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# What is the state of digital architectural design?

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*Abstract*— Architecture without computers is on the brink of extinction. At least in the developed countries it could be said that nearly no architecture today is designed and realised without the help of computers. The only exception from this rule is probably “informal” vernacular architecture. But even small projects – as soon as they have to get building permission - will very likely become part of the digital world. The degree of pervasion will differ greatly dependant on the size of the projects. In very small projects the computer might be only involved at the drafting stage to create the plans submitted to the building authority. At the other end of the scale, we find large architectural projects where the computer plays the main role from design to realisation and even further on for the operation of the building during its life cycle. We were interested to find out about the reality “in the middle” done by architectural firms where most of our graduates will work after their studies. To find out more about the reality of the use of computers in design in “small town Europe”, for the past 4 years, we have been undertaking two different strands of research. The first is an educational experiment using first year students to find out about the different qualities of designing with and without the computer. The results have been presented at previous conferences and, since we are doing a last run of these experiments this year, we will update and finalise our findings in this paper. The second strand of research we have followed is a survey amongst practitioners. The results of our research, and our experience as teachers and architects, leads us to the main question of how we can give recommendations on how to teach design to the new generation of architects. In many aspects, most of the teaching that is done in our faculties is still strictly divided into teaching design and teaching computer skills. The crucial question for architectural education is the implication of the ubiquity that the computer will have, especially in the field of design. We will try to give some suggestions for the effects that this could have on our teaching. In the long term, this is the only way to avoid some of the pitfalls and bring the benefits of computers in design to our small architectural firms.

The paper will present a summary of the results of our research and try to propose an answer to the question: “*What is the state of digital design in small town Europe?*”

## INTRODUCTION

The ubiquity of the computer in architecture can be seen in the many computer based presentations from famous architectural practices. BIM (Building Information Modelling) is the key word and we can see implementations in very ambitious projects all over the world. Glossy magazines show the results of this kind of architecture and predict that this is the future of our profession. But when we go out into the “small world” (in Europe) and talk with architects in small practices, there is a very different reality – at least at the moment. Although they all agree that the computer is crucial for their work, it is a love/hate relationship for many them. Most still use the computer purely as a drafting device and AutoCAD is still the dominant tool. Although many of them agree with the statement that you can use the computer for design, only a minority really use the computer as a design tool in the early design stages.

To find out more about the reality of the use of computers in design in “small town Europe” we have been conducting two different strands of research over the past four years. The first is an educational experiment using first year architectural students to find out about the different qualities of designing with and without the computer, both in the process and in the final result. To make it comparable to previous years, we use largely the same set of parameters using the same type of student (first year) and the same project/site. We will also be comparing the results for students designing ‘freestyle’ i.e. in the way that they want against the previous years controlled groups. The second strand of research we have followed is a survey amongst practitioners and some of the above statements came out of this survey. This survey was conducted using a web questionnaire and focused on a particular region of Europe. Although the numbers of participants for this survey were quite satisfying, we are re-

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running it in a different region and country to see whether there are significant differences.

#### SUMMARY OF THE EDUCATIONAL EXPERIENCE

It is inevitable when using a large number of students (from different countries and backgrounds) that there will be differences in approach to, and opinions of, design. Over the four years of this project we have tried to accommodate these differences by using more or less the same project brief on the same site. All the students worked in pairs on their design. Most of the design work was done during an intense workshop week. One of the main ideas was to work with first year students with as little history of design education and CAAD experience as possible so that they had as few preconceptions as possible. In practice, this was not quite so easy as in our curriculum, CAAD courses start quite early. The chosen software was SketchUp which is (despite its name) is more focused towards digital model making than sketching.

Our main parameters were:

- Students worked in pairs from different universities, being split into analogue and digital groups developing independent design solutions
- Students working in pairs developing digital design solution – no paper and pen allowed
- Students could choose how to work – final result should be digital and analogue

These resultant designs over the years were compared and analyzed and we have reported on our experiences at past conferences. (eCAADe, Sigradi and CAADfutures) [1][2][3][4]

Our studies show that students can and do use the computer to generate richer design solutions in a shorter time span. Strong students in the digital group were quicker in developing design ideas than those in the analogue group. They also produced more design variations and were stronger and more confident in explaining the spatial aspects of their design. The weak students were weak in both groups – the digital group did not manage to find proper solutions with their models and the analogue group was equally failing in developing adequate solutions using traditional tools. But the strong analogue students managed to catch up with the strong digital students during the rest of the workshop.

