, the current curriculum and where it is at the moment and then looking at the future of the curriculum and where it has to go in order to continue to compete with other Leaving Cert subjects.

Figure 8 Change management

Participants

Due to the scale of this work and the limitation of time, a collection of representatives who are involved in Teaching DMT subjects, or involved in teacher training, or examination preparation were asked to participate.

The following interviewees were specifically chosen to obtain a non-biased, varied picture of opinions on engineering and DMT subjects. Each of the selected interviewees followed the same curriculum and has a significant position in their subject. However, they did so in different capacities and with diverse backgrounds, and they were picked intentionally so that the results would reflect many engineering viewpoints. This allowed for an exploration and identification of a 'comprehensive' study of the concerns, gaps, and impediments to be processed. The table below shows the diversity in which the interviewees share.

Participants now teach or have previously taught Leaving Cert engineering. It must be emphasised that the invited parties' level of response was low, which prevented us from reaching the target number of interviewees. Consideration should be given to whether this may be a sign of avoidance and the potential causes such as 'the fear of change'.

Role of Importance	*Position*	*Years of Experience*	*Number*
1	PDST Teacher Trainer and Influencer	20 Years' Experience	**Interviewee 3**
2	DMT teacher And Exam Writer	12 Years' Experience	**Interviewee 2**
3	Teacher of Engineering with BIMM masters	7 Years' Experience	**Interviewee 5**
4	Teacher Of Engineering	5 Years' Experience	**Interviewee 4**
5	Teacher Of DCG and Engineering	10 Years' experience	**Interviewee 1**

Stage 2 of the Interview process

Stage 2 of the interview process was about analysing the qualitative data received from the 5 interviewee responses. Through the lens of the change

management process shown in Figure 8, the data was analysed and processed.

a) Content

In order for change to occur there needs to be a starting point or a reason for change to begin. It is important to create a strong incentive to look for a new equilibrium between people, it may be necessary to arouse powerful responses in individuals. You can't make any significant change without buy-in and involvement, which you won't obtain without this drive [17].

To begin the interview, each candidate was asked about what subjects they have taught in schools and for how long as a setting question. Following on with from that two questions were asked to provoke interest in the interview. With Question 1, "Do you think the number of students sitting DMT subjects has fallen? The result of this question became consistent with all 5 interviewees stating that the number has grown in Junior Cycle however at Senior Cycle there has been a larger drop off rate than usual. With a big emphasis put on drop off rates in DCG, Engineering and Construction studies. It was obvious once the interviewees had given their opinions, they expressed concern simultaneously. One of the four participants agreed numbers have fallen but nothing major. Their main concern was more on the lack of students studying DMT subjects at 3rd level in any form and believed that the "quality of student has fallen". It was obvious one candidate did not like the question and struggled to admit imperfection but quickly turned to blame "covid and lack of Hand skills". One subject that the five interviewees agreed upon was that the drop off rate was higher in DCG than any other DMT subject, which raises a major concern as DCG has been the only subject to undergo change in the last 50 years.

The second question in the area of content was about curriculum. "*What was their opinion on the curriculum today?"* in relation to their strongest subjects of course. There were many similar answers as shown in Figure 9. It was clear here that the younger teachers who have studied the same curriculum when they were in school and were now teaching it to students today, despite having seen major changes outside of the classroom walls. Four of the Five participants said that the curriculum was outdated and needed to be updated immediately before "risk of falling too far behind" as the DMT subject similar to Junior Cycle will be the last to be changed at Senior Cycle. However, one participant felt the syllabus was in "accordance to today's world but felt small changes could be made". This answer was given by the participant with the most experience. It could be said that he is correct and has the experience to back it up but on the other hand studies would show that he may not be as progressive as the other participants and has a fear of change.

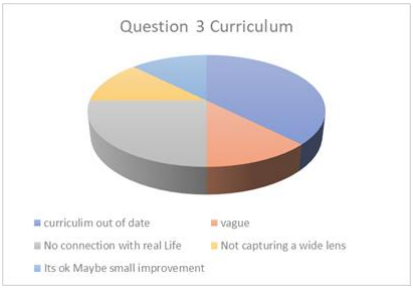


Figure 9 Opinion on Curriculum

b) Process

In relation to the process, it is important to relate to the worker and provoke a process that they could adhere to or follow themselves. In relation to process, two questions were designed to get the interviewee to "craft a Vison and Plan for change" [22].

