The University of Manchester

School of Mechanical, Aerospace and Civil Engineering

The University of Manchester
PO Box 88, Sackville Street
Manchester, M60 1QD

THE CURRENT POSITION OF DESIGN WITHIN THE BUILT ENVIRONMENT

C.G Bailey
T. Alonso
M. A. Orzechowski
K.A.L Johnson
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PO Box 88
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E-mail: Colin.Bailey@manchester.ac.uk

Summary

Design is a major factor in economic success and in improving the quality of life for society. To summarise the current position of design within the Built Environment this paper presents the results obtained from a suite of questionnaires. The questionnaires were sent to clients, practitioners, graduates, academics and students as the main stakeholders, within the industry, in the supply of design services and projects. A total of 828 people completed the questionnaires representing a large number of organisations and universities within the UK. The general conclusion is that higher education currently prepares graduates adequately for detailed design activities but does not provide them with the required skills to understand and undertake the holistic design process. The response to the questionnaires also highlighted, from the clients' point of view, that there is room for improvement in the quality of designs and in the methods of assessing both the design service and completed projects. In their response, both clients and practitioners identified shortages of resources in design and design related professionals.

1.0 Introduction

According to ^{n}CRISP[(1)], the UK built environment, which includes professional services, materials and products, produces a gross annual output of £100bn., equivalent to 10% of GDP. CITB[(2)] defines the gross annual output as 8% of GDP, with a workforce of over 2.1 million. The UK Government Department for Trade and Industry (DTI) rates the UK construction industry as one of the strongest in the world and ranks its output in the global top ten. However, as outlined in the Egan Report, which led to Rethinking Construction[(3)] (renamed as Constructing Excellence in 2004), there is deep concern that the industry is under-achieving, with low profitability and low investment in research, development and training.

A diagrammatic representation of the education base and supply of services to generate the final construction project is shown in Figure 1. In simplistic terms, the project is delivered by the client who requires financial investment together with design and construction services from practitioners. To deliver this service the practitioner requires competent graduates who have come through the education system. Academics provide an educational service to the students, prior to graduation, as well as a service to research activities. The research activities are required to develop new design methods/processes and more efficient and innovative projects. Secondary education provides the foundation upon which higher education can build. The final projects (particularly those that are iconic and innovative) provide the enthusiasm and encouragement to the students who enter higher education Built Environment programmes. As shown in Figure 1, there are a number of interfaces in the supply chain. These interfaces can be defined as between:

- Secondary and higher education.
- Higher education and industrial practitioner.
- Practitioner and client.

To deliver the most effective solution to a project, all the components shown in Figure 1 must be effective. If one component is underperforming the continuum underperforms. When analysing the effectiveness of the construction industry most previous studies have concentrated, in isolation, on a single part of the continuum shown in Figure 1. These studies(4,5) have mainly focused on the higher education/industrial practitioner interface. However, one must ask the question whether this is sufficient to deliver the projects which are acceptable to society. What is the point of fixing the higher education/practitioner interface if the practitioner/client and higher/secondary education interface are not working?

In the case of the higher/secondary education interface recent headline news(6) has highlighted to the general public the reduction in basic standards and lack of independent thought of students entering higher education. To most academics this is no surprise and indeed the UK-SPEC(7) defining the requirements needed for registration to Engineering Council^{UK} has moved away from entry standards into higher education and now focuses on minimum output standards. However, this has not solved the underlying problems. The solution outlined in the UK-SPEC has simply moved the problems at the higher/secondary education interface and placed them at the higher education/practitioner interface (Figure 1).

To totally understand the efficiency of the design service provided by the construction industry, and the educational base from which future practitioners will emerge, a suite of questionnaires were developed by the authors to attempt to tease out the views of the major stakeholders comprising clients, practitioners, graduates, academics and students. The position of these stakeholders within the supply chain is shown by the hatched boxes in Figure 1.

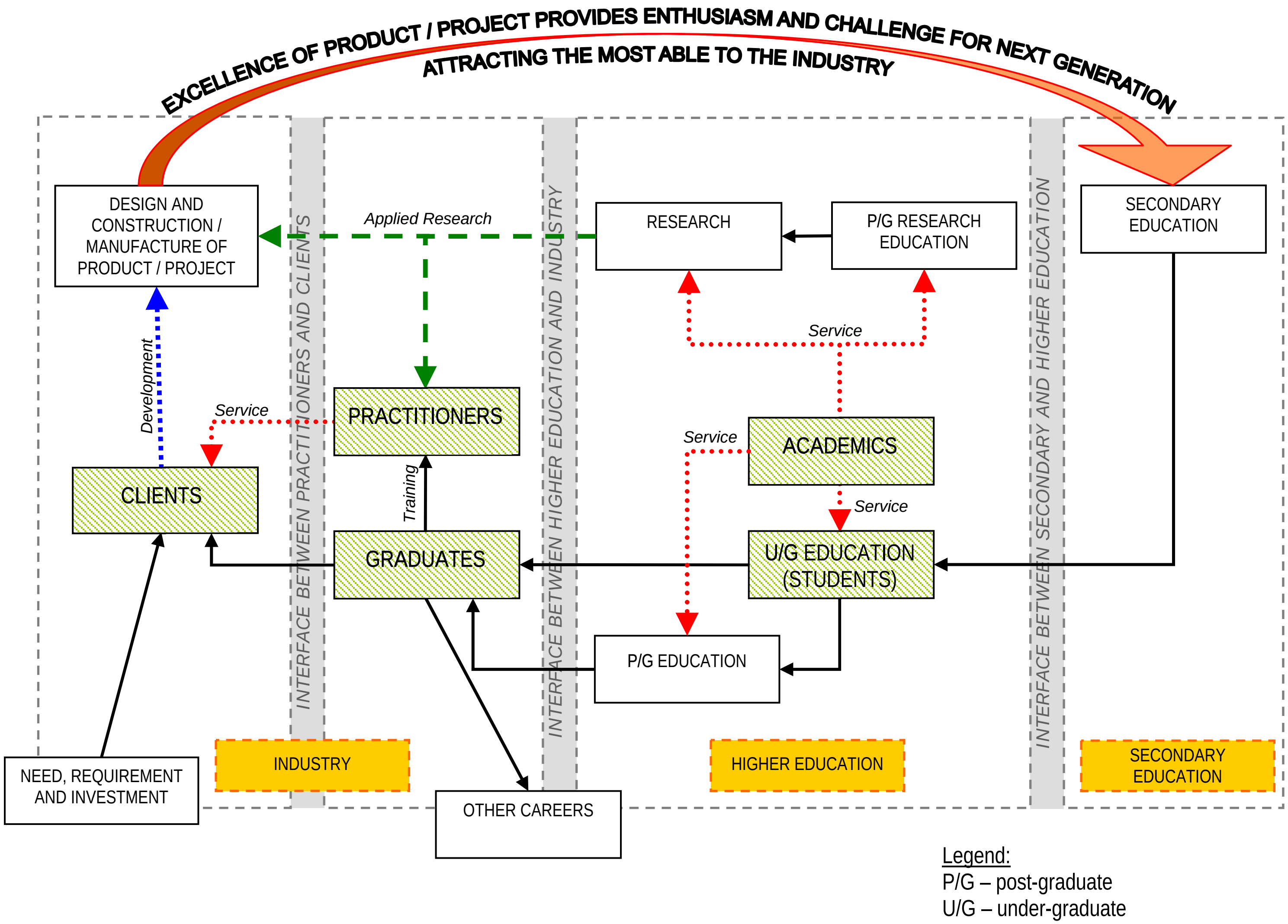

Figure 1: *Education base and supply of services to deliver the final construction project.*

Design can be defined in many ways, for example:

- A conscious activity guided by aims and objectives; requiring creativity, expertise, knowledge and thoroughness, with close links with society needs, aesthetics and technology.
- The art and science involved in conceiving and making.