One very interesting aspect of our last run of the project in February 2008 was where students were given free choice in how to work (i.e. digitally or analogue or any combination) no

one decided to work in a completely analogue way and some designed purely digitally. In previous years we had different experiences. In the year where pen and paper was banned, some students tried urgently and persistently to do some additional sketching and 2D drawing and ended up using AutoCAD and Photoshop for that (which did not really work out for them). They simply tried to replicate their perception of manual methods in a digital manner.

As a summary of our educational experiments we can state that we are at a design crossroads in the way in which sketching and digital model making are being used. Students are coming to architectural education with an innate familiarity with computers and technology. The use of 3D digital design methods are clearly moving more towards the beginning of the architectural design process. Our results seem to indicate that the balance will shift further so that digital methods will be the main tool in the design process and there is the possibility that we might move on to a new generation using only digital tools.

#### The survey amongst practitioners

To see whether we were discussing the topic in an academic ivory tower, we wanted to find out the current use of CAAD in architectural practices. As we carried out our educational experience with students from both the UK and Austria, we decided to do a survey in both countries. The chosen method for this survey was a web questionnaire. (<http://www.stdb.tugraz.at/survey/en/>)

The test regions were the RIBA North West region in England (500 offices) and the area of the “Ingenieurkammer fuer Steiermark und Kärnten” (600 offices) in Austria. Due to unknown and unforeseen circumstances there was a significant difference in the degree of participation. We received 107 answers from Austria and only 12 from England. Because of this imbalance, we decided to use only the results from Austria until we can rectify the situation.

The Questionnaire itself has two parts. The first part set out to find out the practice's attitude to the use of CAAD. The second part is focused on the background of the practices. This allows us to see the results of the first part in the context of the practice's structure, size and workload.

In the first part we used a five degree semantic differential scale between the limits of “disagree strongly” and “agree strongly”. The following is a list of the questions.

#### *Attitude towards CAAD*

- we use CAD only for production drawings
- we use CAD for concept modeling or massing studies

- we use CAD as an electronic drawing board
- we originate complete designs in a 3D CAD environment
- we create a 3D CAD model for visualization purposes only
- current 3D CAD packages are not intuitive enough for design use
- it is not possible to design using a CAD system
- clients require us to produce computer generated images
- clients require us to produce 2D CAD information
- statutory bodies require us to produce computer generated submissions for approvals
- CAD is used as a tool alongside “traditional” methods of sketching and modeling
- as a practice we are open to new ideas and technologies to use in the design process

#### *Background*

- what age are you?
- what size is your practice?
- what is your professional experience?
- what is your job role?
- how many hours a week do you spend using a CAD package?
- is training available to you?
- what type of work does the practice undertake?
- which CAD system is predominantly used in the practice?
- do you use external consultants to produce 3D images/animations?
- any other comments on the use of CAD either in your practice or in architectural practice generally

## RESULTS

We were quite surprised at some of the results of this first initial run of our survey. Several of the comments we received were very critical towards CAAD and expressed a traditional, long established picture of CAD usage. (ie. as a 2D drawing board tool). But looking at the results in more detail reveals significant changes. A substantial amount of offices already claim to use CAAD methods in the design process. (This does throw into question exactly what individuals class as ‘design’) In question one a high percentage of the answers - app. 56% disagree quite strongly that CAD is only for production drawings (answers 1+2). Additionally, Question 4 shows that 32% of the offices originate their designs in a 3D environment (answers 4+5)

It is very clear that CAD systems are still used in their traditional ways – Question 3 – 69% agree strongly in using CAD as an electronic drawing board (answers 4 + 5) and question 9 indicates that 2D CAD information is still a major part in the building process (77 % agree with that)

Question 6, in combination with the background question 20, is not a very surprising result - the main software package is still AutoCAD even for 3D . Only 12% are using more intuitive packages like SketchUp (only 13 offices) – not a single one Revit from Autodesk. So, the information about more intuitive, design based software is not really getting to people yet. Some of the comments give some indication of the possible reasons. Lack of time for the evaluation of software packages, coupled with the substantial costs of both purchase, training and support involved, are definitely factors that slow down the adoption process.

