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Comparing the meaning of 'thesis' and 'final year project' in architecture and engineering education

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ABSTRACT

Architectural education shares much in common with engineering, including the use of a culminating capstone experience in the final year. The form of this experience varies, with the research-based thesis and final-year project being most common. This paper explores the literature on traditions of enquiry and the meaning of research in various fields and the evolution of the 'thesis' and 'final year project' approaches over time. It then briefly summarises empirical research conducted on a case study institution struggling to bridge gaps in understandings of these distinct forms of learning and teaching. Throughout, the paper presents a comprehensive set of diagrams to explain various paradigms and positions on research and design education. These diagrams depict processes used in architecture, engineering, and natural sciences to conduct research and generate designs. A new model is proffered to help unify competing conceptions of the final year project and thesis, for the case study institution and beyond.

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Introduction

For centuries, the fields of architecture and engineering had similar history, evolution, and topics of discourse. Only during the Enlightenment (circa 1680–1780) did structures of education, professionalisation, and specialisations begin to emerge to distinguish architecture and engineering as separate branches of knowledge and practice. Before that, under the Vitruvian approach (the classic Greek approach revived in 1400 and 1500s), statics and construction were significant components of architectural education (Proudfoot 2000). Notably, Leonardo Da Vinci's (1452–1519) approach involved observing the built environment as a combination of art and engineering (Stephen 1962). As science and philosophy progressed in Enlightenment times, and under the pressure of industrialisation, theories by Descartes (1596–1620) and Newton (1642–1726) revolutionised engineering; in a parallel way, the first formal school of architecture was established in France (in 1671) rooted in classical ideology (Griffin 2022). These activities mark the perception of engineering and architecture as discrete bodies of knowledge requiring specialised knowledge and skills. Nevertheless, because of their common roots, the two fields continue to share many common courses, topics, techniques, and educational approaches.

Education in architecture and many sub-fields of engineering includes instruction and experience in both design and research. Technical material is presented to engineering and architecture

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students alike, and students in both fields are expected to integrate such learning into their design projects. Moreover, students in both fields are expected to conduct research to inform their design activities. Today, design and design-related research are core components in civil and structural, mechanical, and product design education, and are frequently practiced via group design projects, cornerstone (first year) and capstone (final-year) design and/or research experiences (Ertas and Jones 1996; Ullman 2009; Ulrich and Eppinger 2008). Typically, expectations for research and design integration are highest at the final year level when students are expected to 'bring it all together' in addressing an overarching research or design-research question. Engineering and architecture alike use problem-, project-, or design-based learning (PBL, PjBL, or DBL respectively), parallel technical modules, and some sort of culminating capstone experience; all these usually involve some level of 'learning by doing' (Schon 1987).

A contrast between the fields, however, is the use of the studio model across all semesters in most architecture degree programmes. For architecture students in almost all parts of the world, design is considered a core skill, and undergraduate degree programmes use the studio format as the primary pedagogical approach. Design studios are used to educate student architects and indoctrinate them into the culture and profession of architecture (McClean and Hourigan 2013). Studios consist of project-based learning (PjBL) activities, integrating research throughout the design process. These projects (PjBL) in architecture are most often conducted individually, perhaps with a few collaborative learning activities integrated, and this is a distinguishing feature from engineering's practice of PBL as inherently group focused. In architecture schools, projects can last a matter of hours or can span an entire academic year. Via studios, architecture students learn abstract concepts, develop practical skills, and learn to bridge art and science, under the supervision of instructors. Today's system follows the tradition of the atelier, with its long history in the Italian and French schools of architecture (Dizdar 2015; Draper 1977; Drexler 1975; Griffin 2022).

Courses using a studio format are conducted across most if not all semesters of any given architecture curriculum, with the final year's work normally being more in-depth and student driven than previous years' (Borden and Ray 2006; Evans, Gruba, and Zobel 2014; Mauch and Park 2003). The final-year project typically involves a higher level of complexity, comprehensiveness, creativity, and synthesis than prior projects (Proudfoot 2000). In some universities, this final year capstone activity is framed as a 'final year thesis' whereas in other places it is defined as a 'final year project' (Borden and Ray 2006; Tafahomi 2021), and this appears to be the case in design-related engineering degrees, as well (Cross 2005; Pahl et al. 2007).

Globally in both fields, professional accreditation plays a central role. Academic programmes are designed to prepare students for professional practice and are regulated for quality assurance and/or professional accreditation by professional bodies (DoA 2012; FAED 2009). In engineering, national accreditation systems (like ABET) and global transnational agreements (like the Washington, Sydney, and Dublin Accords) require students to demonstrate design skills (Cross 2005; Duerk 1993; Pahl et al. 2007; Pena and Parshall 2012). Twenty-three countries are full signatories of the Washington Accord. Similar structures have been adopted to align architectural education globally, including national accrediting systems like the National Architectural Accrediting Board in the USA with the Canberra Accord achieving mutual recognition of professional architecture degrees across Australia, Canada, China, Korea, Mexico, the US, and the Commonwealth associated with the UK.

In architecture, the 'gold standard' is the 'first professional degree' which is professionally accredited and typically involves a five-year plan of study. A major culminating design or design-research activity is required of students in their final year within nearly all professional architecture degree programmes. The final year of architecture usually requires a capstone activity in one of two forms: a comprehensive design project called a 'final year project' or a more exploratory, speculative, or highly synthesised design project called an 'architectural thesis'.

Perhaps reflecting the standardising influences of accreditation and industrialised practice, some of the terminology surrounding final-year architecture and engineering experiences is shared (e.g. DBL, PBL, PjBL, project, thesis, capstone). Yet, there are nuances that yield a lack of common understanding – conceptions of these terms and practices vary from place to place, and person to person.

Moreover, 'project-based learning' (Blumenfeld et al. 1991; Prince and Felder 2006) and 'problem-based learning' (Barrows and Tamblyn 1980; Hmelo-Silver 2004; Seifert and Sutton 2009) often use differing forms of assessment, with PjBL assessed via project presentations (typically with juries and critiques by peers or experts) and PBL often assessed using exercises, equations, written reports, and exams.

Capstone engineering research and thesis projects are often understood as being more technical in nature than those in architecture, and they employ experimental research designs more often. Architecture 'thesis' activities are frequently understood as prioritising aesthetics, composition, and philosophical or phenomenological aspects of a designed product (Evans, Gruba, and Zobel 2014; Franz 1994; Gomez 2003; Lang 1987; Tafahomi 2022). Thesis schemes of architectural education contrast with 'final-year project' schemes, as the latter often focus on the professional design process (Rade 2019) and technical competencies (Neveu 2009; Owen 2009).

Similarities and differences between these two forms (thesis and final-year project) are the primary subject of this article. This paper briefly explains one case, an academic department of architecture, that attempted unsuccessfully to shift from using 'final year project' to 'thesis.' The case study involved the Department of Architecture at the University of Rwanda (FAED 2009), which attempted to shift from using final-year projects to using thesis projects in its undergraduate curriculum (DoA 2012). The study uses established research methodologies to understand why and how this change failed, the mental models the various participants held, and where discrepancies occurred. Case-specific results were generated using structured observation, content analysis, storytelling, and by generating a series of diagrams. Analysis of the case, conducted alongside a comprehensive review of research literature, facilitated the generation of new knowledge regarding differences and similarities across terms (thesis vs. project) and fields (architecture, engineering, and science), and generated new ideas for promoting continued evolution at the case study institution. A detailed report of the empirical data and research methods used to assess the case study institution will be published elsewhere, so that this text can focus on issues most relevant to engineering educators and engineering education researchers.

Relevance to engineering education

The transition attempted in the case study organisation is one that has been made and/or considered by many architecture faculties, department, and programmes around the world. This case holds relevance for the engineering education community because engineering capstone activities may, quite similarly, involve a research thesis, a design thesis, or some other culminating activity to help students integrate and synthesise learning that has accrued over the student's matriculation.

Understanding the context of this case can help readers assess transferability. In the university under investigation, engineering projects typically occur for one semester in the final year; moreover, some engineering departments also assign creative design projects from third year onwards. Design is more heavily emphasised in architecture, however. In architecture, the case study organisation offers the 'first professional degree' and requires a capstone activity – although whether this is to be a 'final year project' or a 'thesis' has yet to be agreed (Borden and Ray 2006).

Because the case study organisation has thus far failed in clearly defining and transitioning from 'final year project' to 'thesis', we wanted to distilled lessons that could inform others attempting similar curriculum shifts. Our analytic process allowed us to produce a series of diagrams of wide transferability, that contribute new research-informed understandings to the fields of engineering, architecture, and design. More specifically, to pinpoint how and why this shift was problematic at the case institution and identify the logic behind various reactions to the proposed change, we conducted content analysis of curriculum documents as well as unobtrusive structured observations of events occurring across the curriculum change process. We generated a series of diagrams to isolate specific variables and illustrate their relationships. We used these diagrams to identify where and

how processes varied. The diagrams helped us recognise where differences had occurred in faculty members' perceptions of the final year capstone activities.