Due to the number of different definitions of design, it was decided to provide the following definitions within the questionnaires:

- **'Design [structure, product, process or system]** – a final solution to a need/requirement/problem; denotes a blue print'.

- **'Design Development Process** - a system of interactive loops, many iterations may be necessary: interpret/ conceive/transform/converge'.

The detailed aims of the questionnaires, considering the views of all stakeholders, were to assess:

- The adequacy of undergraduate education programmes.
- The quality of graduates.
- Good design practice.
- Level of design skills.
- Requirements for continuing professional development.
- The typical design process adopted.

The questionnaires were divided into a number of sections, with the aim of exploring the respondent's abilities, experience, education, organisation's/department's view of the design process, the ability of graduates, and the effectiveness of the current design process, as well as identifying their requirements for CPD.

The questionnaires were developed electronically and completed 'on-line', through a dedicated web-site address. The distribution of the questionnaires was predominantly through the data-base of members belonging to the Institution of Civil Engineers and the Institution of Structural Engineers, resulting in most respondents being either civil or structural engineers, or both. In addition, the academic and student questionnaires were sent to every Head of Department, related to the Built Environment, of all UK universities, asking them to pass the electronic questionnaires (web address), and covering letter, onto their colleagues and students. The response to the questionnaires was mixed, with the distribution of the total 828 responses shown in Figure 2.

The Built Environment comprises a wide range of types of projects and activities commissioned by clients of many different natures, size and experience. This study focuses on major projects, infrastructure, structures and buildings together with their repair and maintenance, corresponding to the experience base of the respondents.

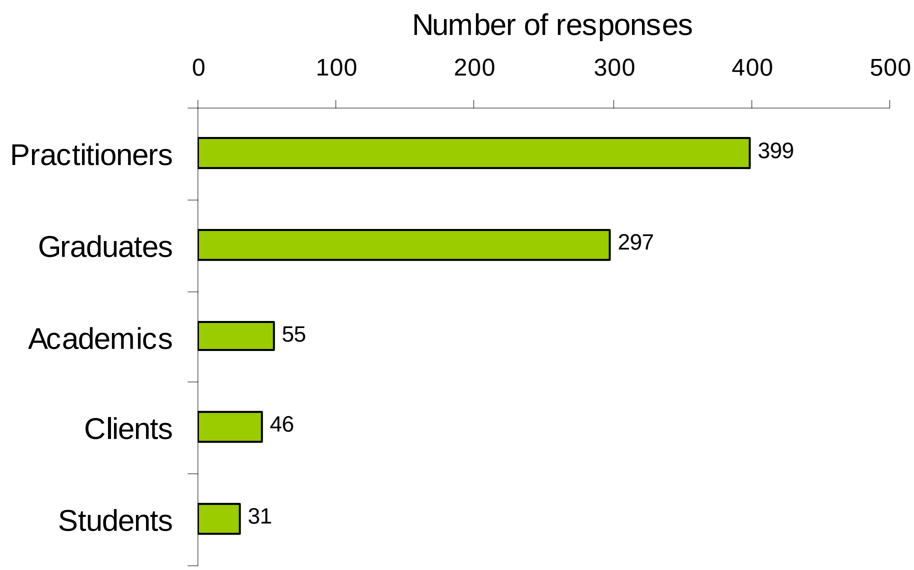

Figure 2: *Number of responses to the questionnaires.*

A number of different organisations were represented by the respondents, with practitioners representing 190 organisations, graduates representing 79 organisations and 66 UK universities, clients representing 37 organisations, academics representing 30 UK universities and students representing 19 UK universities.

Most of the practitioners and graduates were consultants, with the next major discipline represented being contractors. The breakdown of disciplines for both practitioners and graduates is shown in Table 1.

Discipline	**Practitioners**	**Graduates**
Consultants	65.7%	72.4%
Contractors	13.3%	19.2%
Others	20.1%	7.7%
Not answered	0.9%	0.7%

Table 1: *Disciplines represented by practitioners and graduates.*

2.0 Adequacy of undergraduate education programmes

Practitioners were asked to indicate, from a supplied list of examples, or their own defined list, what they would have wished to change in the process of their university education. Only 1.5% of the respondents stated that their education was adequate and they would not change it. Practitioners could provide multiple answers on suggested improvements to their education and, as shown in Figure 3, the most popular answers related to increased exposure to (and knowledge of) the practical side of engineering. For example, lecturers with industrial/practical experience, development of design process skills and use of case studies.

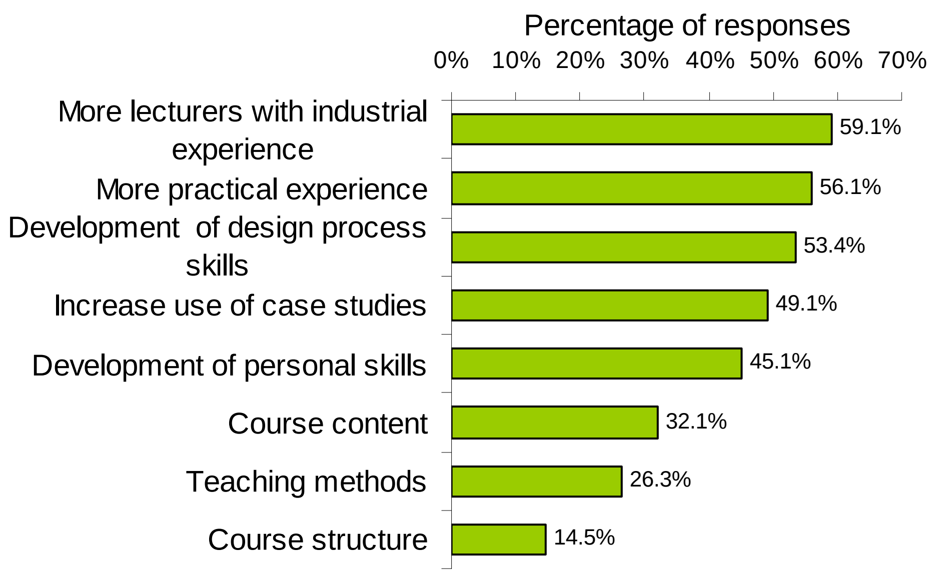

Figure 3: *Practitioners' proposed changes to undergraduate education.*

As well as listing what they would have wished to change in their undergraduate education, practitioners were also presented with the chance to explain how they would change it. In total, 248 participating practitioners provided a written, and typically a very detailed, response. The main thrust of the responses was to relate the course more closely to the '*real world*' by employing lecturers who have practical experience. In addition respondents suggested strengthening links between academia and industry, introducing more problem solving/team-based projects and increasing the emphasis on commercial/management/communication skills. Apart from suggesting that lecturers should have practical experience, a further 5% of the responses specifically mentioned the lack of competency of lecturers suggesting that all lecturers should undergo adequate training and have sufficient teaching qualifications.