The small size of the offices in Austria (80% are less than 9 persons and app. 60% less than 5) might also be a decisive factor.

A very important statement is that more than 50% disagree with the statement that it is not possible to design with CAAD. At least in Austria this marks a significant change - a few years ago the majority of architects claimed that it is not possible to design with the computer!

Finally, we can say that for the majority of architects CAD as a tool is essential and all pervasive – one submission stated that working as an architect is unthinkable without CAD! But the reality of daily work in an architectural firm shows that the computer is ubiquitous. 82% of the submissions were from partners or project leaders which makes the 65% who claim to work with a CAD package more than 20 hours a week even more impressive!

## OUTLOOK

Our next step will be to extend the survey amongst the practitioners. Our experiences this year indicate that this will be very problematic in England. There were again not enough submissions from that region to be useful for our research. So we decided to widen the survey on a more personal basis and already started to interview architectural firms directly. As this is work in progress and still a little behind schedule it was not possible to include the results this year. However, some initial comments are worth including.

It is evident in talking to architects of differing ages and background that the definition of exactly what constitutes ‘design’ varies greatly. One interviewee considered that the use of the bubble space planning diagram in Architectural Desktop to be the height of CAAD design, whilst for another, only 3D mass modeling with shadows studies would do. It was also becoming evident that the current economic

downturn is starting to have a significant effect and that investment in any CAAD system is dramatically slowing.

We still intend to use the survey as a pilot project for a more wide ranging European-wide study. This seems to be quite important because although the ubiquity of the computer in architecture is not in question, most of the architects are still conservative in attitude when compared to other areas of design. Additionally the new rules of the European Union in the building industry will have a big impact. Without the use of BIM (Building Information Modelling) many of those rules can not be introduced successfully. If Architects ignore this fact, other professions will take over to do the job. There is no question that the larger firms in Europe are aware of this fact but there is only little evidence that the small architectural firms are aware of it. The recent shift away from AutoCAD towards Revit (at least in Austria) might indicate the beginning of a change. This is not explicitly documented in our statistical data but a known fact which is expected to become evident in a larger and more widely spread survey. We hope that our research will help to widen the discussion and bring the topic also on the agenda of the smaller firms.

#### CONCLUSIONS AND IMPLICATIONS

So what can we conclude as to the implications for education and practice? Aside from the ever present tension between the profession and education (training vs. education) it is clear that the new graduates must inform the profession in new and innovative ways of digital design. It could be argued that the pervasiveness of AutoCAD in practice is perpetuated by the training that some schools of architecture provide, fuelled by the misconception that a good working knowledge of 2D CAAD draughting is needed to 'get a job'. It is clear from our studies that the curricula of schools of architecture must change to give a grounding in innovative and cutting-edge CAAD design techniques in the widest sense. This would enable the profession at large to embrace advances in technology rather than it remaining in academic realm or it being restricted to specialist architectural practices.

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#### APPENDIX

##### SUMMARY OF THE RESULTS OF THE QUESTIONNAIRE

107 submissions (out of 600) 17,83%

##### 1. we use CAD only for production drawings

1 Disagree strongly	42	<b>39,25%</b>
2	18	<b>16,82%</b>
3	10	<b>9,35%</b>
4	22	<b>20,56%</b>
5 Agree strongly	15	<b>14,02%</b>

##### 2. we use CAD for concept modeling or massing studies

0 not submitted	2	<b>1,87%</b>
1 Disagree strongly	20	<b>18,69%</b>
2	16	<b>14,95%</b>
3	15	<b>14,02%</b>
4	20	<b>18,69%</b>