An aim of this study has been to analyse the failed curriculum shift and explain the story through a variety of perspectives – analysing data collected by an observer within the department of architecture who was using establish methods for educational research – and generating diagrams to explain major concepts, expectations, assumptions, and workflows. Specific objectives of the process were to: (1) document reasons for the proposed curricular shift, (2) explain the implementation process and its context, (3) identify the role of conflicting 'schools of thought' or 'conditions within a paradigm shift' that arose and played a role in preventing adoption, (4) identify additional barriers and challenges that prevented uptake, (5) distil lessons for other educators aiming to make a curriculum shift of this type, and (6) present findings in text and diagram form. Ultimately, we have summarised a variety of existing shared paradigms (or shared systems of thinking and assigning value and meaning) that underly design and research in engineering and architecture.

Meaning of 'paradigm'

We referred above to 'schools of thought' or 'conditions within a paradigm shift', but what does that mean? A paradigm is defined as a typical example or pattern of something – a pattern or mode (Oxford 2021; Webster 2021). According to David Wang (2009), the *idea* of a 'paradigm' has roots back to the theory of knowledge itself. The *term* 'paradigm' was proposed by Thomas Kuhn (1922–1996) under the influence of Karl Popper's (1902–1994) works. Popper (1959) challenged the processes for the generation and verification of knowledge that had previously been defined by Hume, Kant, Hegel, Marx, and others. These predecessors saw 'verification of knowledge' as applying laws of philosophy and science using an approach from the empirical sciences. Contrary to these prior ideas, Popper took a more socially constructed approach, arguing that 'finding the truth' is not about discovering laws governing philosophy and science. Rather, Popper argued, that conventional agreement among users/people provides a valid definition of a given phenomenon that holds true when there is no evidence to refute it in the specific time and place. Any definition is subject to change over time and varies across cultures. Once a theory or definition has lost its meaning or its validity, Popper posited, a new theory or way of thinking has emerged to replace it. This process involves the conventionalisation and/or falsification of ideas and theories. Although the common way of thinking, related to a communally shared 'mindset' or 'schema' regarding how things in a system work, is often referred to as a 'paradigm', these terms came along after Popper.

Thomas Kuhn, one of Popper's followers and critics, subsequently developed the term 'paradigm' (Kuhn 1962) to signify the general trends and understandings held by people about a specific topic that carry across time and place. According to Wang (2009), this is generally seen, in retrospect, as a style or era. While Popper believed that scientific progress is based on the falsification of theories, Kuhn argued that scientific progress is driven by paradigm shifts, which involve the replacement of one set of theories and methods with another. Kuhn defined a paradigm as a set of assumptions, concepts, values, and practices that define a particular scientific discipline at a given time. According to Kuhn, paradigms provide a framework for scientific inquiry, shaping the questions that are asked, the methods that are used, and the answers that are considered acceptable. Kuhn argued that scientific progress is not a linear process of accumulating knowledge, but rather a series of revolutions in which one paradigm is replaced by another. A paradigm shift occurs when anomalies or problems arise that cannot be explained or resolved within the existing paradigm. This leads to a crisis in the field, which can be resolved only by the adoption of a new paradigm (Mertens 2012; Mertens and Wilson 2012). The adoption of a new paradigm involves a significant shift in the way that scientists approach their work, including new assumptions, concepts, methods, and values.

Wang (2009) asserted that Kuhn's (1962) theories were extended by Foucault (1972) regarding discontinuity and disconnection in history (Dreyfus and Rabinow 1982). Wang noted that the idea of paradigms maps closely with architectural movements or styles. More specifically, the consistency

of language within an architectural movement reflects a set of standards, or a common way of thinking about the world and about how pieces work together or interrelate.

To articulate a process within the domain of architecture where new styles or schemas for thinking and making are discovered or created by groups of people over time, Wang (2009) drew from Popper (1959) and Kuhn (1962). Each new 'style' of design evolves, over time, ultimately reflecting a set of common understandings and beliefs about space, time, acceptable vocabulary, appropriate relationships among architectural components parts, the role of human experience and history, a shared vision of the future, and the like. According to Popper's philosophy of knowledge creation, any new claims or definitions must offer the possibility of being falsified through testing. Similarly, Wang's (2009) explanation of architectural paradigms suggests that the acceptance or rejection of an architectural work depends on whether it adheres to the agreed-upon standards of the specific paradigm it belongs to. These standards can be implicit or explicit. Over time, certain theories and paradigms have proven more resilient, with their underlying principles withstanding challenges and becoming more widely accepted and conventionalised.

We believe that the architectural movements and/or styles in design, education, and project work are similar, conceptually, to the theories about knowledge generation articulated by Popper, Kuhn, and Wang. In our understanding, the word 'paradigm' is associated with four clusters of meaning: (1) usual patterns of activities; (2) a heuristic model for doing something; (3) a theoretical framework; or (4) an epistemological approach to understanding a phenomenon (Borchert 2006). In this study, we endeavour to explore the fourth of these – to explore the participants' shared understandings of the world and their implicit understandings of how knowledge is created and used. Specifically, we assess efforts to reject previously trusted methods and perceptions of reality (use of final-year projects) in response to the recognition of epistemological gaps and the desire to replace perceived shortcomings with a new set of knowledge (on how to facilitate thesis studios in architecture).

Shift in terminology at the case study organisation

It is important to identify the rationale underpinning the intended shift at the case study institution and to understand the role of two prominent paradigms: the thesis model versus the final-year project model. As noted above, most architecture programmes in the world, like many engineering programmes, ask students to prepare a project in their final year of study. The activity includes similar stages such as problem definition, programming and/or planning for the project, conceptualisation, and the design of some sort of final product (Cross 2005; Duerk 1993; Pahl et al. 2007; Pena and Parshall 2012). Popular names for this culminating experience include 'thesis', 'final year project', 'comprehensive design', 'capstone design', 'capstone project', or 'portfolio' (Borden and Ray 2006; Ghonim and Eweda 2019). In architecture, the nouns 'design' and 'project' are central to the outcomes expected from students in all these types. However, subtleties embedded in the specific name selected for use also reveal tacit/underlying values and thoughts of the staff regarding what the culminating year should entail, as well as more formal policies of the department.

In 2015–16 at the University of Rwand, the head of department and the dean requested the department shift from the final-year project approach to the thesis approach. They reasoned that this would better engage academic staff in the supervision process (Doidge, Sara, and Parnell 2000), add problem-solving to the projects (Wang 2006), give students experience in research and analysis (Borden and Ray 2006), and enhance the quality of production and citation of external sources (Stone and Lowe 2014). The lead author of this paper was not the coordinator of the resulting thesis studio, but he restructured the modules into the thesis format and helped the coordinator and staff run thesis project activities using the intended research approach. The programme ran, with staff engagement, for three years. Then a new set of staff arrived who were not experienced in using research/thesis approaches. The lead author was then appointed as the thesis coordinator (to run the programme) and realised that the problem among the staff was much bigger than just a disagreement – the issues were complex. Thus, despite the curriculum explicitly using the term

'thesis' to describe final-year activity, the course was implemented for more than six years as a final-year project. Staff members' pre-existing beliefs, assumptions, and backgrounds seemed to be the cause of the incongruence. The final year studio was never truly conducted on the thesis model, and this paper examines why.

For at least three years, students were led to select a specific building type (such as a kindergarten, school, or hotel). They then selected a site and designed the final project across the span of one academic year. The instructor of the final-year studio led the students in the design process for the project and other staff members performed advisory roles, providing comments on the progress of the students. Marking and evaluation of the students was the job of the 'master' of the studio, to whom the students presented their individual projects via an exhibition that was called the 'final exam' as one would find in the Beaux Art tradition (Garric 2017; Garric 2017). After the final exam, the mark of the students was formally submitted. It is worth noting that the project reports and presentation materials (e.g. project drawings and physical models) were not systematically archived as intended, and this was due to shortages of space, staff, and administrative processes (Bloomberg and Volpe 2019) in the department.

The department staff started holding meetings on the 'thesis or final year project' topic at the outset of the intended paradigm shift, but these meetings did not continue. There were changes of administrators, approaches, and a low number of participants in these meetings that caused to them to fade away. In retrospect, the attempted transition did stimulate a wide range of reactions – from acceptance to disagreement – across the department, which led to inconsistent and unclear expectations being placed on the students. The academic staff expressed their own differing expectations when they participated in various panels, highlighting the absence of a harmonised approach to the capstone curriculum (Dutton 1991). Despite the idea that variety can enrich academic and theoretical discourses from philosophical, conceptual, and poetic perspectives, such was not the case here. Effective variation and an adequate level of alignment have not yet been achieved.

We believe that there is a lack of analysis and publication on cases of *failure* in engineering and architecture education (Rade 2019; Roberts 2007; Tafahomi 2021). Too often, we focus attention on what leads to *success* without fully considering how to avoid failure or increase the chances of success within a change initiative. We intend to contribute on this transferable scale, but we also hope that the analysis conducted for this study might build understanding and help achieve a more harmonious outcome at the case study location. The whisper of Prince Hamlet, 'to be or not to be, that is the question', still echoes, asking the staff to decide what will 'be' in the coming years: thesis or final-year project?