The first question in this reviewed the pedagogy within their classroom asking, "*do you feel you can update the content in your classroom to keep students interested?"* Followed by a second question which asked, "*do you think the topics you teach are up to date and relevant?".*

These questions provoked unexpected responses with all five participating teachers reporting that A) they can update their content, and B), a lot of the topics they teach are out of date with the modern student. A bizarre strand I observed across all five interviewees was that they proceeded to state there was issues with the content yes, but it seemed they were not taking control of their own classroom and instead of giving ways to update the syllabus and proceeded to construct ways in which each subject could be modernised with strong reference to engineering and construction studies. With one participant questioning the profession saying "there is no expectation for teacher to be up to date" which questions the professionality of the job and the teachers that are in charge of these subjects. However, two participants did say, they would like to be more creative in class but there is a lot of content to get covered in a small window of time.

c)Purpose

The next part of change management is all about purpose. Which refers to implementing ways for bringing about change, managing change, and assisting individuals in adapting to change, all being the goal of change management. The questions in

this area triggered responses to see what the purpose of change is and what should be overall aim of curriculum change.

Question 1 in this topic asked the participating teachers "*do you think our DMT subjects prepare students for college?".* There was widespread agreement in that DMT subjects do prepare students for college more so than many other Leaving Cert subjects. With all DMT subjects having a self-directed project which promoted self-directed learning and evaluation. With many students *"using IT and becoming sufficient in Microsoft suite".* This is a major bonus for students entering 3rd level as it is important to have acquired these skills before entering their chosen college course.

Question 2 asked, *"do you think there is a gap in the Leaving Cert content and college course?"* There was a general consensus that there is a massive gap in the content and that a lot of the knowledge in 2nd level is basic, with some stating that college content can be a lot more difficult as it is specialised. However, many participants did say that the fundamentals that were been taught in 2nd level could be updated to help bridge the gap in this content, such as in engineering, *"rather than sitting down with a board and T-square why not use CAD"*. Another candidate said that a lot of time is wasted on topics that are outdated and not studied in colleges. Although it is clear the level of detail and knowledge at 3rd level is higher there is still a major barrier and very little follow on for students who study DMT subject at 2nd level and who want to study in the DMT area. The severe lack of modernisation of the subject at second level is clearly affecting the students entering at 3rd level.

d)People

Resistance to change is a common and natural response. Each person has a limit to how much change they can take [3], people will always be resistant to change. Even when people can align the change with their own self-interest and belief system, the dread of the unknown and the uncertainty of success can still prevent change. If change resistance grows it can become a major roadblock to success. Teachers, parents, and students play a major role in change management and this is why it was very important to ask the participants the correct question that would draw out information instead of defiance.

Four questions were asked in this section. The first question *"Would you like to see the subjects updated and evolve like the construction industry around us?"* This question was incorporated to see would the interviewees be open to change. Would they like to see change happen in their subject. Four out of the five replied that they would like to see the curriculum reform *"with much more scope for the subject to develop into".* One participant was hesitant with change and stated, *"only some topics*". Could it be that they are resisting change and could this be one of the major factors that in influencing DMT subjects today and the factor that keeping them form growing and developing?

The second question in this stage of the process asked, *"Do you think applying real practical course into the subject would help students on their career choice"* This question was about capturing the teacher's perspective of getting the DMT subject more realistic and giving students a taste of what it would like to be working in this AEC industry. Across the board all interviewees began listing limitations of getting subjects more realistic with 5/5 stating that cost would be too much, 3/5 said limited to the classroom with 2/5 saying that there would be a resistance to change, stating *"teachers would have to leave their comfort zone"*. The 6 six main factors that was produced can be seen if Figure 10 below.