5 Agree strongly 34 31,78%

*3. we use CAD as an electronic drawing board*

0 not submitted 1 0,93%

1 Disagree strongly 10 9,35%

2 6 5,61%

3 16 14,95%

4 33 30,84%

5 Agree strongly 41 38,32%

*4. we originate complete designs in a 3D CAD environment*

1 Disagree strongly 35 32,71%

2 22 20,56%

3 16 14,95%

4 16 14,95%

5 Agree strongly 18 16,82%

*5. we create a 3D CAD model for visualization purposes only*

0 not submitted 1 0,93%

1 Disagree strongly 18 16,82%

2 18 16,82%

3 10 9,35%

4 32 29,91%

5 Agree strongly 28 26,17%

*6. current 3D CAD packages are not intuitive enough for design use*

0 not submitted 2 1,87%

1 Disagree strongly 28 26,17%

2 19 17,76%

3 17 15,89%

4 22 20,56%

5 Agree strongly 19 17,76%

*7. it is not possible to design using a CAD system*

1 Disagree strongly 32 29,91%

2 22 20,56%

3 28 26,17%

4 16 14,95%

5 Agree strongly 9 8,41%

*8. clients require us to produce computer generated images*

0 not submitted 1 0,93%

1 Disagree strongly 11 10,28%

2 11 10,28%

3 16 14,95%

4 30 28,04%

5 Agree strongly 38 35,51%

*9. clients require us to produce 2D CAD information*

0 not submitted 1 0,93%

1 Disagree strongly 7 6,54%

2 5 4,67%

3 13 12,15%

4 21 19,63%

5 Agree strongly 60 56,07%

*10. statutory bodies requires us to produce computer generated submissions for approvals*

1 Disagree strongly 24 22,43%

2 10 9,35%

3 27 25,23%

4 30 28,04%

5 Agree strongly 16 14,95%

*11. CAD is used as a tool alongside "traditional" methods of sketching and modelling*

1 Disagree strongly 1 0,93%

2 8 7,48%

3 16 14,95%

4 31 28,97%

5 Agree strongly 51 47,66%

*12. as a practice we are open to new ideas and technologies to use in the design process*

0 not submitted 1 0,93%

1 Disagree strongly 1 0,93%

2 1 0,93%

3 9 8,41%

4 34 31,78%

5 Agree strongly 61 57,01%

*13. what age are you?*

20 – 29 6 5,61%

30 -39 47 43,93%

40 – 49 42 39,25%

over 50 12 11,21%

*14. what size is your practice?*

1 to 4 63 58,88%

5 to 9 23 21,50%

10 to 19 10 9,35%

20 to 49 7 6,54%

over 50 persons 4 3,74%

*15. what is your professional experience?*

1 to 2 2 1,87%

3 to 4 6 5,61%

5 to 9 38 35,51%

10 to 19 42 39,25%

over 20 years 19 17,76%

*16. what is your job role?*

Partner 70 65,42%

Project leader 18 16,82%

Job Runner 10 9,35%

Architectural Assistant	9	<b>8,41%</b>
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17. how many hours a week do you spend using a CAD package?

1 to 4	12	<b>11,21%</b>
5 to 9	7	<b>6,54%</b>
10 to 19	18	<b>16,82%</b>
20 to 49	66	<b>61,68%</b>
over 50 hours	3	<b>2,80%</b>

18. is training available to you?

not submitted	9	<b>8,41%</b>
formal	15	<b>14,02%</b>
informal	12	<b>11,21%</b>
in-house	22	<b>20,56%</b>
by external company	49	<b>45,79%</b>

19. what type of work does the practice undertake? (tick all that apply)?

residential – private	93	<b>86,92%</b>
residential – local authority	66	<b>61,68%</b>
residential – commercial	60	<b>56,07%</b>
commercial – office	81	<b>75,70%</b>
commercial – industrial	65	<b>60,75%</b>
competition	91	<b>85,05%</b>
educational	58	<b>54,21%</b>
hospital	43	<b>40,19%</b>
other	89	<b>83,18%</b>

(percentage of the 107 submitted /multiple answers possible)

20. which CAD system is predominantly used in the practice?

AutoCAD	59	<b>55,14%</b>
Microstation	1	<b>0,93%</b>
Vectorworks	3	<b>2,80%</b>
Archicad	28	<b>26,17%</b>
Rhinoceros	9	<b>8,41%</b>
SketchUp	13	<b>12,15%</b>
Allplan	14	<b>13,08%</b>
Revit	0	<b>0,00%</b>
Maya	6	<b>5,61%</b>
Abis	9	<b>8,41%</b>
3Dsmax	5	<b>4,67%</b>
Cinema 4D	3	<b>2,80%</b>
Archline	3	<b>2,80%</b>
Accurender	2	<b>1,87%</b>
Spirit	2	<b>1,87%</b>

(percentage of the 107 submitted /multiple answers possible)

21. do you use external consultants to produce 3D images/animations?

yes	55	<b>51,40%</b>
no	52	<b>48,60%</b>