Asked if they had received adequate design training (from any source) to prepare them for their profession, 77% of the practitioners felt that they had received adequate training, 21% felt they had not, with 2% not providing a response. Of the practitioners that felt they had received adequate training during their career they were asked what was their source of training from presented choices of 'practical experience', 'CPD', 'postgraduate course', and 'undergraduate course'. Allowing multiple answers, the response is shown in Figure 4, which indicates that most practitioners felt that their training came from a 'rounded' combination of higher education, 'practical experience' and 'CPD'. A total of 16.3% felt that their required training came from only practical experience and CPD, whilst 9.4% felt that it was only obtained from practical experience.

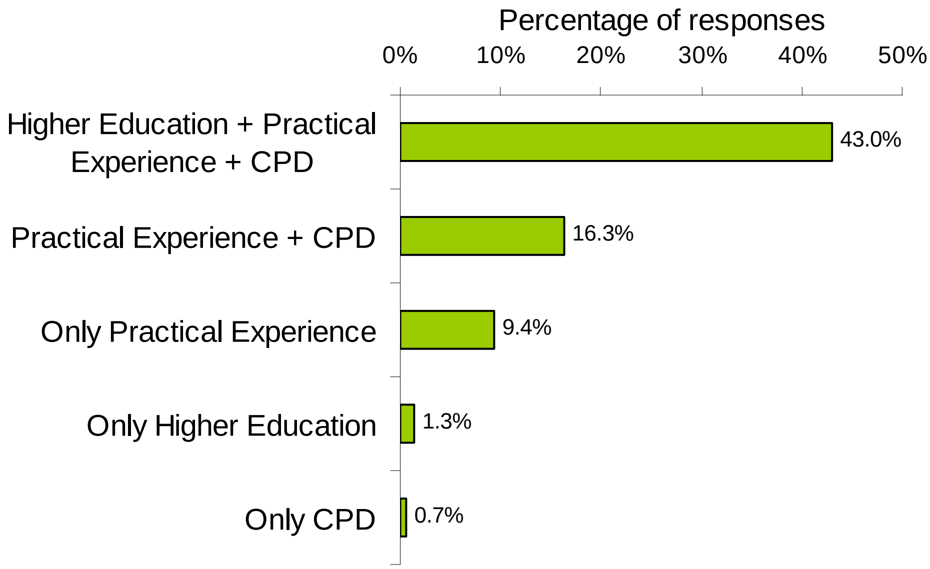

Figure 4: *Sources of training to prepare practitioners for their profession.*

Since it was felt that the experience of graduates could vary, alternative questions to those posed to practitioners were presented. In the first instance graduates were asked to list the four main subjects that they had particular difficulty with and to explain why. The most mentioned subjects were Structures/Structural Mechanics, Mathematics, Geotechnics and Design. The main reasons, given by graduates, as to why they had particular difficulties with these subjects during their university studies are shown in Figure 5. Similar to the answers given by practitioners, on how they would change their education, graduates had difficulty with their education due to the fact that the subject was not related to the '*real world*' and '*poor teaching*'.

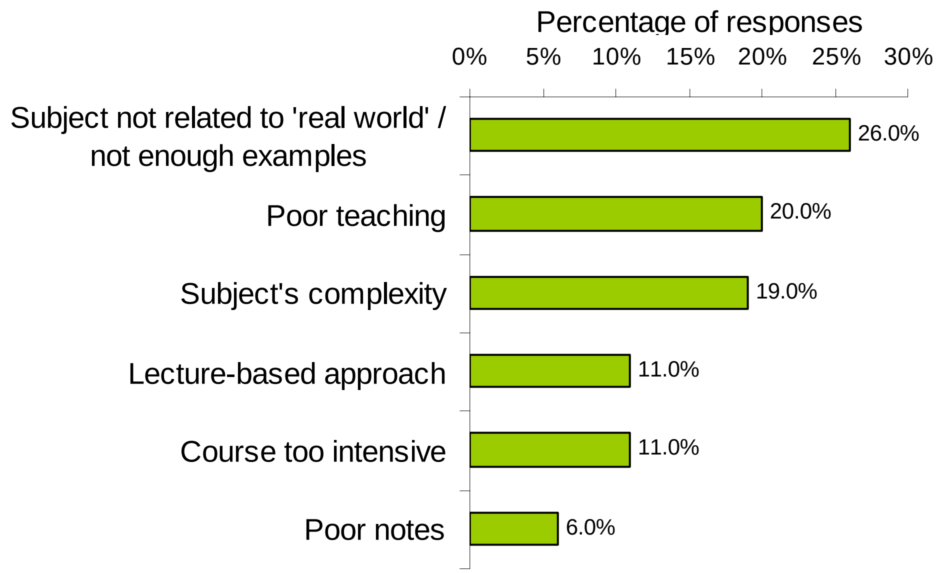

Figure 5: *Graduates' reasons of why they had difficulty on their undergraduate course.*

Most of the Graduates were between 21-25 years of age, with most of the practitioners between 46-60 years of age. Comparison of Figures 3 and 5 show that the main problems of university education of not relating the subject to the *real world*, the need for more lecturers with practical experience and poor teaching has been an on-going problem and is not just a recent problem as commonly mooted.

Academics were asked whether they felt that there was a gap or weakness in the educational programme. The analysis showed that 10.9% did not think there are problems related to the programme and 18.2% did not answer the question at all. However, the majority (70.9%) felt that there were gaps/weaknesses in the programme, which corresponds to the replies from practitioners and graduates. Figure 6 shows the reasons cited. In addition a number of academics mentioned that '*industry does not take an active role but complains about the quality of students*', '*the problems of employing academic staff with design experience (due to the need to be more research focused)*', '*the ability of departments in sustaining design teaching*', '*lack of resources*', and the '*time required to teach design properly when the university has other more important priorities that need to be addressed (i.e. research)*'.

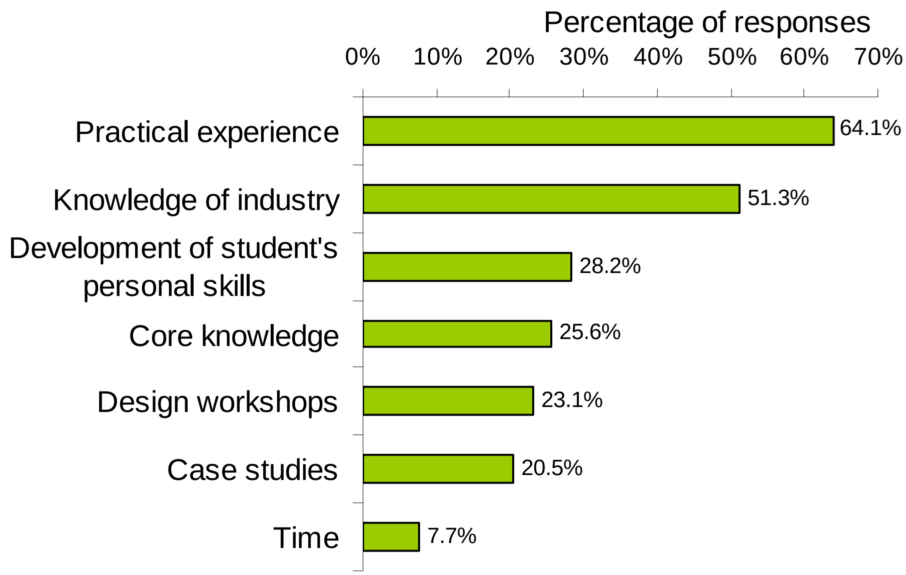

Figure 6: *Academics' views on current gaps in undergraduate education.*

Clients were asked what changes they considered necessary in the design education. Their replies are summarised in Figure 7. It can be seen that top of the list is the development of personal skills, which was also mentioned by 28% of the academics and 45% of the practitioners.

