Perceptions about the Role of Problem Specifications in Design Learning and Studio Assessment: A Study in Jos, North-Central Nigeria

Dr Ebelechukwu Obianuju Enwerekowe and Elizabeth Tidak Dassah
Department of Architecture, University of Jos, Plateau state, Nigeria

Abstract. Problem specifications are useful for framing the problem solving context within which the designer acts. This study looks at student and mentor perceptions on the role of problem specifications during the design process and the resultant outlook on the outcome during the critique or jury. Using empirical and theoretical data obtained from the Department of Architecture, University of Jos in north-central Nigeria, the study findings examine student and mentor perceptions and preferences on the composition of problem specifications, and the relationship between student performance and staff assessment of project assignments using problem specifications. The study also considers obstacles and aids to the development of problem specifications. The study proposed firstly, increased mentoring during the formative years of design education to guide students on the significance of problem specification as a problem framing tool; secondly, expanded use of digital tools of production due to the emergence of virtual studios; and lastly, expanded and continuous study of teaching methods on problem specifications to promote enduring cognitive, creative skill in the profession.

Key words: design education, problem specifications, student/mentor perceptions

Introduction

The purpose of architectural design education is to prepare students for a future in the profession (McClean, 2009). This is achieved by teaching them to interpret the contents of a design brief extracted from a list of user needs and wants, and to translate those interpretations into a tangible physical form. The International Union of Architects (UIA) advocates that this process of interpretation and translation be conducted with full consideration of health, safety, and ecological balance in line with global standards (UIA, 2014, p. 9). The process of design is widely accepted as a conceptual activity taking its origins from the traditional apprenticeship model of professional practice which is replicated in a design studio where studio is both a course to be learnt, as well as a space for learning and other pedagogical activity (Olotuah, 2000; Aderonmu, 2013; Crowther, 2013). Thus, a student must learn about design (development of knowledge), learn to design (develop and apply design skills) and learn how to become an architect (transformative pedagogy) attained to a certain level of mastery (Adedapo, Ezema & Opoko, 2017; Ambrose et al, 2010).

Modern day design education faces challenges from evolving pedagogy where an increasing number of students fail to transfer knowledge from theoretical courses to design tasks (Aderonmu, 2013; Joyner, 2019), and from cognitive barriers which hamper students' abilities to structure knowledge and engage in design thinking (Gray, 2013, Deutsch, 2020). Other pedagogical drawbacks include the somewhat greater emphasis on the evaluation of the design product rather than the learning process or cognitive skill of actually designing (Franck & Lepori, 2007; Hargrove, 2011), and coaching detachment by design instructors who fail to demystify the design process (Oxman, 2001; Tezel & Casakin, 2010). Some researchers have suggested that students are less likely to struggle with the design process and approach mastery faster if they received instructional support from their tutors at critical points in their engagement with design activity which replicates professional task performance (Ravenscroft, 2019).

The aforementioned challenges lead to an even bigger concern about the quality of graduates entering the profession who, despite innate or latent design skill and the latest technology, struggle with thinking and communication of ideas which are crucial to academic success and eventual practice longevity (Akande, Olagunju & Ayuba, 2006; Maina & Salihu, 2016). In these times of upheaval and challenges to wellbeing of mankind (as in the case of the massive global pandemic caused by the novel coronavirus, COVID-19), developing the ability to think and communicate constructively, creatively and critically has never been more important. The shift to technology for hard skill sets such as process-driven production tasks will certainly render most present day architectural skills obsolete in the near future. This in turn, calls for greater emphasis on the refinement of creative and soft skills such as thinking and communication of such ideas that robots, automation and artificial intelligence cannot replicate (Crowther, 2013; Ioannou, 2018; Deutsch, 2020).

The new reality of "working from home" and distance learning means architectural educators are faced with the challenge of stimulating their students in a virtual studio that needs to re-evaluate its strategies for assessing the development of effective metacognitive and communication skills. What are the indicators of potential successes or failures in the ability of a design student during the execution of a design studio project? How can architectural design education encourage critical thinking, creative problem solving and collaborative thinking in an environment that differs from the norm of in-person supervision? What rational and intuitive presentation tools should form part of an action plan or checklist used to walk-through the mind-set of the design process and product? These are some of the questions this paper seeks to address in a quantitative assessment of the perceptions of design students and instructors on process- and product-oriented problem specifications for in-person and virtual evaluation exercises.

Literature Review

Design is one of the highest forms of human intelligence. The word 'design' takes its etymological origins from a combination of the prefix '*de*' and the Latin word '*signare*' meaning to mark or mark out a thing (Terzidis, 2007); and carries with it three divergent ideas depending on its contextual use. As an activity or a process, it is a verb; as a description of special qualities of artefacts and built space, it is an adjective and in reference to a designers output or product, it becomes a noun. Dorst (1997) describes design as a rational problem solving perspective stemming from the 'white box' view of the designers mind derived from scientific domains that seeks to rationalise the design process. Alternatively, design is also seen as a mysterious act, undertaken in the closed, 'black box' mind of designers who see themselves as creative, reflective geniuses. This attribute of mystery and reflectiveness elucidates why many designers find it difficult (rather becoming wilfully obscure, arrogant or even genuinely clueless) to explain how they design, instead preferring to talk about the product of their design and not the process (Cross, 2011).