Traditions of inquiry in architectural education

Exploring various meanings of the terms 'thesis' and 'final project' can open new perspectives, particularly regarding appropriate methodologies for research. The original meaning of the term 'thesis' indicated a dialectic theory. Western dialect forms have their roots in Classical philosophies and methods championed by Socrates, Plato, Aristotle, and others. Ideas were reformulated in modern times, notably by Hegel (1770–1831) in his lectures on history and Fichte (1762–1814) via explanations of dialectic in the 1800s. These involve exploring contradictions between opposing sides. This form of contemplation, popular in architectural discourse, is known as the Hegelian dialectic theory (Zizek 2006). Mindrup (2014) noted that one of the duties of design has been to push against or challenge standard (e.g. typical, or readily accepted) design ideas. These 'avant-garde' and 'out-of-the-box' aspects of design are popularly understood today. We note that these values are closely held in architecture, whereas engineers might prize invention, rather than outright defiance of accepted design practices, as the best way to make progress and step forward.

Hegel explored epistemological aspects of knowledge – asking what it means to know, what knowledge is, and where knowledge comes from. He was attempting to extract new evidence

through synthesis based on critical thinking for self-awareness, self-experience, and self-consciousness processes (Mindrup 2014; Pippin 2010; Secolsky and Denison 2012). Since the time of Hegel, the architecture thesis has been conceptualised as a process for active learning that uses critical thinking to develop knowledge and skills within the individual student (Drisko 2017; Taylor and Vlastos 2009). More recently, the development of interpretivist, constructivist, and constructionist ways of thinking and knowing has expanded our ideas about how knowledge gets generated and shared by groups of people. Across time, framing issues has become a critical feature of doing a thesis; diagnosing one or more core issues or problems to be addressed by the student has become a critical step in competing a thesis (Agricola et al. 2018).

Terminology-wise, 'thesis' refers to an idea that requires comment, justification, approval, and/or application (Borden and Ray 2006; Creswell 2012). Although today the word 'thesis' commonly refers to a long piece of academic writing, the word previously meant to present an idea for approval and discussion. Presentation of ideas was a necessary part of delivering knowledge about architecture history (Borden and Ray 2006). In this regard, Wang and Ilhan (2009) argued that innovative imaginations and creative ideas in art and design can become embedded in the sociological context, as products that are considered 'exemplars' by users (e.g. the people who inhabit an architectural work). Today, in final-year projects and thesis studies alike, the student identifies and analyses precedent projects – existing designs and artefacts – considered to have characteristics relevant to the student's intended study that may hold keys for application or novel integration. In the final-year project format, however, the recommended precedents and the advice and vision of the master/teacher/design authority often frames the project, providing boundaries for exploration and guiding, but also limiting, what can be discovered (Figure 1 illustrates this point).

The paradigm of curriculum in architecture appeared in history when architects who had been educated via apprenticeships wanted to teach architecture courses in the same way they had been taught (Drexler 1975; D'Souza 2007; Tafahomi 2022). This meant any curriculum specifications were secondary to the habits and opinions of the 'master' or the leading instructor in the studio (Garric 2017; Tafahomi 2021). The master's experience was to guide the learning and it defined the content and structure of delivery, and it dictated how design outputs were achieved. This archetypal 'master/apprentice' relationship maintained a set of traditions, styles, and schools of thought across multiple generations. It continues today in cases where the curriculum is not clear enough to guide the instructors regarding how to develop knowledge, skills, and attitudes in students (Owen 2009). In such cases, the studio leader has free rein to structure the module based on personal habits, interests, and understandings.

In the context of the case study department, the practice of 'redrawing the precedent' refers to the tracing the plans, sections, elevations, and the like, for buildings created by elite architects and publicly revered over time. Dorst and Cross (2001) identified protocol as a traditional principle,

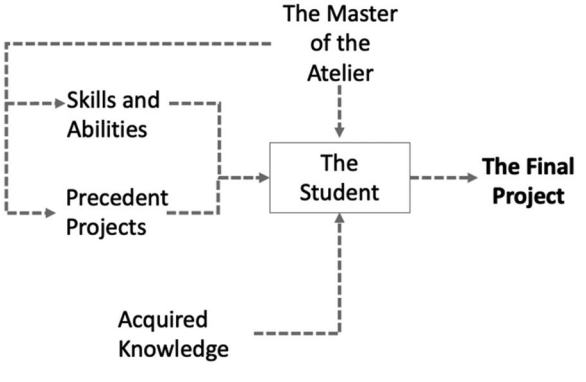

Figure 1. Final year project studio relationships in architecture.

discipline, or method in (industrial) design studios that can be used to harmonise activities. In this understanding, protocol can mean instruction, guidelines, and even studio culture. The logic embedded in the selected precedent provided the protocol for every new design generated from it (Dorst and Cross 2001). Such precedents are celebrated by the master of the studio as an exemplar in, for example, art, science, technology, and design. There is a strong implication that all architecture should be like the exemplar. In this context, it was thought that through redrawing a selected masterpiece, students would learn appropriate proportion, composition, and relationships between architectural components. Beaux art and art schools were among those using such practices, redrawing design to include technical aspects (e.g. building sections and construction details) as well as replicating and extending the protocols or instructions to students (Draper 1977; Drexler 1975; Garric 2017).

The 'final year project' is geared toward developing the skills and abilities of the students to draw and design a project based on existing ideas, drawings, or constructed projects. For a time, this approach was advocated for architecture schools in European counties (Drexler 1975). The redrawing technique, often referenced as composition style of design (Taura and Nagai 2013), sought to assimilate lessons learnt from elite architecture projects into student's new work. Critics of this technique called it old fashioned and style-focused (Doyle 2016). It separated decisions from the context too much, they said (Anderson 2014; Rocane 2015). They saw it as an outdated and 'unmodern' form of education (Garric 2017).

In contrast, from the perspective of the architectural thesis project as defined by Dorst and Cross (2001), the student typically identifies a core topic or problem, conducts research on the issue, and applies the findings to the design of a new (hypothetical) building, using a variety of media (e.g. sketches, drawings, models, animations, etc.) to express and present design concepts and ideas. There is an underlying assumption that students will introduce new aspects of originality (Mindrup 2014) and creativity (Nulman 2012) in the thesis design process. The main ideas or concepts embedded in available precedent examples are presumed to have overcome challenges, either being rejected or confirmed in architectural form, thereby prompting the development and application of these ideas in new, novel, or avant-garde ways. Thus, implicit in the word 'thesis' in architecture is the notion of a proposal for design – a design that differs from its precedent projects in terms of good copy. Wang (2006) advocated an additional aspect, which he called the 'descriptive imagination' behind a design. Moreover, the word 'thesis' implies there is a personal journey (Tafahomi 2021) that occurs during the architectural training process, via an analytical approach, wherein the student acquires essential skills and abilities (Kavuran and Dede 2016) including self-reflection (Chance 2010). Overall, the variety of the style in architecture education was constructed based on three important movements in architecture schools called the Beaux Art, Polytechnique, and Bauhaus (Armstrong 2016; Craven 2019; Doyle 2016; Draper 1977; Drexler 1975; D'Souza 2007; Garric 2017; Griffin 2022; Laroche 2008; Littmann 2000).

The last of the three movements to appear was the modernist Bauhaus approach, developed between 1919 and 1933. This prominent example was underpinned with avant-garde preferences. The Bauhaus encouraged problem-solving through design, often integrating art, technology, and science in a social context where research and personal experience were primary learning tools (Mindrup 2014). Hands-on experimentation was encouraged, whereas looking at existing precedents and traditions was typically not. As such, a focus of the Bauhaus was providing workshops (e.g. equipped spaces, courses, times, and/or events) to facilitate exploration, making, and craft. Workshops involved the thoughtful making of textiles, ceramics, painting, theatre, construction, and the like (Doyle 2016).

The Bauhaus approach was transferred to USA via Walter Gropius (founder of the Bauhaus, who lived 1883–1969 and fled Germany during WWII) and Ludwig Mies van der Rohe (the last director of Bauhaus, who lived 1886–1969 and, likewise, fled the war). Gropius and Mies brought Bauhaus concepts to schools of architecture in the USA, with eventual influence around the globe. Thousands of schools adopted Bauhaus values and emulated its approach.

Gropius (1970) emphasised that the objective of architectural education is to liberate the learner from limitations and biases. This objective became a fundamental value of modern design, accomplished through the integration of research and experimentation into design via workshops (Marttila 2018). Today, it is widely expected that students will do their own research into concepts, dimensions, examples, details, and other elements of the architectural project to continually bring new ideas into their practice (Borden and Ray 2006). They will draw from various fields of study (Drexler 1975) and use a range of thesis tools including discussion, discourse, critique, and approval (Mauch and Park 2003). This learning system is still considered 'modern', and it takes into serious consideration the personal experience of the students in the research, learning, and problem-resolution process (Lupton and Miller 1993). Figure 2 illustrates this point, as observed in various institutions the authors have been associated with. Figure 2 depicts the process a student goes through.