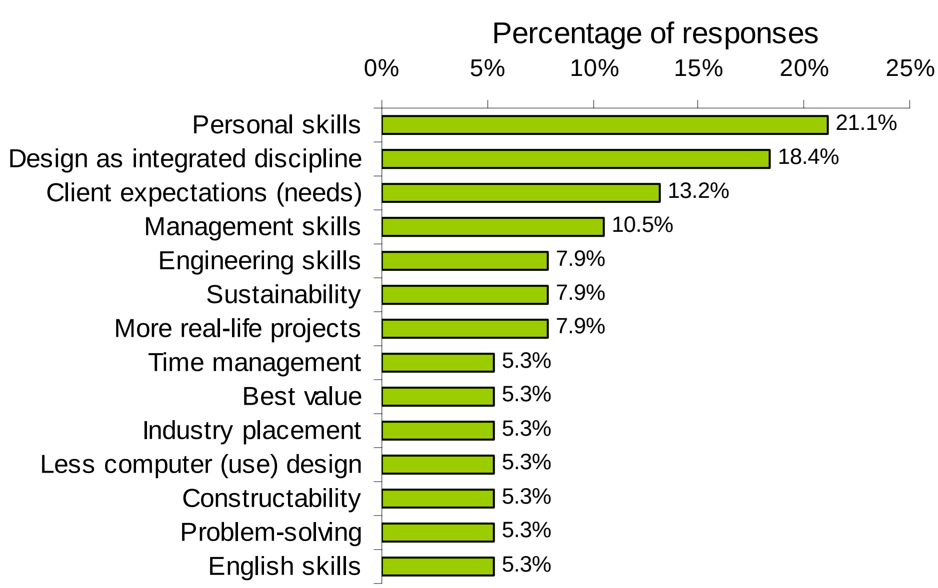

Figure 7: *Clients' proposed changes to undergraduate education.*

Less than half of the graduates questioned (43.4%) indicated that they had gained design process experience during an industrial placement. During this placement, their main duties included office based project design, shadowing other engineers and office based project administration. On site duties were less common with construction activities being specified by 38% of graduates and project management by 24%. Computer and CAD duties were undertaken by just 1.6%.

Just over a quarter of the graduates that undertook industrial placement indicated that they had experienced some problems with this particular part of their education. '*Lack of knowledge and experience*' was the main reason given by the graduates followed by '*problems with adaptation*', '*lack of confidence*', '*understanding procedures*', '*interpersonal skills*', '*lack of opportunities*', '*problems with reading and understanding drawings*', and '*asking for help*'.

A total of 41.6% of practitioners stated that they were taught the design process through a mixed approach, consisting of a lecture and problem-solving approach. This figure increased to 58.6% for graduates and 67.7% for students. A purely problem-solving approach was experienced by 7.3% of practitioners, 9.1% of graduates and 6.4% of students. The results show that there is an increase in adopting a mixed approach to design teaching, moving away from a purely lecture approach. The purely problem-solving approach does not seem to be increasing significantly.

Both graduates and practitioners were asked to list four main courses, from their university education, which are of particular benefit to their current working practice. Graduates listed detailed design-related courses (41.1%), including Reinforced Concrete and Technology, Steel Design, Foundation Design, Bridge Design, Integrated Design, and Pavement Design. This was followed by, Structural Engineering (35.4%), Geotechnical Engineering (26.9%), Mathematics (15.8%), Construction and Management (15.5%), Surveying (14.8%), Soil Mechanics (13.5%), Highway Engineering (13.2%), Hydraulic Engineering (12.5%), general computer skills and CAD (11.4%).

The main courses listed by practitioners were Structural Analysis (51.8%), followed by Soil Mechanics (19%), Geotechnics (15.3%) and Mathematics (14.8%). The remaining subjects mentioned comprised Design Projects (11%) and Materials Science (10.3%)

3.0 Quality of Graduates

Practitioners and clients were asked to rate, as 'extensive', 'good', 'average' or 'poor', graduates' preparation for professional practice. It was felt that academics could not be asked the same question and were instead asked to rate graduates' ability of understanding design and problem-solving skills. This approach of asking slightly different questions assumes that practitioners and clients are looking for an understanding of design and problem-solving skills as preparation for practice when a comparison, as shown in Figure 8, is made.

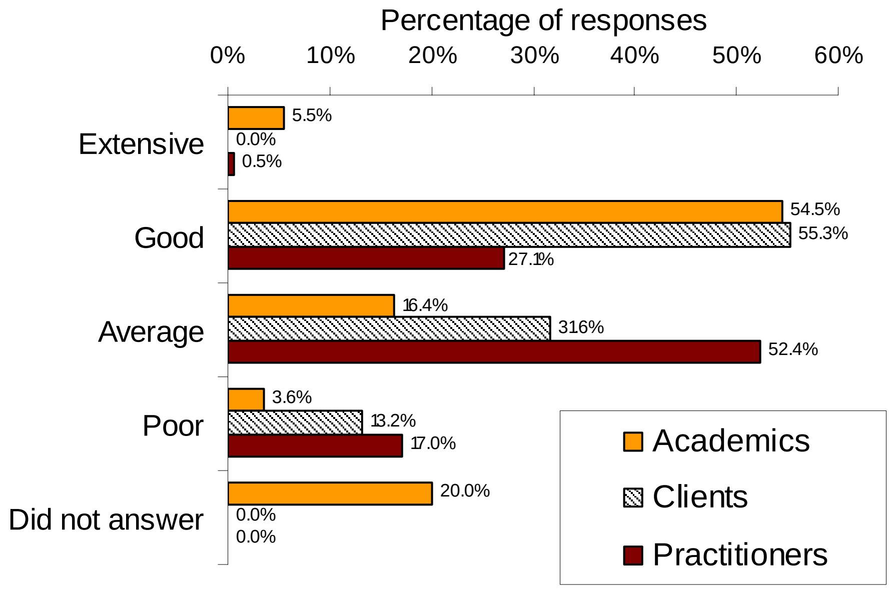

Figure 8: *Quality of graduates as perceived by practitioners, clients and academics.*

The most striking conclusion from Figure 8 is the fact that no clients and only 0.5% of practitioners felt that the graduates' preparation for practice was extensive, which is surprising, and of concern, considering that generally 10% of students obtain a first-class degree. Academics marked graduates' ability of understanding design and problem-solving skills higher with 5.5% stating that graduates' skills were extensive. Overall, it can be seen that most practitioners and clients rate graduates as 'average', whereas academics rate them as 'good'.

Practitioners and clients were asked to list graduates' strong and weak points. For comparison, graduates were asked to list their own strong and weak points. The results are shown in priority order, in Tables 2 and 3. The first striking conclusion from Tables 2 and 3 is that practitioners and clients clearly distinguish between calculations and design skills, with calculations (detail design) being the strongest or second strongest ability of graduates and design skills being the weakest ability of graduates. This does indicate that the education programme is producing graduates with competent detail design skills and theoretical knowledge but with a lack of appreciation of the holistic design process.