Explaining the design process becomes relatively simplified through the use of 'problem specifications' which frame the problem solving context within which the designer acts (Özkaya & Akin, 2006); outlining the scope of the design problem, the design aim and objectives and the possible sequencing of a solution based on preferences or constraints (Uluöglu, 2000). Distinct problem specifications assist students with cognition of the intricacy of the design problem and subsequent generation of the consequent solution and the primary assessment criteria of the assessors (Tezel & Casakin, 2010). Students and design educators engage in an interactive process of, ideally, what should be a personalised teaching experience involving free exchange of ideas and educational experiences in a social environment – the design studio – which is the backbone of design education. The educator presents the design problem in the form of a program contained in a brief from which students elaborate on their design projects and internalise new abilities represented in graphic and verbal languages (Schon, 1985; Roberts, 2006). In response to the given brief, students are subjected to various one-on-one critiques from their studio mentors as they navigate their way through the ill-defined nature of the design problems, much of which require framing and constraining to set concrete boundaries that will guide the potential direction of the eventual design solution (Eshun, 2016). This eventual solution is what will be subjected to a more detailed review or critique (popularly called the "crit" or jury) by a panel of independent judges to whom the students explain how and why they developed ideas and concepts during the design process (Ola-Adisa, Enwerekowe & Audu, 2015; Eshun, 2016).

In order to support the dialogue between the design problem and solution, students are expected to adopt a number of 2- and 3-dimensional tools that include (but are not limited to) a detailed analysis of the brief, case studies, schematic consideration for ergonomics, conceptual analyses, site reviews, design development, block or tissue models, walk-through models, construction details, perspective drawings and building specifications (Enwerekowe, 2011). Juxtaposing these requirements on synchronised perceptual models of the design process by Dewey (1910), Archer (1965), and Lawson (2006) leads to the composition of the design problem specifications which guide the students in their presentation (see Figure 1).

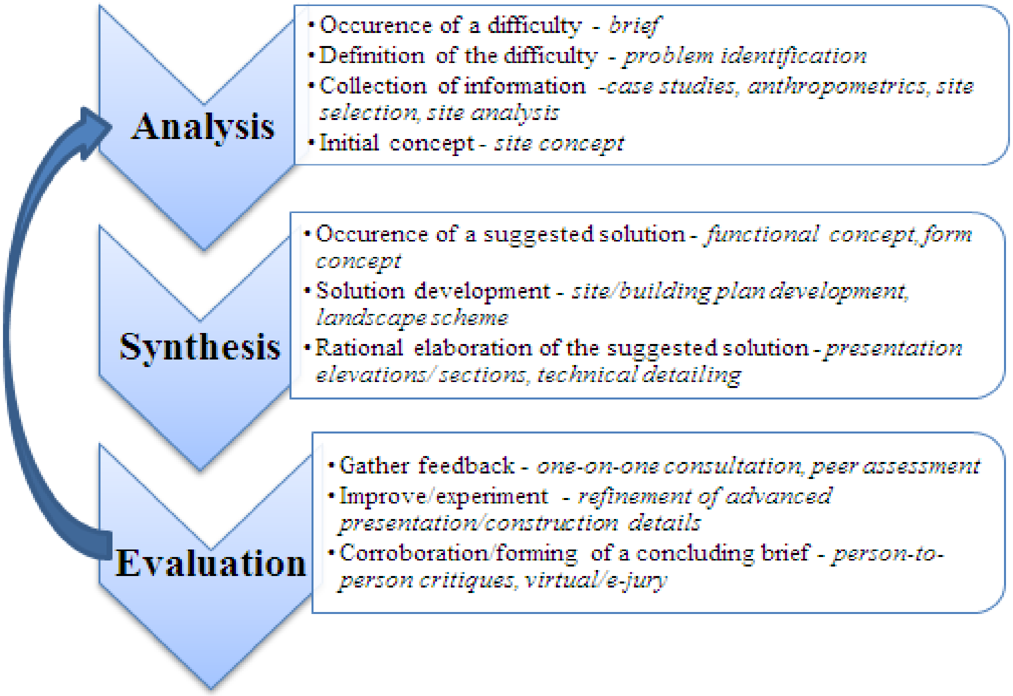


Figure 1. Juxtaposition of design process models and necessary problem specifications (Dewey, 1910; Archer, 1965; Lawson, 2006; Cross, 2011; Chicago Architectural Centre [CAC], 2019)

The presence of a feedback loop on the figure above highlights the importance of the sequence of the design process on the success or failure of the resultant design solution. The inability of design students to adequately develop and present the problem specifications which guide the generation of workable design solutions often leaves assessors unable to understand student cognitive or creative thinking skills (Wu, Huang & Weng, 2014). More importantly, students who are unable to adequately frame design problems with specifications are less likely to be able to proffer workable solutions that allows for performance at acceptable levels of competence in the architectural design studio (Cross, 2004; Emma-Ochu, 2009; Curry, 2017). This paper seeks to assess student and staff perceptions about the role of problem specifications in the execution of the design process and the resultant outlook on the outcome during the critique or jury.

Methodology

This paper centres its discussion on findings from previous studies and the results of a primary study conducted among undergraduate and postgraduate students in the Department of Architecture in the University of Jos. Additional information was obtained from design tutors within the same department in order to keep the discussion objective. It was deduced that 85% of the total student population eligibly participated in design studio programs during the period under review (the 2018/2019 academic session). Using the Moser and Kalton (1974) derivation method to generate the sample size with a standard error margin of 5% from total population of 360 registered students at undergraduate and postgraduate level, a minimum of 36 responses would be needed for a credible student sample. 75 questionnaires were distributed and 51 were correctly filled and returned indicating a 72% response rate. Similarly, a derived sample for staff required a minimum of 12 responses for analysis; 30 questionnaires were issued and 24 were correctly filled and returned representing an 80% response rate. The sample size was consistent with prescribed standards and represents conformity with the statistical means of determining the sample size (Onwuegbuzie & Collins, 2007; Fincham, 2008; Uji, 2009).