The thesis approach depicted in Figure 2 differs from traditional or orthodox master-apprentice approaches. These older approaches presume that the master/teacher always knows best (Rocane 2015). Such approaches focus on replication and good copy by the student apprentice, and they praise a student's intelligence above the new abilities the student develops (D'Souza 2007). The apprenticeship model of education leads students through the thinking process of the master, the style of the existing project, and context of the project so that the student's new design would work in essentially the same way as the ideal model being used as a precedent for the design (Draper 1977; Drexler 1975). In final year projects, teachers sometimes recommend precedents that the student should study and then restructure into a new project.

In the traditional Beaux-Art format, prominent from 1819 to 1968 (Griffin 2022), students worked under the supervision of the master of the atelier, typically a famous and highly respected architect, who provided the plan, material, and budget for the running of the studio. The students learnt art and architecture in an integrated way, through sketching, drawing, and designing – ultimately presenting their idea in an artistic form (Drexler 1975). The structure of the educational training was based on competition and portfolio, and studying sets of drawings, redrawing aspects of them, and detailing the design. A crucial factor in the style of Beaux-Art teaching was that it was detached from the university (Laroche 2008). The context of redrawing traditionally focused on classical and Roman buildings (Armstrong 2016).

In the Beaux-Art tradition that continues on in some schools today (e.g. the Notre Dame School of Architecture in South Bend, Indiana, USA), the redesign of precedent projects has been a standard method of teaching (Taura and Nagai 2013), although architecture literature indicates this restructuring approach is no longer commonly applied in architectural research (RIBA 2014). The approach

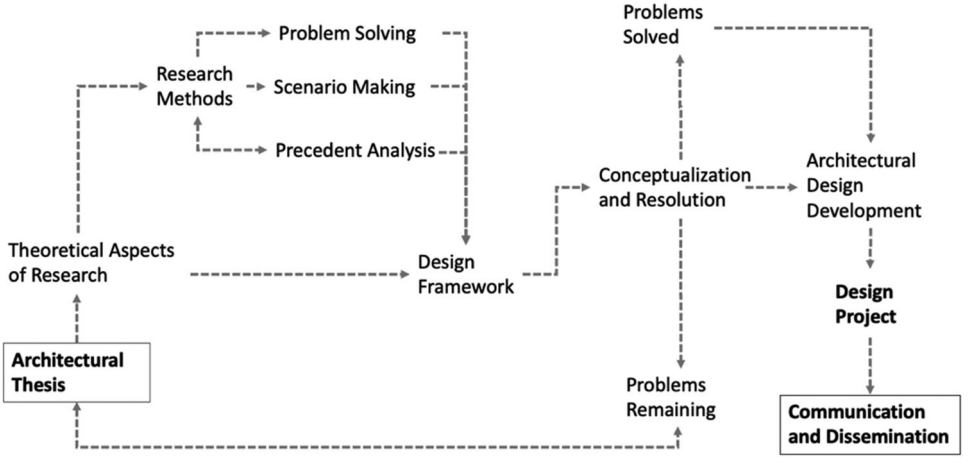

Figure 2. Thesis process in undergraduate architecture.

was previously identified and criticised by Drexler (1975) as a tradition used in many architectural schools in the south European countries. Armstrong (2016) argued that with this approach, the skills developed by students were predominantly compositional. Doyle (2016) described this 'good copy' design process as old fashioned. Likewise, Garric concluded that the École des Beaux-Arts represented an unmodern system of education. Garric noted that students in the Beaux Art setting were not permitted to leave the studio/atelier or have any contact with the outside world during the period of a design competition, or intense burst of work, referred to as a *charrette projet* (a term still in use in many schools of architecture around the world today). Although some researchers have emphasised social context (Anderson 2014; Lefebvre 1976; Simone 2004) as an essential part of the architectural design process (Franz 1994), there are prominent cases in the Beaux-Arts tradition where the design studio became an activity quite separate from the social context.

The Ecole Polytechnique movement was a critical reaction, in education, to the evolution of science and technology. The Polytechnique inherited aspects of the Beaux-Art tradition, but it added science and engineering courses. Some of the great modernist architects, such as Le Corbusier (aka Charles-Édouard Jeanneret), came through Polytechnique education (Proudfoot 2000). The Polytechnique gave rise to a new generation of architectural schools in southern Europe. These schools emphasised construction details and science, resembling engineering more than art. Yet, Garric (2017) argued, the educational and contextual aspects of learning were often overlooked.

The Bauhaus was designed as a contrast to both the Beaux-Art and the Polytechnique. With its new style of teaching, the Bauhaus blended sciences, philosophy, and workshops, infusing craft into the curriculum (Doyle 2016; Kavuran and Dede 2016). The sense of duty underpinning this new form of architecture education included responsibility to respond to social demands and movements (Mindrup 2014). Research, craft, and learning by making became inseparable elements of architectural courses (Doyle 2016). Discovery and new forms of expression, steeped in formalism and now also celebrating the technology available in the various workshops, became central values of education and design (Mindrup 2014). Overall, the Bauhaus valued forward-thinking, functionality, and usability in addition to form.

As a result of this history, today, when it comes to evaluating final-year work in architecture, three types can be identified. Evaluation and assessment usually focus on the products made by students and the student's ability to explain, defend, and justify the work. The first type of evaluation, based on the Ecole Paris and Beaux Art tradition, was based on exhibition, presentation, and/or portfolio. In this tradition, all the students exhibit their work in the halls to be observed by juries who typically select the 'best' projects with regard to creativity, artistic style, and comparison with other design projects (Draper 1977; Drexler 1975; Garric 2017). This evaluation format was not explicitly defined as a competition, and the format was applied in many architecture schools for showcasing and marketing as well as providing feedback and evaluation. The second format came from the tradition of final projects, wherein the team of the instructors and/or jury members evaluate the students' outputs as a fulfilment of an exercise, comparing the design outputs with the original architectural works used as precedents (Clark and Pause 2006). The third format is more related to the thesis structure (Borden and Ray 2006; Doidge, Sara, and Parnell 2000). It utilises academic evaluation with a critical perspective, comparing the design with knowledge and theories used in architecture, and assessing how effectively the student applied these in the thesis project. In the first two approaches, evaluation is mostly in the hands of the instructors and jurors; however, in third format students also are engaged in the evaluation process.

Ongoing debates persist in architecture about educational methods and methodologies that have their roots in the mode of questioning, critiquing, and voicing doubts as practiced by the Bauhaus. Over time, forms of education and the schools of thought underpinning them have changed and shifted. Industrialisation, mass production, the evolution of the urban economy, urbanisation, standardisation, and globalisation have all affected the role of the architect. Additionally, the

role of architects within the design and construction team has shifted away from the Renaissance master-builder (circa 1500) toward a more collaborative, team-based approach today. The imperatives of our time have forced changes (Bryant 2014; Fraser 2014; RIBA 2014).

Similar demands have influenced engineering. As technologies have evolved scales of work and application have grown, specialisations have developed, and a single 'master builder' no longer oversees all aspects of the design and construction of infrastructure projects. Engineering education reflects such cultural and paradigmatic shifts, with tensions evident between practical and theoretical aspects of design. Engineering education has compartmentalised its approach to teaching, with many discrete subjects covered and an emphasis on the parts, whereas architectural education continues to emphasise synthesis and individual expression. Engineering education reflectes a thrust toward group – and problem-based activities are used to supplement more traditional, lecture and lab-based forms of education. This contrasts starkly with architecture's emphasis on individual exploration and artistic innovation, with a focus on project-based learning and long-term design work occupying a significant portion of the student's overall learning hours.

Intersections between architecture and engineering education

Architecture and engineering education do, nevertheless, reflect several points of intersection. These include pedagogical approaches and underlying values related to design, as well as hands-on learning. Both disciplines involve prototyping and making physical models, printing in 2D and 3D in computer labs, visiting sites and documenting their conditions. Both also use various forms of problem-based learning (PBL) which often include research activities geared toward discovering various critical aspects of the overall problem. Both fields also incorporate team-based learning (like peer-to-peer tutoring and critique, collaborative projects, and teams of varying sizes) and interdisciplinary work (at times simulated with team members adopting assigned roles, and at other times more extensive, with students working alongside peers from outside their own department).

Yet, there are important similarities and differences in the way these two fields understand and apply the term 'problem solving' to initially recognise or frame a problem within a system or product, and then examine ways to improve the situation. This type of work can encompass 'scenario making' (exploring alternative solutions to meet the diverse needs of the client and users), precedent analysis (distilling knowledge and experiences from past successful or unsuccessful projects), and conceptualisation (identifying design solutions that are apt for achieving resolution in the design).

The aspects of design and design-research in engineering education may be more challenging to define than in architecture due to the multitude of engineering sub-fields. The level and nature of design education can vary significantly among different branches such as chemical, electrical, mechanical, and computer engineering. Civil and structural engineering, product design, design engineering, and mechanical engineering, in our view, align most closely with architectural education in terms of pedagogy. This is because they all incorporate design thinking and frequently influence or shape the built environment and/or physical artifacts.