Overall, it can be seen that both practitioners and clients list the same top four strongest abilities. Graduates list 'problem solving' and 'communication skills' in their top four strongest abilities, whereas both practitioners and clients list 'communication skills' and the practitioners also list 'problem solving' as the graduates' weakest abilities. It is worth noting that although practitioners and clients list 'design skills' as the main weakest ability, graduates also list it as their 4th weakest ability behind 'innovative', 'self confidence' and 'job confidence'.

Both practitioners and clients rate 'self confidence' as one of the graduates' strongest abilities, whereas graduates rate this as one of their weakest abilities.

Graduates' strongest abilities according to:			
	Practitioners	**Clients**	**Graduates**
1	Open minded	Calculations	Team-working
2	Calculations	Open minded	Problem-solving
3	Self confidence	Self confidence	Communication skills
4	Team worker	Team-worker	Open minded

Table 2: *Comparison of graduates' strongest abilities listed by practitioners, clients and graduates.*

Graduates' weakest abilities according to:			
	Practitioners	**Clients**	**Graduates**
1	Design skills	Design skills	Innovative
2	Communication skills	Communication skills	Self confidence
3	Problem solving	Job confidence	Job confidence
4	Innovative	Innovative	Design skills

Table 3: *Comparison of graduates' weakest abilities listed by practitioners, clients and graduates.*

4.0 Defining Good Practice

Asked to list the five main characteristics that describe a good design professional, practitioners, graduates and academics provided similar results, as shown in Table 4. The only major difference is that practitioners included 'comprehensive technical knowledge' whereas graduates and academics included 'team worker' in the top five facets. Asked to indicate what makes their chosen design team better than other teams, clients specified in order of preference, '*teamwork*', '*producing required quality*', '*understanding*', '*communication*', '*reliability*', '*delivery to time*', '*innovative thinking*', '*providing confidence*', and '*cost effectiveness*'. The first five characteristics are included in Table 4, for comparison.

	Characteristics that define a good design professional according to:			Characteristics that **Clients** indicate make their chosen design team better than other teams
	Practitioners	**Graduates**	**Academia**	
1	Ability to communicate	Ability to communicate	Can solve problems	Teamwork
2	Can solve problems	Can solve problems	Ability to communicate	Producing required quality
3	Comprehensive technical knowledge	Team worker	Team worker	Understanding
4	Can think laterally	Knows when to obtain advice	Knows when to obtain advice	Communication
5	Knows when to seek advice	Can think laterally	Comprehensive technical knowledge	Reliability

Table 4: *Top five characteristics (in order of priority) that define a good designer and top five characteristics that clients feel defines a good design team (note: 61% of clients have in-house design teams).*

The clients were asked to rate the service they receive from their design professionals. Only 15% of the clients stated that they were definitely satisfied, 61% said they were generally satisfied, 17.4% indicated that they were not satisfied, with the remainder (6.5%) not answering the question. Clients were also asked whether they were happy with their methods of measuring the performance of their completed projects or products, 50% of clients stated that they were not satisfied, with 47.8% saying they were satisfied, and the remainder not providing an answer. On a similar theme clients were asked if they obtain a second opinion and/or evaluate their products or projects. A total of 69.9% of the respondents stated yes (always), 15.2% stated that they do not at all and 13% said that they do only if '*there is a high risk involved*', '*there is requirement to ensure/check compliance with brief*', '*further confirmation is needed*', '*complexity requires it*', or '*the business case is thought to be wrong'.*

A total of 66.7% felt that their investments (projects) were treated in an innovative way, considering aspects such as, performance, value for money, increase in quality of life, energy conservation, and sustainability. The remainder (33.3%) felt that their investment was not treated in an innovative manner. However, only 46.2% of respondents have been surprised by their design team presenting non-standard solutions, with the remainder stating that they have never been surprised with the design solutions. Most of the respondents provided examples of non standard solutions, which were very client/job specific and fitted under the broad areas of more efficient construction methods, intelligent use of materials, integrated design, better features and lower costs.

Asked if they were 'always', 'mostly', 'sometimes', 'never' satisfied with their final products, only 5.1% stated that they were 'always' satisfied, 82.1% said they were 'mostly' satisfied and 17.8% said they were 'sometimes' satisfied.

Clients were also asked, choosing from a pre-defined list, what defines current best practice in design. It can be seen from Figure 9 that all clients mentioned '*delivery to cost and time*', with nearly all mentioning '*whole life performance*'. '*Low initial cost*' was only mentioned by 12.8% of the clients.

A shortage of design and design related professionals was identified by over 59% of clients and 44% of practitioners.

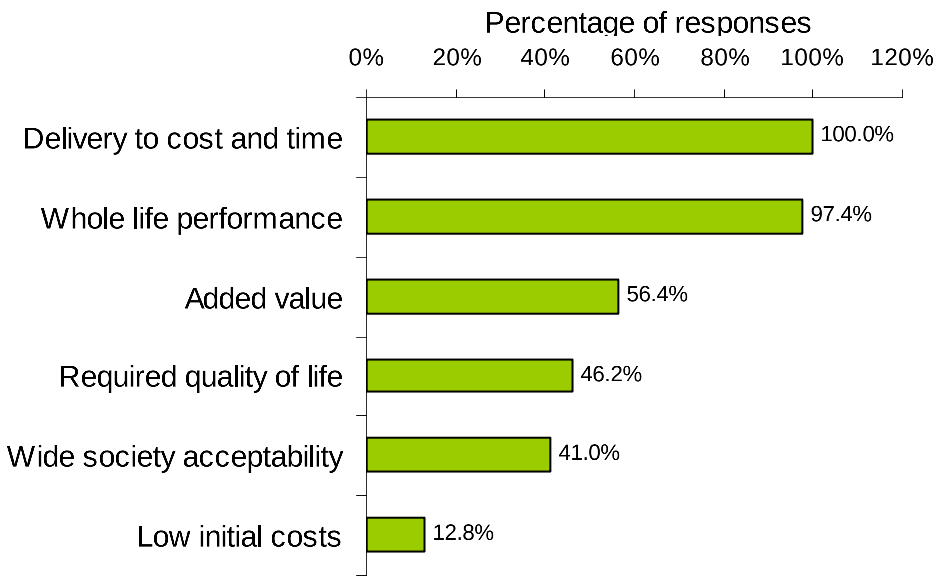

Figure 9: *Clients' definition of current best practice in design.*

5.0 Level of design skills

Practitioners, graduates, academics and students were asked to rate their skills as 'extensive', 'good', 'average' or 'poor' in:

- Undertaking complex designs.
- Designing for sustainability.
- Designing for health and safety.
- Teamworking.
- Solving complex problems.
- Communication.

To allow respondents to carry out a more critical self-assessment they were asked to rate their skills on graduation and currently. For students, they were asked to rate their skills at the start of their course and currently.

As expected there was a clear progression from the level of skills at graduation and currently (or for students at the start of their course and currently). The results of how practitioners, graduates, academics and students rate themselves currently is shown in Figure 10.

Overall, practitioners rated their skills higher than graduates, which of course is no surprise but does give confidence in the results. The areas where practitioners were slightly less confident in their skills were designing for sustainability and designing for health and safety.