The study presents a fusion of quantitative and qualitative data sourced from literary research, field studies and data interpretation. The literary research reviewed existing knowledge on the subject background and reviewed developing trends on students learned behaviour in the design studio and staff perceptions on the relevance of problem specifications in student studio submissions. The descriptive analysis of the data obtained was interpreted using tables, charts, pictographs and other simple means of statistical analysis such as percentages. Respondents in the survey were encouraged to make use of the open-ended questions for further clarification where necessary.

Results and Discussion

An inspection of the emerging trends of design education in Nigeria and the current issues surrounding the role of problem specifications in studio submissions for student evaluation draws attention to a few underlying themes surrounding the generation of their workable design solutions. Design competency (the desired goal of design education) is achieved when the student progresses through the design process as proficiently and accurately as possible while satisfying the requirements of the brief. Examining the parameters that determine effective communication of the successes and/or failures depends on how well the student is able to describe the design development through a series of definitive stages. There are 4 (four) main parameters identified from a qualitative examination of the field data on student and mentor perceptions of problem specification on design communication, each discussed below.

Perceptions and Preferences of the Composition of Problem Specifications

For the purpose of identification and analysis in this study, the main features of problem specifications were broken down into the following stages:

I. **Preliminary analysis** comprising of project/problem definition, brief interpretation, case studies, concept formulation, anthropometric analysis, site analysis reports;
II. **Design development** comprising of site and building plan layout development, presentation sketches of floor plans, sections and elevations, landscaping sketches;
III. **Advanced presentation/construction details** comprising of working drawings, building specifications, 3D modelling.

Students learn about design and how to design through a series of structured modules over the course of their design education. Interaction with mentors and assessors in the studio guide students through the systematic (yet somewhat intuitive) process of effectively communicating their navigation from design problem to design solution. Problem specifications act as a language of communication which tell assessors, in detail, how the designer traversed through the process of the design sequence to arrive at an eventual solution. Despite the significance of this dialogue, particularly between assessors/mentors and students in design education, the findings from the study reveal slightly differing perceptions by students and mentors about the significance of problem specifications in this exercise as shown in Table 1.

Table 1. Student and mentor/staff opinions on requisite submissions of problem specifications

	Mandatory requirement (%)	Optional requirement (%)	Not sure /Undecided (%)
I. Preliminary/Analysis			
1. Students			
a. 1st year	43	57	-
b. 2nd year	71	28	1
c. 3rd year	74	19	7
d. 4th year	70	23	7
e. Postgraduate students	79	20	1
• ***Student Average***	*67.4*	*29.4*	*3.2*
2. Mentors (staff)	93	7	-
II. Design Development			
1. Students			
a. 1st year	60	25	15
b. 2nd year	62	28	10
c. 3rd year	82	12	6
d. 4th year	92	3	5
e. Postgraduate students	91	9	-
• ***Student Average***	*77.4*	*15.4*	*7.2*
2. Mentors (staff)	93	7	-
III. Advanced presentation /construction details			
1. Students			
a. 1st year	75	25	-
b. 2nd year	60	32	8
c. 3rd year	53	44	3
d. 4th year	62	35	3
e. Postgraduate students	61	38	1
• ***Student Average***	*62.2*	*34.8*	*3*
2. Mentors (staff)	73	26	1

The distinct stages of preliminary analysis, design development and construction detailing play very different roles in the design process. 67.4% of the students sampled felt that preliminary analysis as the 'problem framing tool' should be considered mandatory requirements in problem specifications. Closer scrutiny reveals that students at more advanced levels understood this stage to be an integral part of design communication which accounts for the higher acceptance rate for 2nd, 3rd, 4th and postgraduate level students. Nearly all mentors (93%), regardless of years of experience or rank perceived that preliminary analysis information should be a compulsory requirement in problem specifications. A similar observation was made about the support for design development components by the students and the mentors. However the 1st year students (who were yet to commence formal design courses) understandably showed greater support for submissions such as construction detailing components. This was largely due to the fact that their project assignments comprised mostly introductory schemes such as use of architectural graphics, model making, freehand drawing and other foundational courses, not design development.

Additional findings from the study reveal the preferred composition of the problem specifications from stages I-III as illustrated in Figure 2. Most students preferred to prepare problem specifications incorporating select items from the stages which may be deemed relevant to the given brief or scope of the design; effectively distinguishing between those required for major assignments and those considered to be ‘quick schemes’, mock ups or thumbnail sketches. When asked why they felt only selected items were necessary components as problem specifications, they offered open-ended responses such as “they are time consuming and [cause them] to fall behind deadlines” and “my [resultant] design is self-explanatory without them”. This posture reflects the general attitude of students to the inclusion of all submission requirements as problem specifications, either in part or as a whole. By contrast, tutors/mentors and assessors rely on the presentation of a complete set of problem specifications in order to make informed appraisals of the student’s progress through the design process: the absence of these, oftentimes crucial, elements results in ambiguity and subjective assessment.