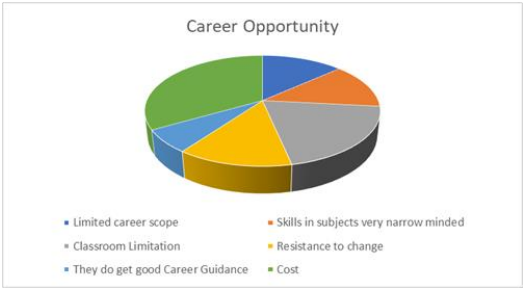


Figure 10 Career Opportunity

Although limitation was drawn to light by many of the interviewees, 5/5 agreed that something needs to be done and that change is needed in order to attract a higher brand of students. 2/5 teachers said that they would like to educate the students more on *"what jobs they can get from DMT subjects".* Also, they said that running small modules in the classroom similar to that of the pilot study would help give students an understanding of *"a day in the life of an architect, engineer etc"*. The teachers interviewed really did believe there was issues that needed to be resolved in the subjects with the industry way beyond what is been taught and with the access of information students have today it is difficult to keep them motivated to learn about dated skills.

The third question in this section looks at how can we influence student to DMT subjects with, "*What do you think could change to get more students taking up DMT subjects and catch the interest of a higher brand of student*?" Many of the responses that came back refrained from looking at the subject itself but more so of its surrounding factors which can be seen in Figure 11 below. With three of the participants, who interestingly were the oldest, blamed the bust in 2008 as many of these students'

parents would have seen "*difficult times in the construction industry with a lot of job loss".* Which is in direct correlation with another two Interviewees who stated that there was a stigma attached to the subject, *"they are only for apprenticeships"* and *"practical Jobs"*. With the same three teachers saying that parents need to be educated and shown that there is more to the subjects than what is publicised. Parents play a major role in the direction their son or daughter take on their career path. With this been said 2/5 interviewees suggested that the best way is to target the students themselves and that *"industry involvement would be the best possible solution going forward".* "Students need to be shown the different opportunities available to them when studying a DMT subject.

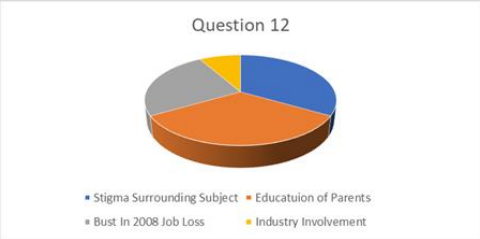
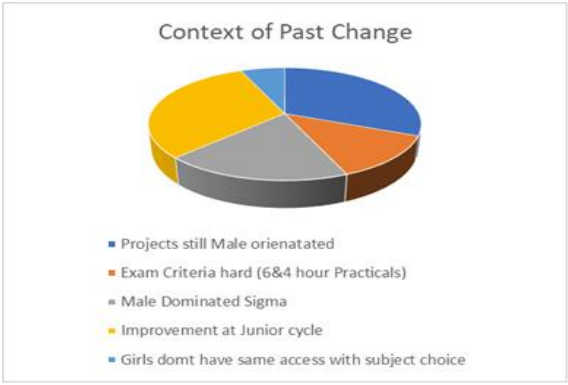


Figure 11 Question 12 Results

e) Context

With regards to this study the final stage of Zeynalov's change management process cannot be reached as it is all about reinforcement, reviewing and evaluation. As there has been no change put in place, participants were asked about a major topic that was introduced many years ago and asked to evaluate it. The Final question of the interview, "*Have teachers encouraged more girls doing our subjects and was it possible?"* all of the responses, shown in Figure 12, believed that there was a lot more awareness and consciousness of attracting girls into the subject but felt that it wasn't coming from the top down with the exam layout and projects very male dominated, such as projects like *"F1 cars and Helicopters".* 5/5 stated that it has improved at Junior Cycle but needs to progress into Leaving Cert level. Another aspect that cropped up again was the stigma surrounding the subject and that girls hadn't the same access as other male cohorts in their year. It was evident that all teachers could see that change was not occurring at Leaving Cert and that the subjects were male dominate. The culture has not changed and therefore the change management was not a success in this instinct.



V Findings

In this section, a summary of the results of the three goals and the findings of the literature review will be discussed. It is acknowledged that this study only included a small sample size, with one year's worth of data, and a small number of interviewees. It will be evaluated and aligned to provide a synthesis of the findings from the pilot research, literature review and the interviews data. The conclusions will provide guidance and suggestions for further research.