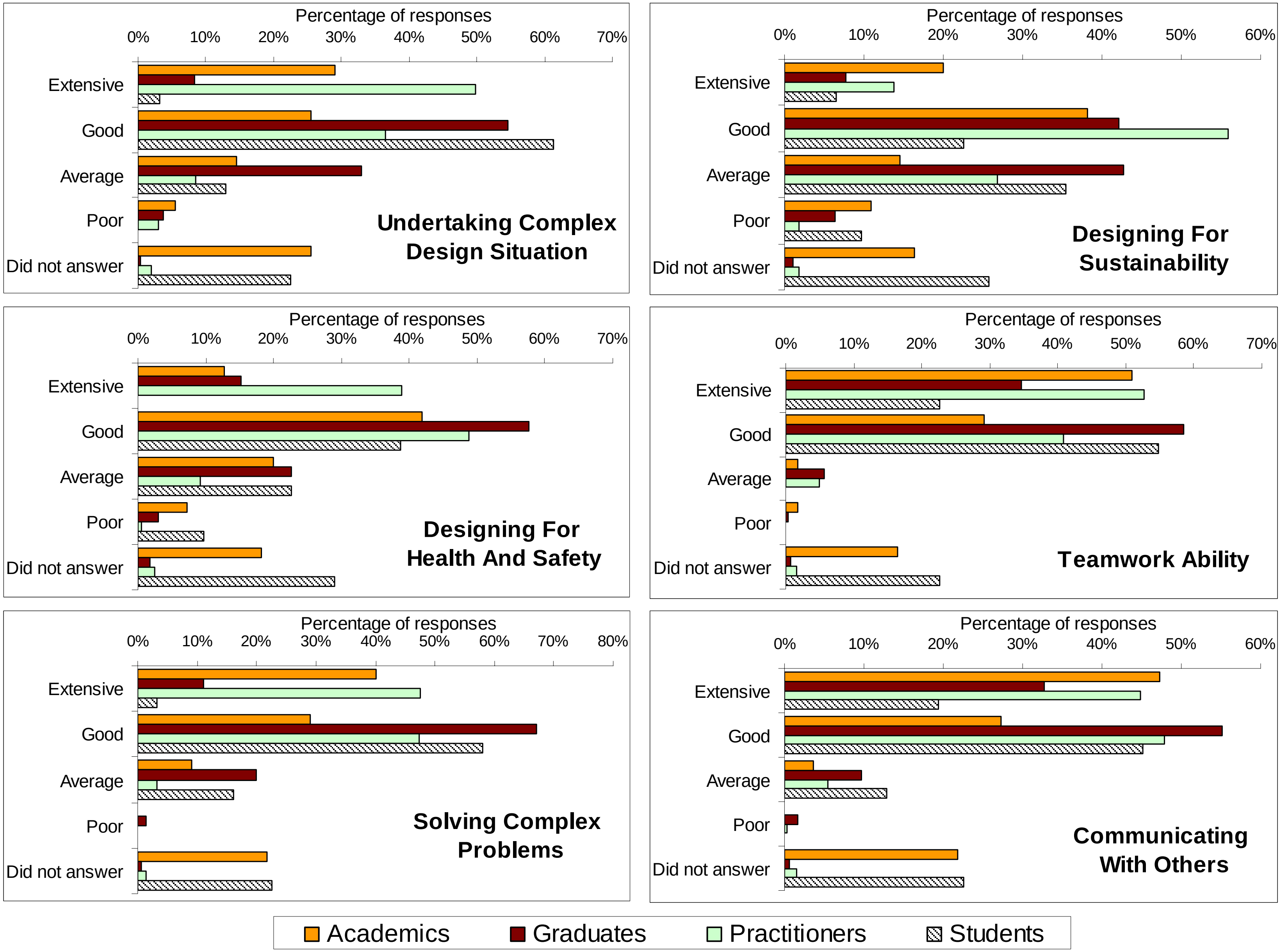

Figure 10: *Personal Evaluation of current level of design skills.*

6.0 Continuing Professional Development (CPD)

Both practitioners and clients were asked to indicate how much time (hours/per week) that they actually spend on CPD. From Figure 11 it can be seen that most practitioners and clients spend ½ to 1 hour per week on further development. At ½ hour a week this equates to approximately 3.3 days per year and 1 hour per week equates to 6.5 days per year. Most professional institutions recommend at least 5 days per year on CPD activities.

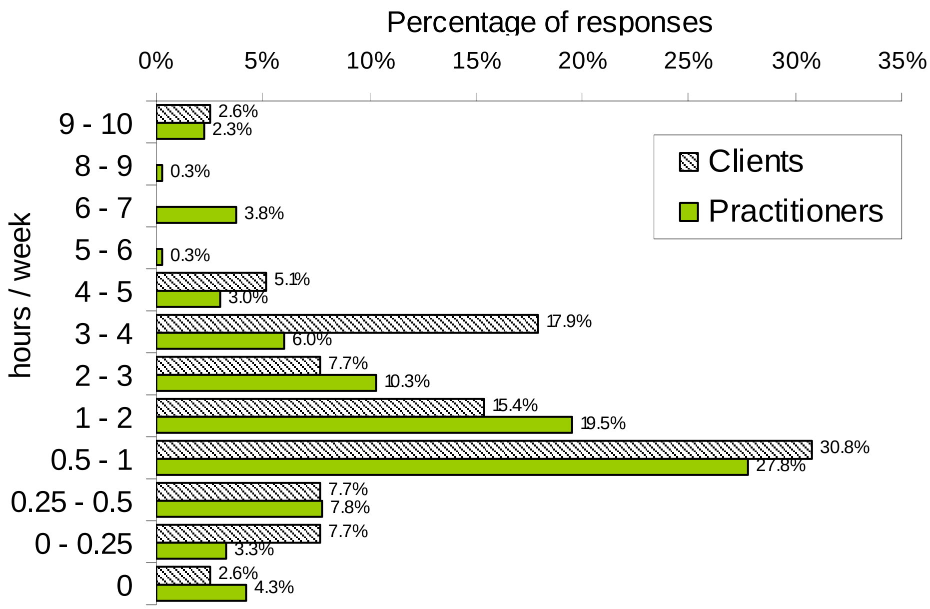

Figure 11: *Actual time spent on CPD (hours/week).*

Practitioners, graduates and clients were asked to list in priority order the most beneficial CPD workshops. The results are shown in Table 4.

Order of priority for CPD Workshops according to:		
Practitioner	**Graduate**	**Client**
Design for minimizing energy use.	Design for minimizing energy use.	Design for best value.
Design for best value.	Working with distributed teams.	Risk assessment methods.
Working with distributed teams.	Working in multidisciplinary design teams.	Managing the design process.
Working in multidisciplinary design teams.	Increase use of ICT for management.	Communication in design and supply chain.
Design for sustainability.	Design for Health and Safety.	Working in multidisciplinary design teams.
Design for Health and Safety.	Design for best value.	Designing for sustainability.
Incorporating new technology/techniques.	Incorporating new technology/techniques.	Review and evaluation process.
Increase use of ICT for management.	Risk assessment methods.	Promoting creativity and innovation.
Risk assessment methods.	Promoting creativity and innovation.	Future maintenance and durability requirements.
Promoting creativity and innovation.		Communication.