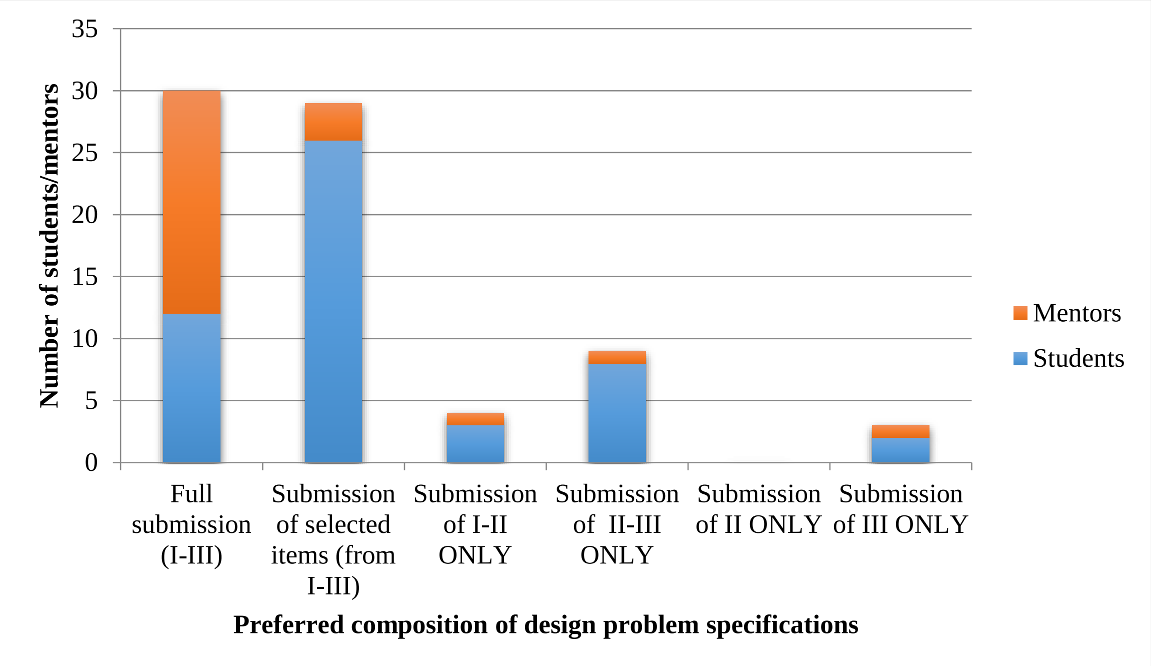


Figure 2. Student and mentor preference for the preferred composition of design problem specifications from stages I-III

The findings seem to corroborate existing studies on student cognitive and creative skills which suggest that students who understand and utilise problem framing tools as part of their problem specifications proffer workable solutions showing improved performance at acceptable levels of competence in the architectural design studio.

Student Performance and Mentor Assessment

The studio experience for students resembles an apprentice workshop where dialogue between mentors, students and their peers engage in closely-monitored exchange of ideas, development of communicative abilities and problem solving skills. Juror appraisal and assessment of designs in the studio is the pinnacle of the learning process to both assess and educate students on design knowledge, skills and abilities which mimics client satisfaction in the real world. The assessment process enforces academic standards in design education and the findings from the study show that the preference by mentors for the full submission and student preference for partial submission of problem specifications accounts for the disparity between student expectations and the eventual outcome of the assessment of student project assignments. The study findings show that only 14% of students routinely endeavour to meet all the submission requirements of problem specifications for project assignments; 49% fail to meet those same requirements on a regular basis as shown in Figure 3.

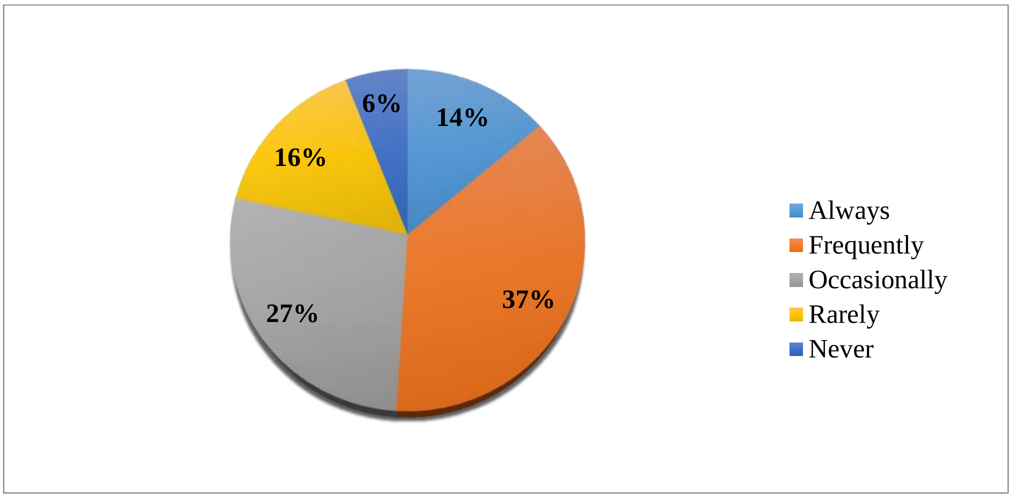
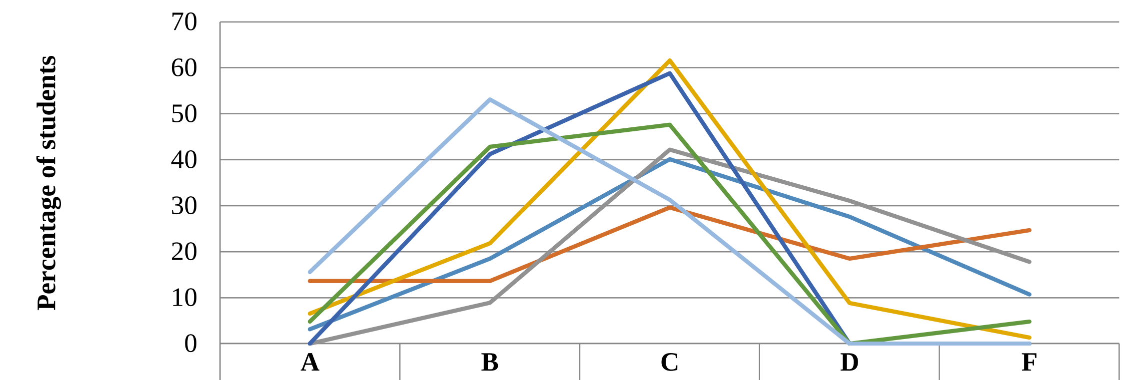