The meaning of 'research' in architecture, engineering, and science education

Perhaps the definition of 'research' in architecture can be considered the primary distinguishing feature separating 'thesis' from 'final project', although this might not be the case in engineering education. While it's frequently assumed that conducting research is a natural part of the process of designing architecture (Groat and Wang 2002; Niezabitowska 2018), reports indicate that architects often bypass research in practice, opting instead for heuristic rules of thumb. Moreover, one of the concerns in architectural practice was how to bring 'knowledge to practice in architecture' (RIBA 2014, 7). Exploring this perspective, Frayling produced an analytical paper defining three distinct types of research activity applied in the typical art and design studio. He looked at 'research in', 'research for', and 'research through' art and design (Frayling 1993, 5). He adopted a Vitruvian

approach to architecture in terms of construction, functionality, and aesthetic that respectively needed three forms of assessment: analysis, criticism, and evaluation (Proudfoot 2000; Tafahomi 2022). In the realm of architecture, this can be equated to 'research in architecture', 'research for architecture', and 'research through architecture' – the last of which some architecture departments call 'research by design' or even 'research by redrawing' (Frayling 1993; French 2014).

'Research in architecture' can be described as all the activities a researcher or architect does to document, study, and understand an architectural project. Frayling (Frayling 1993) placed architectural histories and theories in this category. 'Research for architecture' includes activities conducted in other fields – such as in engineering, science, and social sciences – where the results can be seen as applicable or transferrable to architecture. Frayling grouped all social, psychological, cultural, economic, environmental, and other contextual aspects of research into the 'research through design' category, a consolidation that has been criticised (Rust, Mottram, and Till 2007; Tafahomi 2022; Till 2008). Rust, Mottram, and Till (2007) asserted that architecture domains are affected by political conditions and contemporary contexts, and that architectural design does not rest solely upon the experience of the designer nor what takes place in the studio. Rather, many of the events and activities that influence an architect's research and design take place outside of the studio. Moreover, these classification systems do not include all aspects that influence architectural processes, products, and performances (Till 2008). Research and experience get translated by the architect into strategy (Groat and Wang 2002), or into techniques and methods (Deming and Swaffield 2011; Moughtin et al. 1999; Neuman 2006; Niezabitowska 2018; Tafahomi 2022).

Franz (1994) was a critic of Frayling (1993), mentioned above. Franz (1994) classified research in architecture into three main clusters, oriented (1) technically, (2) conceptually, or (3) philosophically. Technical research involves the material, scale, performance, construction, and maintenance of building, and technical researchers normally apply quantitative methods of measurement, testing, and evaluation. These methods can be seen as systematic and computational. Conceptual research targets the personal interests of architects as well as the contextual factors used as drivers for the design. These methods use psychological and contextual frames of reference. Conceptual researchers normally apply qualitative research methods to explain and interpret results from both emic (insider) and etic (outsider) perspectives. Philosophically oriented research assesses embedded meaning and epistemological aspects. Philosophical researchers identify relationships between inhabitants and their built environment and seek the acquisition of knowledge in this process. In the philosophical approach, there is no separation, differentiation, or specification dividing the architectural field from the larger body of scientific and philosophical knowledge, and architects may apply a wide range of methods and techniques (Alexander 1977; Altman and Chemers 1984; Gomez 2003; Lynch 1964; Moughtin et al. 1999; Mugerauer 1995; Norberg-Schulz 1984; Rapoport 1969). This highlights the fact that many architects already utilise a broad array of methods for generating knowledge and designs, which include both qualitative and quantitative approaches (with the application of quantitative methods often underpinned by building codes).

The architectural project typically starts with a request from a client (or a simulated client as is often the case in academia) and the expectation to produce a project or design. Although research may be necessary in the process, it is assumed that the primary activity of the architect is to design an architectural product (D'Souza 2007; Garric 2017; Madanovic 2018). This highlights similarities and differences with engineering. A similarity is that an engineering project is typically assumed to result in a product/design that is functional. Perhaps in contrast, the engineering design often is based on the request from the consumer market, and it frequently involves prototypes that are used to pre-test the design.

Even though architectural research shares some similarities with both science and engineering research, an architectural project is typically guided by a client brief and is rooted in a specific site, with an expectation for the design to creatively and artistically address that setting. The project normally includes some frame of reference – a scenario or other basis for problem solving – that helps the architect generate an overall concept. This can be seen as a core method or strategy

that unifies the architect's overall design process and strategy (Groat and Wang 2002; Moughtin et al. 1999). Dorst (2006)responded to critiques of the design process as problem-solving by noting that work in the field of architecture requires defining and answering 'ill-structured problems' in an iterative fashion. Addressing open-ended or ill-structured requires different processes than needed to solve 'well-structured problems' that have clear objectives and design outputs.

Even well-structured problems are often poorly resolved, argued Dorst (2006), despite appearing clear and straightforward. Engineering education nevertheless prioritises problem-solving, and doing so quick and efficiently, whereas architectural education prioritises problem exploration and problem framing. It appears that architects tend to seek out problems, whereas engineers strive for straightforward problem solutions.

Research in architecture is often considered more flexible (e.g. 'soft', socio-cultural, or qualitative) than research in engineering and ('hard', physical) science (Frayling 1993; Groat and Wang 2002). For this reason, some may question if it is as structured and rigorous as research in other fields. Reichhardt (Reichhardt 2005) explains differing perceptions between 'hard' physical and 'soft' social sciences. For a field like architecture that integrates social, experiential, and physical concerns, it can be difficult to satisfy the expectations and the definitions of rigour coming from just one perspective (e.g. hard sciences). However, an editorial published in *Nature* praised 'soft sciences', asserting that '"Hard" scientists should stop looking down their noses at social scientists, and instead share methods that could help them address pressing societal problems' (p.1003). The field of architecture has tended to bridge this gap, drawing from, and applying, methods from both sides of the perceived divide.

In the case being examined, some staff members posed the question, 'If research is the essence and the labour of the sciences, does that make architecture an unscientific field of study?' If we accept that architecture is part of science and engineering, engagement in research is inevitable. In fact, architecture bridges art and science. Education, projects, and research in architecture include aspects of both science and engineering (Till 2008). Moreover, engineering projects are quite like architecture projects in that they often involve design, research and the construction or the production of artefacts (Niezabitowska 2018).

Architectural research differs from engineering research, as well as science and social science research, in its questions, contexts, methods, and modes of dissemination (Rendell 2004, 145). In science, the final product of research is not always a thing or artefact (consider, for example, basic research as opposed to applied research). Scientific research typically starts with a scientific question and seeks to find a solution or answer – which can also be defined as scepticism driving discovery in

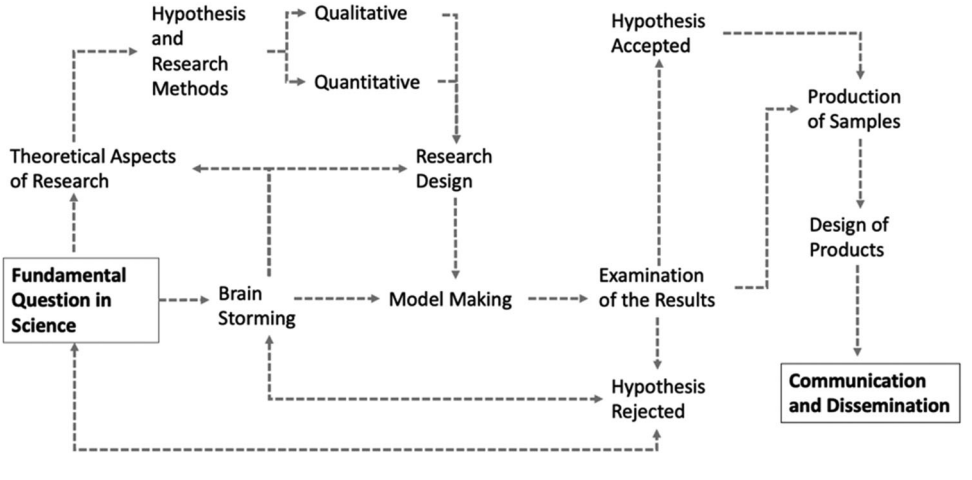

Figure 3. The process of science research.

science (Figure 3, presented in the next section, attempts to illustrate this point). Often, a major part of scientific research involves investigating a new question or finding further topics for research (Henn, Weinstein, and Foard 2006). Architectural design may also push at the edges, looking for new avenues of expression and construction, but an architectural work is also expected to be functional. It must address an array of physical and pragmatic specifications (Borden and Ray 2006), and it must propose or deliver a new artifact, which most often provides space for activities and shelter for people. In the following section, we present an argument concerning the structure of research in science and engineering to further validate the rationale for our comparative analysis.