Table 4: *Priority list for CPD workshops.*

7.0 Design Development Process

Both practitioners and clients were asked whether they follow the four-stage design development process (where it was emphasised that many iterations may be necessary) outlined in Tables 5 to 8. The definitions for each of the four stages were presented in the questionnaires and were based on two major publications: Template for Design (from Royal Academy of Engineers[(8)]) and RIBA Plan of Work. The definitions were derived to be generic to all disciplines within the Built Environment.

Of the practitioners questioned, 72.2% indicated that their team followed the four-stage design process given in Tables 5 to 8, 26.6% said that they did not follow this process and 1.2% failed to answer the question. Those stating that they did not follow this process were asked to describe their own design process. The vast majority of these responses indicated that, broadly speaking, the design process as stated in the definition was followed. However, it was pointed out that the stages may be referred to by different names, that stages often overlap, that several stages may be combined into a single stage and that there were further steps following the converge stage, such as producing construction drawings and contract documents, on-site completion, commissioning, design evaluation, and decommissioning.

Numerous respondents pointed out that the design stages defined above are not fixed or rigorously adhered to, but can vary from project to project. In particular a number of respondents stated that the process was too linear, indicating that there were a number of iterative loops and emphasising the need to think of the implications (such as cost, environmental impact, programme change, etc.) of decisions at every stage of the process. In a small number of cases the respondents indicated that conceive and transform stages of the process were not discrete elements, with designers relying on experience and 'gut' feeling to address these stages. The need for review, and assessment of risk and safety considerations to be taken into account, at each stage in the process, was highlighted. In many cases it was noted that a detailed investigation of alternative designs does not take place due to '*time and cost constraints*', '*procurement methods'* and '*reliance on the knowledge gained from similar previous projects*'. It was also pointed out that some designers (mainly working for contractors) were commissioned at the detail design stage, with the client being reluctant to revisit the previous stages of the design process.

In total, 84.8% of clients were aware of the four-stage design process outlined in Tables 5 to 8 and 15.2% indicated that they were unaware. In one instance a respondent asked why a client should be aware of the design process. An analogy was presented of, '*why would a buyer of a car be interested in the intricacies of design? Surely they would only be interested in the quality of the final product*'.

Out of the 84.8% of the clients who were aware of the design process outlined in the questionnaires, 74.4% stated that they actually follow the process, with the remaining stating that they generally follow a similar process using different definitions, or with stages revised or removed depending on the specific project.

Both practitioners and clients were asked to briefly explain what activities are typically performed within each of the four stages presented, with the common responses shown in Tables 5 to 8 for each of the stages.

Stage 1: Interpret (clarification of task).

For stage 1 (Table 5) several responses from practitioners mentioned the importance of incorporating risk into this and subsequent stages. It was pointed out that each project is different and that it is rare for projects to follow the defined stage-by-stage process rigorously, with some stages being carried out simultaneously. The activities included in the clients' response for stage 1 (Table 5) are broadly in line with those given in the design process definition provided in the questionnaires, with the exception that they did not mention the need to set criteria against which proposed solutions can be assessed.

Stage 2: Conceive (conceptual design).

From the practitioners' response on stage 2 (Table 6), it is interesting to note that many consider tasks such as '*deciding on a preferred solution*' and '*rank solutions*' to be part of this stage. This highlights the fact that in many projects, stages 2, 3 (conceive and transform) and sometimes stage 4 (converge) are combined into a single stage, with no clear distinction being made between them. Many practitioners referred to stage 2 and 3 as an 'optioneering' process with the final detailed design following in quick succession. Considering the clients' response to the activities carried out under stage 2 (Table 6), it is worth noting that some respondents also considered tasks such as '*choose preferred solution option and develop*' to be part of this stage. This again highlights that the distinction between stages 2, 3 and on occasion, 4 is often not made. None of the clients mentioned the use of creativity, brainstorming or 'blue-sky' thinking during this stage.

Stage 3: Transform (embodiment design).

For stage 3 (Table 7) most of the activities stated by the practitioners were similar to those given in the provided definition. Once again, many responses indicated that stage 2 and 3 converge with the same activities being carried out. It was also clear from the responses that many consider this phase to include activities that, from the given definitions, belong to the stage 4, converge (detail design) activities such as, '*detailed design of selected options*' and '*producing detailed tender calculations, drawings, costing, specifications, etc*'. Again, this highlights the overlapping and merging of stages that seems to be commonplace from the practitioners' response. From the clients' response (Table 7) it can be seen that several of the activities are in-line with those stated in the provided definition for phase 3, with some notable exceptions. Activities such as; '*select preferred solution and develop, agree final solution with customer*' and '*cost analysis of designs*' belong, according to the design process definition, to the converge stage. Similarly, activities including '*scope project*' and '*obtain funding*' can be considered as belonging to previous stages in the process. Again, it is clear that the overlapping and merging of stages occurs.

Stage 4: Converge (detail design).

For stage 4 (Table 8), many practitioners indicated that the activities in this stage were considered to be the same as those for the previous stage, i.e. no distinction was made between the transform (embodiment design) and converge (detail design) phases. Some respondents emphasised that the detailed design is by far the biggest in terms of manhours, highlighting the need to ensure the previous stages are completed correctly. It was also pointed out that the first 3 stages were carried out by experienced designers with less experienced designers completing the detailed design work. In some cases the detailed design work was typically sub-contracted with the role of the main designer becoming one of a reviewer. It was pointed out, in a small number of responses from the practitioners that the process definitions given in the questionnaires (Tables 5 to 8) stops too early with build, test and commission stages being omitted. It was emphasised that good designers need a clear understanding of all these stages. From the clients' response (Table 8) it is clear that most consider this stage to be one of simply finalising and confirming already fully developed and chosen designs, with no mention of evaluation and choice of alternatives, or the refining of proposals and/or agreements.

Summary of the design process.

Overall the practitioners and clients outlined activities which generally followed the four-stage design process presented, albeit in a number of cases different stages merged. It is of interest to note that the practitioners provided more detail on the activities they carry out at each stage and mentioned the process of brainstorming. Although, as commented by a client respondent, it could be argued that clients may not need to know all the details of the design process. However, it could also be argued that it would be ideal for them to know that the designers have gone through the process of obtaining what is thought to be the most effective solution and they also understand the level of work associated with the designer's fees. In addition, to be able to assess the final project, the client must be confident that the design process has been carried out rigorously. As discussed previously, the response from the questionnaires highlighted that a significant number of clients are not satisfied with their final projects.

Definition provided in questionnaires	Practitioners' view	Clients' view
1. Interpret (clarification of task) *a. Specify the need (broadly define what is required).* *b. Assess requirements (for functionality and performance).* *c. Identify main issues (constraints and priorities).* *d. Define project characteristics (set datums against which proposals/solutions will be assessed).*	• Clarify client's needs and requirements. • Define objectives and targets. • Develop, confirm and discuss design brief with client. • Agree fee for design and clearly define extent of services being provided. • Identify and consult stakeholders. • Identify boundaries of the problem and constraints (site conditions, funding, time, etc.) • Collate, appraise and validate existing design information and data. • Perform desk-top/feasibility/scoping study. • Appraise defined targets (time, financial etc.) • Preliminary risk assessment to address operational, health and safety, environmental and financial risks. • Identify required resources and skills and build design team. • Identify design standards and legal requirements.	• Obtain client's needs and requirements. • Understand client's aspirations. • Defining the objectives, scope and brief (including strategic brief) of the project. • Determine/secure funding. • Undertake desk-top/feasibility studies. • Risk assessments and pilot trials. • Ensure correct interpretation of client's needs by discussion or sketching/written feedback.