Figure 3. Average rate of student abilities to achieve full submission of problem specifications (for undergraduate and postgraduate students)

The high rate of student apathy to the preparation and inclusion of all the necessary problem specifications in their submissions poses a challenge to assessors who are usually guided in their evaluation by a weighted criteria scoring system which places a lot of emphasis on the crucial aspect of problem framing in order to make an informed assessment. An investigation of student submissions over the period of review shows that the aspect of problem framing is routinely overlooked in their portfolios and, where they did exist, they were poorly represented and ambiguous. This condition resulted in the seemingly bottom-heavy assessment of the student project assignments during the terminal jury/crit exercises for each set as shown in Figure 4.



	A	B	C	D	F
1st Year	3,1	18,5	40,1	27,6	10,7
2nd Year	13,6	13,6	29,6	18,5	24,7
3rd Year	0	8,9	42,2	31,1	17,8
4th Year	6,5	21,8	61,6	8,8	1,3
PGD	0	41,2	58,8	0	0
MSc. I	4,8	42,8	47,6	0	4,8
MSc. II	15,6	53,1	31,3	0	0

Figure 4. Student performance in the terminal jury/crit exercise, Department of Architecture, University of Jos, 2018-2019 academic session

Closer inspection of the evaluation shows that the assessment of student portfolios improved significantly in the terminal postgraduate program (the M.Sc. II class). This was deduced to have been as a result of the fact that the exercise involves the participation of external examiners whose assessment is based strictly on the demonstration of coherent analytical and problem solving design skills and the students deliberately go out of their way to make a good impression in order to graduate. Likewise it was gathered that the conspicuously high rate of failure at the 2nd year of undergraduate study (24.7%) can be attributed to the fact that having just made the transition to formal design studio programs for the first time, most students at this stage were yet to fully comprehend the relevance and context of detailed problem specifications in the submission of their project assignments. Thus it was observed that the most frequent score obtained by 1st to 4th year, PGD and M.Sc. I students from the design studio program is the "C" grade average which is the most probable grade earned where a student presents incomplete or inadequate problem specifications based on the scoring criteria.

Therefore, correlating the composition and subsequent assessment of problem specifications, the issue of ***what*** students are expected to present for assessment against ***why***, became a topic of discourse. There was a general increase in concern by the student respondents about the extensive list of requirements that serve as problem specifications which leads them to believe that assessors were more interested in the "…number of meaningless sheets" that assessors "…flip through without [scrutinising] properly". This development raises questions about the quantity of the problem specifications to be presented, as opposed to the quality, and if indeed better grades are awarded to volume over content.

Obstacles and Aids to the Development of Problem Specifications

Opinions between students and mentors differ significantly on the vital role of problem specifications in design studio programs and why most students fail to produce them despite their obvious influence on improved performance as shown on Table 2. From the sample, nearly two-thirds of the students attributed apathy towards fully prepared problem specifications to a persistent shortage of time to work on each assignment. A similar proportion (60.8%) attributed it to conflicting feedback during the process of one-on-one or desk jury consultation from a team of mentors with diverse ideologies. In some instances, reports of conflicting feedback from fellow students or peers led to the perception that certain problem specifications were not necessary in project assignments which raises additional inquiry about the effectiveness of peer-to-peer consultation in design studio programs. On the other hand, mentors opine that students are less likely to produce benchmark problem specifications due to inadequate mentoring (58.3%), poor knowledge of the requirements of the brief (54.2%) and intentional omission by the students (54.2%).

Table 2. Student and mentor opinions on reasons for student inability develop necessary problem specifications for assessment

s/no.	Reasons	Students (%)	Staff (%)
1.	Insufficient time allocated to project duration	66.7	45.8
2.	Lack of or insufficient work materials (e.g. drawing pens, modeling materials, laptop, etc.)	33.3	33.3
3.	Poor background knowledge on the contents of the design brief	29.4	54.2
4.	No idea on how to represent certain features in the submission requirements	25.5	33.3
5.	Deliberate effort not to submit outstanding requirements	-	54.2
6.	Inadequate mentoring/coaching through the design process	33.3	58.3
7.	Unwillingness to focus on “less important” aspects of the submission requirements	9.8	37.5
8.	Lack of understanding of the design brief	23.5	37.5
9.	Improper translation of foundational information from other courses/subjects into practical design	23.5	50.0
10.	Conflicting feedback from mentors during the design process consultation	60.8	37.5

The survey revealed that mentors (staff) opined that improvements to student attitudes to the development of adequate problem specifications can be made through increased monitoring during the design process (83%) and better time management by students (75%). On the other hand, in order to see an improved attitude towards the development of adequate problem specifications in their work, the highest recommendation from students was for an increase in time allocated to each project (78.4%) followed closely by an increased use of digital drafting tools (70.6%) as shown on Table 3.