The meaning of 'research' in science and engineering

Scientific fields often apply a hypothesis in the research process (Figure 3), and they sometimes assume objectivity is possible (the positivist paradigm originated in the 'hard' sciences) (Hmelo-Silver 2004; Prince and Felder 2006). Architects and philosophers of architecture have played leading roles in questioning the positivist paradigm through, for example, deconstruction, post-modernism, phenomenology, and critical thought in architecture (Creswell 2012; Given 2008). When a design is the expected final output, it is anticipated to address the problem, hypothesis, or question stated at the outset. This is quite often the case in engineering as well as architecture, and sometimes in science as well. Overall, the final output of the projects in science, engineering, and architecture is intended to solve a problem or address a need.

Based on our data analysis, supplemented by literature review, we have created Figure 3 to illustrate the research process in science. It starts with a fundamental question (Creswell and Creswell 2018). This question opens theoretical aspects of the problem, leading to the identification of a hypothesis and research methods designed to either validate or disprove the hypothesis using quantitative or qualitative methods that are integrated into an overarching research design. This process often uses brainstorming and testing of various types of models (e.g. mouse models). The models and the data collected are examined in order to support or reject the hypothesis (Leavy 2017). Where design is the goal of scientific research (e.g. development of solar harvesting cells), the findings can then be used to produce samples to inform the design of products. Findings are communicated and disseminated via presentations, journals, and sometimes products, like in architecture and engineering. Not all thesis studies involve a hypothesis, and in many cases, the results do not allow for a full approval or rejection of the hypothesis.Engineering often seeks to solve problems by creating prototypes on the way to developing refined products, following a 'sequential process model' (Albers, Sadowski, and

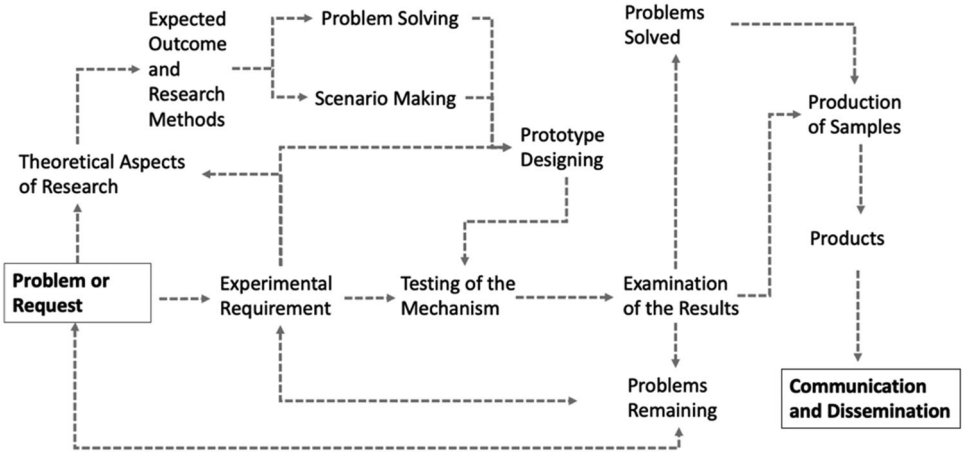

Figure 4. The process of the engineering research.

Marxen 2011). The engineering research process is depicted in Figure 4. A defined problem or request raises theoretical questions and prompts experimentation. The engineering researcher identifies expected outcomes and determines research methods to address the problem. This process involves problem-solving and scenario development, similar to architecture, although there has been criticism regarding the low level of research (Fraser, Tseng, and Deng 2018) and design in engineering (Lindemann 2011). In engineering, a prototype is often developed and then tested. When the results are analysed, some parts of the problem may remain unanswered, whereas other parts many be solved. As in other iterative models (e.g. Figure 4, which we created based on our data and our understanding of the literature), unanswered questions can be cycled through this same process once again (Prince and Felder 2006). Ultimately, the solutions generated are integrated into prototypes and other samples, and then refined into final products. The avenues for communication and dissemination in engineering are quite similar to those in architecture.

Some architecture educators perceive architecture as more closely aligned with art than science, feeling stifled by the rules and established standards for replicating research studies. As a result, some architects, educators, and programmes resist the idea of architecture as a research-based profession. However, by not consistently fostering research capacity within the architecture community, this field may limit its ability to resolve recurring problems in the built environment, and consequently, its potential to secure research funding. Generally, architecture departments obtain less research funding than science and engineering departments.

Summary of methods and case study

The detailed case study was grounded in the interpretive paradigm, and the methods used are consistent with the interpretivist worldview in terms of methodology, ontology, epistemology, and axiology as recommended by Creswell and Poth (2016). Data for the study included curriculum documents and field notes, generated through unobtrusive, structured observation. The primary methodologies were content analysis and storytelling. A set of applied methods, based on the established definitions of content analysis and structured observation cited in the previous literature, was formulated to guide this research. Ultimately, the findings were generated using interpretive storytelling, and these are presented here through text and diagram. Details about the case study will be published elsewhere.

Our research employed a wide range of methods that encompass *content analysis*, *structured observations*, and *interpretive methods*. These interpretive methods included *diagramming* and *drawing*, the results of which are displayed in this paper.

Analyses of the data revealed specific points of conflict between (a) the views and interpretations expressed by students and staff, and (b) the written, enacted, hidden, and invisible curriculum. A detailed analysis was conducted, using words and diagrams, to understand and describe the paradigms being enacted. Analysis considered ways of understanding context, knowledge, and skills in the field and of producing architecture.

The following activities illustrate key conditions within the paradigm shift, related to the case study: curriculum specification; perceptions concerning final year architecture studies; research as a discourse in architecture; and traditions in architectural education (including the contrasting Bauhaus and Beaux Art educational approaches). Each of these conditions is described below, supplementing the explanation provided in the background and context section on the meaning of 'research' in Science and Engineering (presented in Figures 3 and 4).

Final-year architecture studies

The expectations that instructors and juries hold regarding the general character of the final products students should produce constitute a key issue shaping the perception paradigm. In the case under investigation, there were two differing processes and they yielded two very different

characters of design outputs in the design studios. This distinction was particularly evident in the last design studio, where the difference mirrored two distinct modes of instruction: the final year project and the thesis (Rade 2019). Although the confused implementation of these two different modes was apparent through structured observation and data analysis, the students had not been clearly informed about the distinctions between these two paths, leading to confusion and distress.

One set of final outcomes reflected the **final year project** mode. The students who achieved these more traditional results followed the same process of prior design studios (Nulman 2012), although they were expected to exhibit a higher level of detail and integration than in earlier years. In their fifth year, students were asked to apply all the knowledge and skills acquired in previous years to design a specific type of building (e.g. an art gallery, community centre, or research institute). By those instructors embracing the project model (illustrated in Figure 1), individual students were judged on how well their final projects demonstrated the application of expected knowledge, skills, and abilities and combined this with new understandings they had generated by studying precedent projects.

The second set of final outcomes reflected the **research thesis** mode (depicted in Figure 2). In comparison to final year projects, the thesis projects demanded more effort and engagement from the students outside of the studio for research, data collection, and analysis (Owen 2009). In general, the thesis research was designed to answer a question or address a particular architectural 'problem' that the student needed to identify, state, and/or **'**frame**'**. As per Figure 2, the student needed to explore theoretical aspects in the research and apply established research methods for problem solving to include envisioning alternate scenarios and analysing precedents. This involved critical thinking about the precedent projects and deep investigation of them in theoretical as well as practical terms. Whereas the final year project mode required the assimilation of various aspects of the precedent (typically formal or functional), the thesis mode required students to challenge the precedents and use them as a source for criticism and inspiration (Vandenhende et al. 2020). This should help the student identify or develop a framework to apply the results of the research in terms of the architectural findings into design brief and use appropriate design strategies to achieve the project programme (Tafahomi 2021). Following established research standards, this process should help the student to conceptualise and resolve the problem, iteratively identifying which parts of the problem remain unsolved and which have been sufficiently solved in a way they can be integrated into some sort of architectural design, structure, or expression. The ultimate design project can take many different forms – including but not limited to the design of a building that addresses the student's own initial thesis question or problem. The final step of this paradigmatic model (Figure 2) is to communicate and disseminate the results. Architects do this via public presentations and publications, and by producing built artefacts that embed the concepts for others to experience.

The contrast between the two modes – thesis and final year project – emerged haphazardly, as evident in this case study. In this context, the viewpoints of the instructors varied regarding the concept of research in the architecture profession. This led us to identify the next paradigm ….

Research as a discourse in architecture

The data analysis revealed that the majority of the staff and jury members involved in the case study did not agree with the inclusion of research in the design project. When we attempted to collect data for the purpose of educational research on the meaning of research in design, only 30% of the staff responded to the questionnaire; the majority chose not to participate in the survey. To some staff members who did respond, the word 'research' implied simply redrawing famous projects. As the study progressed, students under the supervision of instructors with this concept were simply expected to 'research' their precedent projects by physically modelling and drawing the existing designs (Ching 2010; Draper 1977; Drexler 1975). The group of instructors who perceived research as re-drawing strongly advocated for this approach during student presentations (Tafahomi 2021).