It is believed that teachers play a key role in helping students acquire workplace-relevant skills and abilities as well as in helping them better comprehend the demands and expectations of the business. Teachers' expertise and capacity to create this connection successfully has been questioned [25]. However, with the change in industry it is important for teachers to practice CPD as it aids educators in maintaining their professional knowledge and abilities. In comparison to earlier generations, the younger generations approach learning differently. Through CPD, instructors may acquire new methods for instructing today's students [11]. The study has shown that the professionalism of teachers is at question with many of them failing good practice and attending frequent CPD.

The data from the pilot programme and interviews has really highlighted the fact there is a stigma attached to the DMT departments and subjects in secondary schools today. It is clear that there is a negative view with teachers, students, and parents towards the DMT subjects. Many of the parties involved can see that there are issues within the subjects but fail to change existing habits. However, when these trends are broken, and teacher's take more autonomy in their classroom these views can change. It is evident from the pilot study that when students had access and engaged with a more up to date curriculum their opinions changed and the number of students choosing Leaving Cert Engineering and Technology subjects increased.

The Outdated curriculum seemed to be a constant barrier for progression throughout the study.

The professionalism of the teaching profession has also been examined in this study with lack of CPD and general fear of leaving the so called *"comfort zone".* A non-progressive mind set has been seen throughout the literature review, combined with the attitude of the participating interviewees, who feel there is a need for change but just continue to repeat the same syllabus year after year with very little change implemented. At the moment the numbers of students studying these subjects has fallen but there is still a demand for them in schools which continues to cover up curriculum flaws. These flaws are beginning to have a knock-on effect with the number of students entering the construction industry at 3rd level has fallen.

The study has shown that the introduction and modernisation of subjects in accordance with the industry will have a direct impact on the number of students sitting Leaving Cert engineering. Making all stakeholders more aware of the advancements in the industry. Such as the incorporation of BIM into Leaving Cert engineering which would educate students when choosing a career path and demonstrate the career opportunities that exist if they chose to study DMT at Leaving Cert level. Using a realistic industry approach to education, it would allow deep content knowledge to be developed by students through project-based learning activities. Importantly, PBL promotes the growth of 21st century abilities including communication, teamwork, creativity, and critical thinking [10].

With the rapid growth in industry in the past fifteen years, such as robotics and 3D software's, a big problem facing the education system in today's world is time and money. With the advances in technology and the current generation known as the "tech generation" it will cost a lot of time and money if subjects were to change and adopt with industries. Items such a laser cutter, 3D printers and robotic components, etc. are all expensive machinery to roll out in schools within Ireland. On top of this, money and time will need to be spent of teacher training and CPD in order to progress the subjects.

VI Recommendations

With the pilot study carried out in a single school and a full study condensed into one year, it is important to acknowledge the limitations of the data collected, however it does provide a level of guidance and understanding on the current situation with Leaving Cert engineering.

In observing the inclusion of certain Building Information and Modelling (BIM) aspects into the Leaving Certificate engineering syllabus, it aids the transition of students into 3rd level education, when choosing a course within the construction industry. In conclusion, a number of suggested recommendations were drawn from the analysis and discussion of the results of this study and the literature review:

1) Further research into the problems surrounding the Leaving Cert engineering syllabus at the moment is necessary. With deep regard to updating the curriculum and modernising the subject. The problems to which teachers today face and the needs of the students need to be analysed further in order to create reasoning and evidence base for curriculum reform. Simply stating that curriculum is outdated is not enough of a platform to start from.

2) The inclusion and representation of industry specialists and 3rd level colleges to merge with different schools around the country and get involved in the upgrading of the schools and inform teachers with industry updates. More school initiatives in relation to jobs within the industry and promote awareness of careers available with parents and students involved in DMT subjects that have follow on courses into 3rd level education.

3) In a bid to upgrade the curriculum, the direction to which the subjects are heading needs to become a major talking point with curriculum developers and subject planners. In order to compete with the changing society and industry advancements, a top-down reform is needed. A roadmap for each subject must be developed in coherence with a change management strategy in order to tackle the many barriers discussed in this study such as, resistance and cost.

4) A campaign around schools to create awareness of the modernisation of the subjects in the DMT department and the benefits of studying them in regard to personal growth. The main focus of the campaign should be to remove any stigmas attached to DMT subjects in schools. Education of parents and students at Junior Cycle about the many career opportunities available to them in the construction sector if they study Leaving Cert engineering and technology subjects.

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