Table 3. Student and mentor opinions on remediation strategies to assist students develop necessary problem specifications for assessment

s/no.	Possible modifications	Students (%)	Staff (%)
1.	More time allocated to individual projects in the overall design studio program	78.4	37.5
2.	Fewer major projects in the semester which require full submission requirements	58.8	45.8
3.	Less ambiguous/abstract project briefs/assessment	31.4	37.5
4.	Addition of live (real) projects to the design program	31.4	54.2
5.	Effective monitoring by design studio mentors over the project duration	51.0	83.0
6.	Better time management by students	58.8	75.0
7.	Increased use of computer drafting tools (CADD tools)	70.6	20.8
8.	Introduction of more group submissions	27.5	20.8
9.	Fewer submission requirements	33.3	4.2
10.	More conducive learning and designing environments	58.8	70.8

The use of digital drafting tools remains a huge sticking point in design education based on the findings of the study. Further investigation revealed that most students favoured the collaboration of digital drafting tools in the form of still renderings, photomontages, panoramic renderings, animations and in some cases, virtual tours with manual drafting techniques at all levels of study. Conversely, mentors were divided over the use of digital methods of drafting at undergraduate levels but more accommodating at postgraduate levels where students had attained levels of design competence comparable to real world practice (Figure 5).

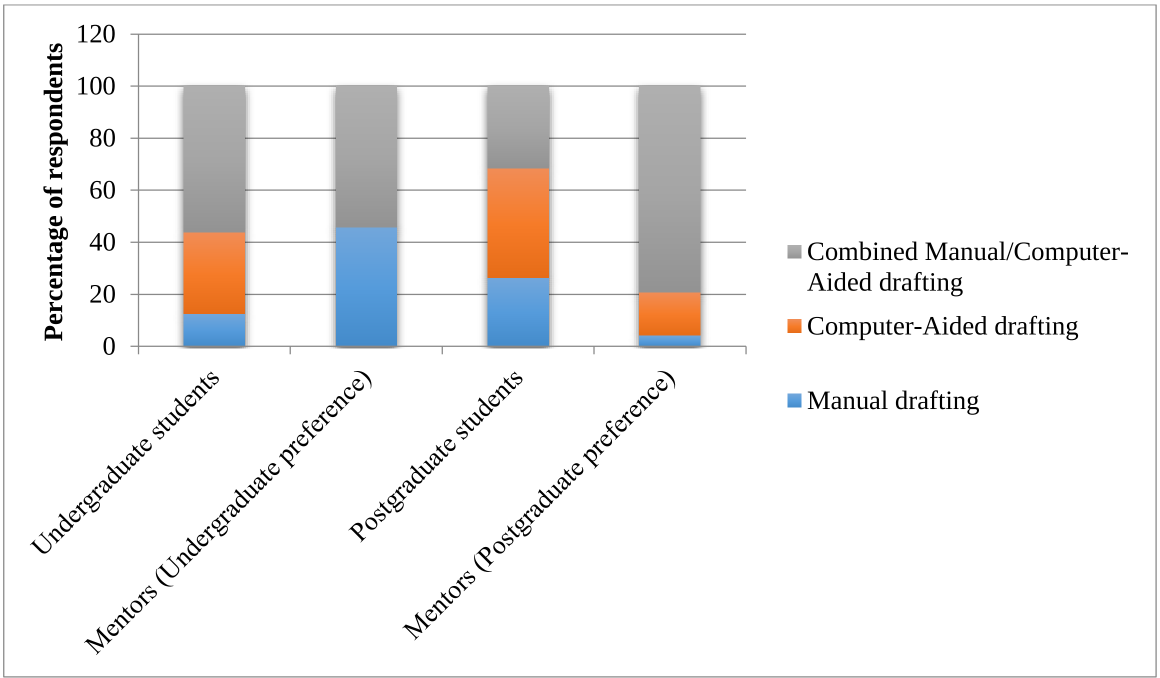


Figure 5. Student and mentor preference for use of digital drafting tools in the development of problem specifications

After a review of the perceptions of students and mentors on the use of digital drafting tools for the development of problem specifications, it was found that there are obvious benefits to blending digital and manual techniques in design studio education as it encourages learner autonomy, promotes virtual consultation and active engagement, eases the process of effecting corrections and editing saving time and cost, and eases mobility. The hesitancy reflected by some of the mentors to the format of digitalised submissions can be overcome when it becomes apparent that the use of shared data does not necessarily mean a standard "cut and paste" approach to cookie-cutter designs as each student develops their own scheme individually. With the increase in virtual/distance learning strategies following the outbreak of the novel coronavirus (COVID-19) in 2020, the study findings justify the need for mentors to upgrade their level of digital literacy in order to spend more time overseeing student design processes which may be presented online.

The Influence of Age and Gender

The study presented data from a heterogeneous sample consisting of students and mentors as shown in Figure 6. However the study does not observe any significant effect of gender on the perception and preference of problem specification composition in either the student or mentor sample. Likewise the study findings are gender-neutral on the issue of mentor assessment and student performance.