In such a process, the research is usually confined to the studio, although it occasionally extends to design labs and workshops (for instance, for modelling). Case study data indicated that this group saw the design product (building design) as the main deliverable by students in their final year of education (Tafahomi 2021; Till 2008), whereas, for those advocating thesis research, the focus was on developing new skills and abilities to ready the students for the critical practice of architecture (Borden and Ray 2006). The group that advocated for 'projects' viewed most forms of research beyond precedent analysis (Groat and Wang 2002) as activities appropriate for science and engineering, but not for design. For this reason, this group tended to advocate for aligning the approach in architecture more closely with that of engineering and science, in order to attract research funding and shape outputs to meet the expectations of those fields.

Traditions in architecture education

The responses of the staff and jury members in the department under study mirror traditions that have evolved in the field of architecture over centuries. The two modes of delivering final year architecture education – project design versus research thesis – mimics differences between the Beaux Art/Polytechnique and Bauhaus traditions mentioned previously.

As such, we relied on various documents, biographies, biographic studies, and historical reviews concerning the Beaux-Art and Bauhaus schools to trace the development of curriculum and ideologies related to design. Research on these helped us better understand shared conceptions held about each of the schools. The term 'Beaux-Art' is linked to eighteenth-century romanticism and nationalism in France, tending to depict glory, wealth, and art (Laroche 2008; Ramzy 2010). Conversely, the Bauhaus school was rooted in twentieth-century modernism, developed under Marxism and influenced by social movements in Europe, aiming to meet the needs of the general public, especially in terms of urban development and social housing – it mirrored the political conditions of Germany, shaped by the constructivist theory of educators (Doyle 2016; Mindrup 2014).

As depicted in Figure 5, schools such as the Ecole des Beaux-Arts and the Polytechnique, which followed its principles, prioritised precedents as the main drivers of design, while the Bauhaus focused on experimentation and transformation. It should be noted that despite differences in the number of building technology and construction courses they each required, the Polytechnique and Beaux-Arts shared similar teaching processes. As such, they have been grouped together in Figure 5, on the right side of the diagram. Overall, the Beaux Arts stressed art and design, the

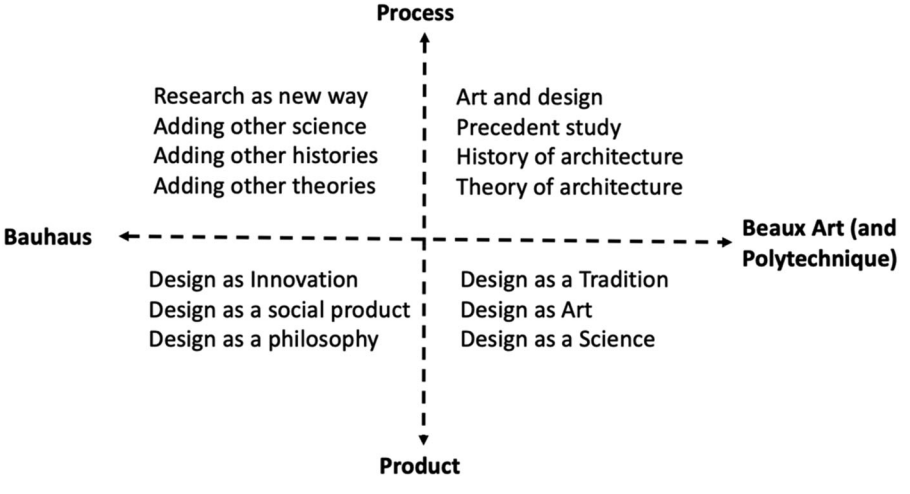

Figure 5. Bauhaus and Beaux Art (and Polytechnique) educational approaches.

study of precedents, and understand the history and theory of architecture. Design was seen as an expression and maintainer of tradition, as well as both an art and a science. In contrast, leaders of the Bauhaus considered research and practical testing as essential. Advocates of the Bauhaus approach wanted to change and transform architecture, art, society, and the way people live. They wanted to contribute new ideas and ways of thinking to enhance other sciences and to make history through innovation, critical thinking, and the development of new theories. They saw design as innovation, a social construct, and deeply interwoven with philosophy.

In the organisation under study, those resistant to change embraced the Beaux-Arts' emphasis on precedent and tradition, while those educators advocating for a shift to research-driven design and the research thesis embraced the Bauhaus' emphasis on research, social innovation, and critical thinking.

Discussion

Jung, Kim, and Kim (2016) criticised the assumption of an individual building being the final output used in many schools of architecture, a pattern he called the tradition of 'design as building' and which he indicated has resulted, over time, in separation of the project from its context. This criticism holds true today, being both relevant and clearly observable in this case. Moreover, although the term 'thesis' refers to critical thinking and dialectic theory (Zizek 2006), many contemporary scholars (Drexler 1975; Littmann 2000; Madanovic 2018) have argued that applying a research thesis structure in the final project is not common in architecture schools. In fact, a report published by the Royal Academy of British Architects (RIBA 2014) on education in architecture in UK indicated that research is far from the domain of architecture in that country. Moreover, there is a contrast between the tradition of the architect as a gifted and artistic genius with skill in drawing for competition and the architect as a knowledgeable human with critical thinking skills and applicable problem-solving approaches (Mindrup 2014; Secolsky and Denison 2012).

Our empirical evidence showed that in some departments, the approach used was constructed more on the tradition of architectural design projects, rather than developing the critical thinking skills necessary for critique, approval, and application through design (Borden and Ray 2006; Creswell 2012). Some scholars still question the meaning of research in architecture projects, processes, and education (Dorst 2006; Proudfoot 2000; Tafahomi 2022; Wang and Ilhan 2009). The case study department had problems integrating research, as has been the situation in other countries, such as the UK (RIBA 2014). Despite a proliferation of studies highlighting research and research methodology as necessary for architecture education (Frayling 1993; Groat and Wang 2002; Niezabitowska 2018), implementation of the approach has not always been successful.

Several studies have recommended using logical arguments (Dorst 2011; Groat and Wang 2002) to examine the validity of theories, following Popper's practice of falsification (Wang 2009), or utilising an integrated approach (Tafahomi 2022). This suggests a more scientific approach, and one that forms a basis of the thesis approach, where an idea is put forward and tested. This is our understanding of true 'thesis' project, where the thesis claim is the main object of study and the main purpose of study is to develop the student. The 'thesis' format may include designing a building that applies/prototypes/tests the thesis concept under investigation, but the ultimate outcome is not a 'building design' per se.

Today, architecture programmes in Europe and North America can be mapped along a continuum, according to their emphasis and alignment with art, science, craft or eclectic (Tafahomi 2022). They have adopted ideals from the Bauhaus, Beaux Arts, and Polytechnique traditions that inform how they approach education of architecture students in the final year. Most emphasise innovation and experimentation in the early years, and thus align with the Bauhaus. As implied above, many of these programmes do still expect students to produce a building design in their final year, although this will be called thesis and will require a wide array of research, critical thinking, prototyping, and analysis.

Some programmes also exist where the objects created via the thesis are these tests and proofs of the viability of the thesis claim and argument. Universities exemplifying the use of research-driven architecture thesis approaches include Hampton University in Virginia (where the second author taught for 15 years). Addressing a specific environmental, social, or cultural issue or challenge is at the core of these programmes. The thesis programme at Hampton University's Department of Architecture requires students to produce a project that demonstrates their ability to integrate design, technology, research, and critical thinking around a specific architectural issue typically with social or sustainability issues embedded. Students must develop a clear thesis statement, which is then tested and proven through the design and execution of components, a building, or some other architectural application. The thesis project is a comprehensive exploration of a specific architectural problem or issue, with the goal of producing a solution that is both innovative and grounded in research and analysis. Students are required to document their research and design process in a written thesis document, as well as in visual and physical models, drawings, and other representations.

It is less common for schools to maintain Beaux Arts traditions, 'characterized by order, symmetry, formal design, grandiosity, and elaborate ornamentation' (Craven 2019). Although there are dozens of Beaux Arts architecture schools existing today in France and Iran (Ghahari 2009), just a few programmes in North America rely heavily upon Beaux Arts traditions (D'Souza 2007; Garric 2017; Littmann 2000). The most prominent of these is the University of Notre Dame. Others, like the University of Miami, and the Prince's Foundation in the UK, align closely with the New Urbanist movement.

In the case study, interactions among staff members in the architecture department led to a regression towards the familiar 'final year project' format seen in the Beaux Arts and Polytechnique traditions. This return happened after a brief period of attempting a shift to the research thesis, relying on experimentation and testing associated with the Bauhaus. Ultimately, research activities disappeared from final year to the extent that the experience can no longer be considered a 'thesis' project. This return to familiar territory (regarding the educational style) reflected the tendency that 'we teach as we have been taught' which has been widely criticised (Tafahomi 2021; Wang 2006; Wang and Ilhan 2009; Williams and Robert 1997).