Table 5: *Practitioners' and clients' interpretation of stage 1 of the design process:* ***Interpret.***

Definition provided in questionnaires	Practitioners' view	Clients' view
2. Conceive (conceptual design) *a. Generate solutions and options. 'Creative and uninhibited proposals'.*	• Consider similar problems/projects encountered previously. • Develop ideas (brainstorming) that could broadly offer a solution to meet the project needs. • Involve all required disciplines. • 'Optionerring' to generate possible solutions (within the capabilities of the company) and analyse the advantages/disadvantages, considering requirements, constraints, budget, health and safety, buildability, environmental impact, whole life costing etc. • Perform scoping, obtain cost estimates, and carry out value engineering analysis on most promising options. • Produce preliminary design proposals (scheme drawings). • Update risk assessments. • Rank solutions. • Prepare documentation/presentation, which is understandable by the client, to allow discussion of various design options. • Decide on preferred solution following consultation with client. • Mobilisation of design team.	• Outline possible solutions. • Develop solution options. • Develop conceptual design. • Perform feasibility study of designs. • Perform cost and risk analyses. • Choose preferred option and develop.

Table 6: *Practitioners' and clients' interpretation of stage 2 of the design process:* ***Conceive.***

Definition provided in questionnaires	Practitioners' view	Clients' view
3. Transform (embodiment design) *a. Combine/develop solutions into a number of usable solutions.* *b. Select suitable solutions. (Eliminate totally unsuitable solutions, prioritise remaining solutions).* *c. Firm up concept proposals (identify gaps in information, co-ordination across discipline boundaries).*	• Develop design solutions/add detail to the design options. • Analyse options. • Collect missing design data. • Rank/score solutions according to criteria. • Consider risks/associated constraints. • Update risk assessment. • Modify concept design after consultation with client and stakeholders. • Carry out value engineering. • Freeze design or carry out further iterations. • Undertake detailed design of selected option and produce detailed calculations and drawings. • Produce detailed tender calculations, drawings, costings, specifications, etc. • Mobilisation of design team.	• Preliminary/outline of designs. • Prepare/develop design solutions. • Obtain funding. • Scope project. • Perform full conceptual design. • Feasibility/option evaluation. • Cost analysis of designs. • Select preferred option and develop. • Agree final solution with client.

Table 7: *Practitioners' and clients' interpretation of stage 3 of the design process:* ***Transform.***

Definition provided in questionnaires	Practitioners' view	Clients' view
4. Converge (detail design) *a. Evaluation and choice of alternatives (relative to one another and to the extent that they satisfy the need and meet requirements).* *b. Refine proposal/agreements: details, costing, identify critical unknowns, document to obtain client's agreement and procure / manufacture / construct.*	• Assemble alternative proposals and carry out cost analysis. • Choose preferred solution. • Complete detailed design comprising, calculations, drawings, specifications, contract documentation, etc. • Consult with other disciplines. • Perform full risk assessment. • Review design in relation to requirements, specifications, constraints, costing etc. • Communicate information to contractor. • Deliver final design and receive payment. • Post project appraisal.	• Implementation. • Carry out detail design. • Carry out final checks/proofing. • Confirm budgets and funding. • Finalise design. • Produce detailed design documents.

Table 8: *Practitioners' and clients' interpretation of stage 4 of the design process:* ***Converge.***

Academics were asked whether they encourage their students to follow the four-stage design process defined in Tables 5 to 8. In total 65.5% of the respondents encouraged students to follow the process, however 5.5% use different terminology, 1.8% followed only stages 1, 2 and 4, 1.8% said they mostly follow the process, and 1.8% indicated that this depends on the project. No answer was received from 20% of the respondents and 14.5% stated that they did not encourage students to follow this process due to the following reasons; '*the design process is not recognised by the department*', '*students should discover their own process*', and '*in early years students do not need this structure*'.

8.0 Conclusions and discussion

The results from the questionnaires have shown that there is a need for significant improvement in the current design services and educational base, with improvements needed between higher education and industrial practice and the interface between practitioner and client. There is also a problem with the interface between higher and secondary education but this is a much wider issue and not just specific to the construction industry.

Both practitioners and graduates criticise the fact that educational programmes are not linked to the '*real world'* and would significantly improve if they were taught by lecturers who had practical experience as well as sufficient training in how to teach. Considering the age profile of the practitioners, these problems with educational programmes have always been an issue and are not just a recent problem as typically mooted. Academics also highlight similar problems with the education programmes but explain that it is now difficult to recruit staff with design experience due to the need to be more research focused. However, considering again Figure 1, it can be seen that applied research in the cycle of the design process is an important component and is required to construct innovative projects of the future. The problem lies in the fact that the industry (and government) currently lacks investment in research and development. This forces universities to employ academics who are carrying out research in areas which attract funding, which typically is not in main stream construction activities. On a positive note, both clients and practitioners state that graduates' top two strongest abilities are calculations (detail design) and being open-minded. This suggests that graduates can contribute very early on in their profession career to the detailed design of the project, which is the major component in terms of manhours, but lack appreciation of the holistic design process.

There is room for improvement at the client/practitioner interface with the majority of clients indicating that they were generally satisfied with the design service they receive and their final projects. A total of 17.4% of the clients indicated that they were not satisfied with the design service, with only 5.1% stating that they were always satisfied with their final project. One area which needs urgent attention is that 50% of the clients indicated that they were not satisfied with current methods of measuring the performance of their completed projects.

Considering the current design process, most practitioners and clients highlighted that they were aware of the four-stage process presented in Tables 5 to 8 and indicated that they broadly follow this process. In some cases the practitioners indicated that they do not carry out stage 2 (conceive) and stage 3 (transform) and instead go straight from identifying the clients requirement to detail design, relying on experience and 'gut feel' to obtain the correct solution. When considering the practitioners' and clients' response (Table 5 to 8) it is interesting to note the level of detail and the activities provided by the practitioners, for each of the stages, is greater than that provided by the clients. Although, it can be argued that there is not a need for clients to understand the detailed design process, they should at least be aware of the basic principles. Only with this knowledge can clients assess whether designers have gone through the correct process to arrive at the most efficient solution, or whether designers have simply obtained the solution be relying on past experience and 'gut feel'. Although both solutions may be acceptable to the client, by understanding the process that has been followed the correct level of design fees can be set and the client is totally aware of the quality of design service being provided.

Figure 1 highlighted the importance of design delivering excellence in the final project/product which will provide the enthusiasm and challenge for the next generation and could attract the most able into the industry. Thus, also addressing the current shortages of design and design related professionals.

Based on the analysis of the questionnaires the authors believe that the following actions are required by stakeholders (Government, clients, practitioners and academe)

1. Set up networks to improve interfaces: clients/industry/academe.
2. Implement changes in the methods of design education for undergraduates.
3. Produce better methods for evaluating the performance of design professionals and of completed projects.
4. Develop a series of CPD modules on the topics which have been clearly identified.
5. To aid all of the above, and to improve communications, produce a specification for the design process and its position in the overall project process for the Built Environment.

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