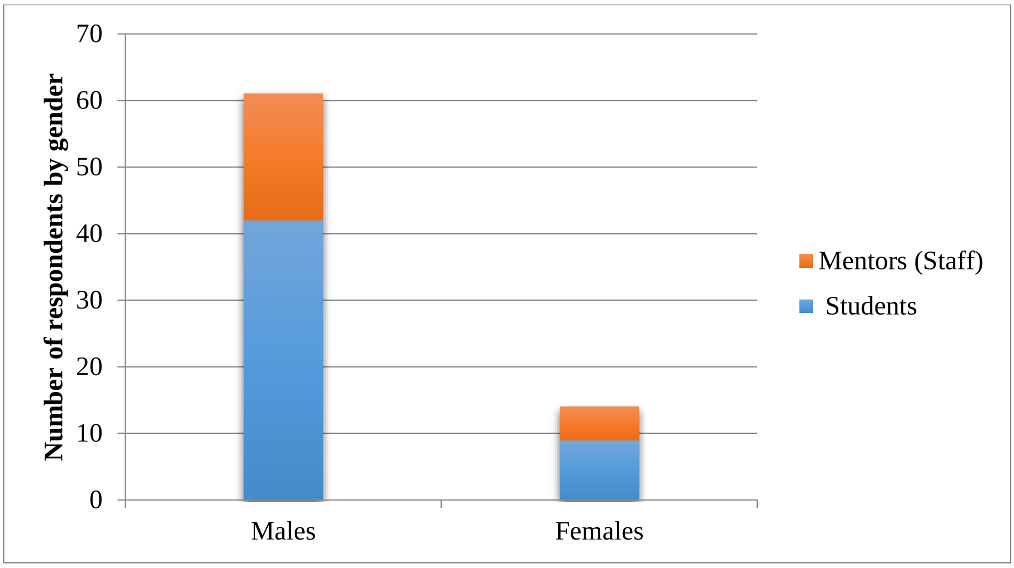


Figure 6. Gender distribution of student and mentor respondents in the Department of Architecture, University of Jos

However there were noticeable differences in the responses along gender lines on the use of digital tools from both students and mentors. Nearly a quarter of the undergraduate female students sampled preferred the use of manual drafting techniques for developing problem specifications, however almost 80% of the male undergraduate students favoured a combination of manual and digital drafting techniques at undergraduate level. Further still, the findings show that 47.3% of the male mentors supported the use of manual drafting techniques for the production of problem specifications; 77.8% of who were aged 51-60 years old. 31.5% of the male mentors favoured a combination of manual and drafting tools at all levels of study, undergraduate and postgraduate. Interestingly, all of the mentors in this group were aged 31-40 years old. 60% of the female respondents who held the same opinion were in the same age range which indicates a preference by younger mentors for the increased incorporation of digital tools in design dialectical interactivity.

Conclusion

Design education is facing perhaps its biggest challenges in recent times. Architecture stands at a crossroad where traditional models of training originating from the Ecole des Beaux-Arts in France meets modern design techniques; fusing old school principle with present day needs and expectations. The ever-increasing transfer of hard skills in design to computerised processes means soft skills such as cognitive thinking and non-verbal communication remain essential to the survival of the architectural profession. Architectural education must therefore direct its attention to the refinement of problem specifications which effectively communicate the designer's knowledge, ability and skill on the interpretation of the design problem into a tangible, physical form to mentors, assessors and eventual clients.

This study looked at the current perceptions of students and their mentors on the role of problem specifications in non-verbal communication of design ideas for the development of cognitive thinking skills needed to improve design competence. Using empirical and theoretical analysis, the study finds that problem specifications have become an area of design communication overlooked and downplayed by a significant number of students at all levels which affects the way their project assignments are supervised and assessed. This worrisome trend has a considerable impact on the quality of graduates coming out of higher educational institutions who many employers feel are detached from real world problem-solving situations. The study therefore proposes intensive mentoring and instruction of design students during formative years of training on the principle of problem specifications in key aspects of analysis (problem framing) and synthesis (design development) which builds design proficiency. The study supports the expanded use of digital tools for production of problem specifications which makes mentoring and assessment easier in rapidly emerging virtual studios. Consequently the study recommends that mentors and tutors improve their knowledge of digital tools of design to be able to effectively monitor students against design infringements. The study also recommends the expanded and continuous study of design teaching methods on problem specifications in different localities and institutions in order to monitor emerging trends so as to institute effective remediation strategies where standards appear to be falling.

References

Adedapo, A. O., Ezema, I. & Okpoko, A. (2013). Development of design expertise by architecture students. *Journal of Learning Design*, *10*(2), 35-56.

Aderonmu, A. P. (2013). *The design studio in selected schools of architecture in south-west Nigeria: A study of pedagogy, culture and environment*. (Unpublished doctoral thesis), Covenant University, Ota, Ogun State, Nigeria.

Akande, O. K., Olagunju, R. E. & Ayuba, P. (2006). Academic excellence in architectural education and opportunities and challenges for the architect graduate. *AARCHES-J*, *5*(1), 40-47.

Ambrose, S. A.; Bridges, M. W.; DiPietro, M.; Lovett, M. C. & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. San Francisco, CA: Jossey-Bass.

Archer, B. (1965). *Systematic methods for designers*. London: The Design Council.

Cross, N. (2004). Expertise in design: An overview. *Design Studies*, *25*(5), 427-441.