The return was justified by the belief that students don't need theoretical knowledge to design buildings and practice architecture. This notion has been criticised by D'Souza (2007), Garric (2017), Madanovic (2018), and Wang (2006). In the failure to operationalise the intended change, the staff also failed to set up the specified archives of student work. Although many official and unofficial discussions were held among staff regarding difference between thesis and project, neither those points nor the outputs generated by students were properly recorded, concluded, or archived to create a body of knowledge. Considering the larger picture, beyond this school, it appears that the definitions of architectural education and architectural research are both weak – there are not very clear shared conceptions across the field of architecture regarding the role of research in design. Thus, we attempted to define the distinctions in this paper.

This case study validated prior findings of Williams and Robert (1997) that the learning background of staff informs their attitudes and behaviours and that staff tend to teach in the ways they were taught (Zizek 2006). The style of lessons staff encountered created their framework to think about architecture, to define what an architecture project is, and to educate others.

Contradictions in the written curriculum contributed to variations in how the final year studios were conducted, leading to significant confusion among staff as well as students within the department. Ambiguity in the curriculum resulted from taking an eclectic approach. It resulted in different perceptions and interpretations among staff and differing levels of implementation of research in the final year activities. Lacking a clear shared vision, an enacted curriculum was implemented by the staff based on their own personal interpretations (Hass 1993; McBrien and Brandt 1997; Remillard 2018). This variation in understanding resulted in the prescriptive approach described by Lawson (2004) wherein many aspects of the final project were dictated to students.

Despite the final year project encompassing projects and project-based activities that appeared to align with engineering (Blumenfeld et al. 1991; Prince and Felder 2006), the implemented curriculum diverged further from engineering and science. In the new format, students did studio-based projects and had no need to connect with the staff in other departments to ask question or solicit advice for their final projects. The students experienced fewer problem-based learning activities (Barrows and Tamblyn 1980; Hmelo-Silver 2004; Seifert and Sutton 2009) than engineering students at this case study organisation, and the connections they made were limited to the architecture design studio.

Conclusion

Through the identification, description, and diagramming of significant conditions within the paradigm shift – which reflect shared thought patterns that were revealed through structured observation, content analysis, and storytelling – this study aimed to underscore the crucial differences in the staffs' interpretation of the final year curriculum. The case study helped expose gaps, between the written and enacted curricula, and the lack of both common understanding and staff buy-in that caused failure to change. Although the written curriculum specified research thesis, the enacted curriculum reverted to final year projects with precedent studies.

The curriculum was crafted by a group of staff who held particular perspectives about the programme. Those individuals no longer work in the department and the new generation of the staff does not believe in the written curriculum, nor its objectives, content, or specified learning outcomes. The curriculum was written and adopted without considering basic principles of change management. The change was mandated from above without achieving shared understanding of what was involved and the rationale behind it; common understanding was not achieved as too few staff members were involved in planning the change. Not enough resources were provided to support the change (there was an inadequate number of staff, and very little support was provided to help staff learn new research methods or engage personally in conducting research). Confronted with a high staff-to-student ratio, the staff showed resistance to investing time in upskilling and incorporating new methods. Implementing change requires building the capacity of the staff to enact change as well as developing staff understand of why the change should happen. In this case, there were not enough people championing the change.

The viewpoints conveyed by the instructors nudged students back into undertaking simplistic 'final projects'. There was indeed a group of instructors who considered the work of the students in 'thesis' terms, and who promoted research, accumulation of knowledge, and robust analysis. But they were opposed by a second group who believed that the final year project should involve only design and not research; they required their students to focus on design, drawing, redrawing, to demonstrate ability to design a building. Despite differences, some similarities do exist across both points of view.

Overall, it's not surprising that the transition from a final project to a thesis was unsuccessful. The narrative above offers plenty of evidence that the shift was doomed to fail from the beginning. Among the most evident reasons are the absence of preparation for the transition, the lack of needs assessment, the provision of no additional resources, a lack of commitment from those expected to execute the change, no planned adjustment for the change after its implementation, and no criteria set to evaluate its effectiveness. Whereas it is easy to see this in hindsight and from an organisation change point-of-view, it was not as easy to see and identify from the inside of the change effort. The work presented here has value in proposing a model to reconcile differences present in the case study organisation so that successful change might be possible in the future.

Can any remedial measures be implemented in the context where this initiative took place? Figure 6 suggests a more integrated approach, one intended to resolve discrepancies between

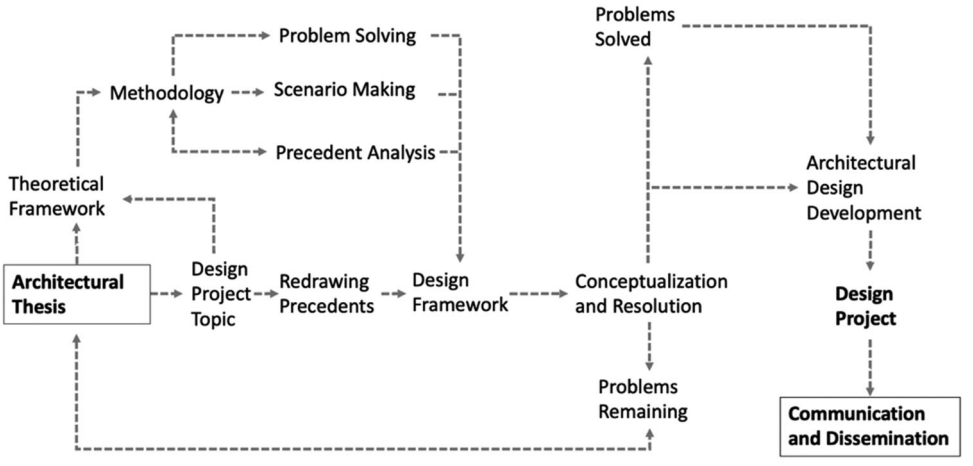

Figure 6. Integrated approach to mitigate the problem.

the opposing points of view. In it, we endeavour to reconcile the differing epistemological approaches discussed throughout this paper.

Figure 6 superimposes components of the individual paradigm diagrams. A linear process for 'architecture as design' is evident in the middle of the diagram. In this integrated approach to the architectural thesis, a design project theme is determined, and the redrawing of precedents contributes to clarifying questions associated with the design topic. Simultaneously, honouring the principle of an architectural thesis project, a question or theoretical framework needs to be identified, as well as a methodology for exploring the topic – this will involve problem-solving and scenario-making as well as the rigorous analysis of precedents selected for re-drawing. All this will inform the development of a new design framework to help conceptualise issues and resolve problems that emerge in the process. Iteration will be required, as some problems will be solved earlier in the process than others. Outstanding/remaining problems will need to be addressed via the same cycle, while the problems that have been effectively solved and be fed into the architectural design as it develops. In the end, a design project will reflect both traditions and the product can be communicated and disseminated via all known means.

Figure 6 was conceived to facilitate the ongoing dialogue of architecture and cultivate collective and contextual understanding. It attempts to graphically depict a platform, using existing ideologies and dogmas evident in the case study department. It provides an illustration of how the various modes of study can work in harmony. As we know, students learn many aspects of life knowledge without class, curriculum, or instructor, therefore, architectural institutes need to facilitate the wayfinding of the students through architectural education. We believe this diagram can help, and we encourage educators to identify which paradigms/figures presented here fit their personal ways of thinking and the ways of thinking promoted by their organisations.

The authors of this paper seek to stimulate dialogue, critique, and discourse to allow the case study institution, among others, to pinpoint suitably aligned educational objectives, processes, and outcomes. Open discussion around these models could clarify the shared conceptions of educators and communicate them to each other and to students. Seemingly, we are in the starting point to open dialogue in this case study location, to help guide the direction of work going forward. From the Vitruvian perspective on architectural training to current discourse on forms of architectural education – from noble architectural styles to social and contextual points of view, from spiritual perspectives to the critical point of view – we seek to construct a shared understanding of the meaning of matters.

Perhaps such a diagramming process can pave the way to initiate new discussions and critiques on the topic. Creating these models helps isolate specific points of distinction, supporting educators to become more purposeful in their thoughts and actions. These diagrams can help the architecture community draw from successful practices developed in other fields of study as well.

As for the implications for future research, it could be valuable to attempt implementing the new model in the future while documenting both the process and the outcomes. A worthy study could investigate how architecture and engineering students end their academic careers – their culminating experiences – and could explore how the final experiences help them transition to practice and life of learning. Data gathered from these burgeoning architects and engineers can aid researchers in analysing and interpreting educational processes, systems, and outcomes. Researchers can ask students to reflect on their memories, achievements, and practices similar to what we have done, to learn more about the 'thesis' and 'final year' experience in other architecture schools (and perhaps again here at the case study institution after a period of years). We encourage others to critique and question the educational practices inherited from previous generations to help construct increasingly effective methods for education. Furthermore, we call for incorporating more cross-, multi-, inter-, and trans-disciplinary approaches into the professions of architecture and engineering, as we believe this cross-disciplinary comparison has yielded some interesting findings. A crucial responsibility of academia is to instill in students a tolerance for new ideas, yet academics also need to stimulate dialogue and discourse on shaping architecture and engineering education that's fitting for today's world and beyond.

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