Cross, N. (2011). *Design thinking*. London: Bloomsbury Academic.

Crowther, P. (2013). Understanding the signature pedagogy of the design studio and the opportunities for its technological enhancement. *Journal of Learning Design*, *6*(3), 18-28.

Curry, T. M. (2017). *Form follows feeling: The acquisition of design expertise and the function of aesthesis in the design process*. (Unpublished doctoral thesis), Delft University of Technology, Delft, Netherlands.

Deutsch, R. (2020). *Think like an architect: How to develop critical, creative and collaborative problem-solving skill*. London: RIBA Publishing.

Dewey, J. (1910). *How we think*. Boston, U.S.A: D. C. Heath and Company.

Dorst, K. (1997). *Describing design: A comparison of the paradigms*. (Unpublished doctoral thesis), Delft University of Technology, Delft, Netherlands.

Emma-Ochu, C. A. (2009). Adapting architecture schools' curriculum in Nigeria towards global competitiveness. *AARCHES-J*, *8*(1), 2-7.

Enwerekowe, E.O. (2011). Mastering the design jury: A guide for architecture students. *Journal of Environmental Research and Policies*, *6*(3), 132-136.

Eshun, E. F. (2016). Graphic design students' perspectives and attitudes towards feedback within peer assessment in design studio pedagogy. *International Journal for Innovation, Education and Research*, *4*(6), 22-33.

Fincham, J. E. (2008). Response rates and responsiveness for surveys, standards and the journal. *American Journal of Pharmaceutical Education*, *72*(2), 1-3.

Franck, K. A. & Lepori, R. B. (2007). *Architecture from the inside out*. West Sussex, England: Wiley-Academy.

Gray, C. M. (2013). Factors that shape design thinking. *Design & Technology Education*, *18*(3), 8-20.

Hargrove, R. (2011). Fostering creativity in the design studio: A framework towards effective pedagogical practices. *Art, Design & Communication in Higher Education*, *10*(1), 7-31.

International Union of Architects (UIA). (2000). *UIA Accord on recommended international standards of professionalism in architectural practice*. Paris, France: Author.

Ioannou, O. (2018). Opening up design studio education using blended and networked formats. *International Journal of Educational Technology in Higher Education*, *15*(47), 1-16. https://doi.org/10.1186/s41239-018-0129-7

Joyner, S. (2019, October 21). Balancing studio with other classes. Archinect [Web log post]. Retrieved from https://archinect.com/features/article/150165476/balancing-studio-with-other-classes

Lawson, B. (2008). *How designers think: The design process demystified* (4th ed.). Oxford: Architectural Press.

Maina, J. J. & Salihu, M. M. (2016). An assessment of generic skills and competencies of architecture graduates in Nigeria. *ATBU Journal of Environmental Technology*, *9*(1), 30-41.

McClean, D. (2009). *Embedding learner independence in architectural education: Reconsidering design studio pedagogy*. (Doctoral thesis), Robert Gordon University, Aberdeen, Scotland. Retrieved from http://openair.rgu.ac.uk

Ola-Adisa, E. O., Enwerekowe, E. O. & Audu, U. A. (2016). An appraisal of jury system as an assessment instrument for students' portfolio examination in the Department of Architecture, University of Jos. *Journal of Environmental Sciences and Resources Management*, *8*(1), 19-31.

Olotuah, A. O. (2000). Architect-educators and the curriculum in architecture: roles and expectations in the 21st century. *AARCHES-J*, *1*(5), 29-32.

Onwuegbuzie, A. J. & Collins, K. M. T. (2007). A typology of mixed method sampling designs in Social Science research. *The Qualitative Report*, *12*(2), 281-316.

Oxman, R. (2001). The mind in design: A conceptual framework for cognition in design education. In C. Eastman, W. Newstetter, & M. McCracken (Eds.), *Cognition in design education: Design knowing and learning* (pp. 269-295). London: Elsevier.

Özkaya, I. & Akin, Ö. (2006). Requirement-driven design: Assistance for information traceability in design computing. *Design Studies*, *27*(3), 381-398. https://doi.org/10.1016/j.destud.2005.11.005

Ravenscroft, T. (2019, July 9). Architecture education is in crisis and detached from the profession, says Schumacher. *Dezeen*. Retrieved from https://www.dezeen.com/2019/07/09/patrik-schumacher-crisis-architectural-education/

Roberts, A. (2006). Cognitive styles and student progression in architectural design education. *Design Studies*, *27*(2), 167-181. https://doi.org/10.1016/j.destud.2005.07.001

Schon, D. A. (1985). *The design studio: An exploration of its traditions and potentials*. London: RIBA.

Terzidis, K. (2007). The etymology of design: Pre-Socratic perspective. *Design Issues*, *23*(4), 69-78. https://doi.org/10.1162/desi.2007.23.4.69

Tezel, E. & Casakin, H. (2010). Learning styles and students' performance in design problem solving. *International Journal of Architectural Research*, *4*(2/3), 262-277.

Uji, Z. A. (2009). *Tools and instruments of research in design and allied disciplines*. Jos, Nigeria: Ichejum Publishing House.

Uluöglu, B. (2000). Design knowledge communicated in studio critique. *Design Studies*, *21*(1), 33-58.

Wu, Y., Huang, C. & Weng, K. (2014). A study of an architecture design learning process based on social learning, course teaching, interaction and analogical thinking. *Mathematical Problems in Engineering*, *1*(2014), 1-8. http://doi.org/10.1155/2014/465294