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Using TRIZ in Architecture: First Steps

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Abstract: Guided by a strategic philosophy, the TRIZ approach consists of restating a specific design task in a more general way and then selecting generic solutions from general formulations of principle, from previously-identified evolutionary patterns, and from databases of patents and designs collated and abstracted from a wide range of technologies. Although initially developed for engineers, TRIZ has been successfully applied to a much wider variety of problem types. So far its use in Architecture has been very limited, but the indications are that the method has a great deal of promise for improving design while reducing risk. In the second half of the twentieth century there was a sudden burst of interest in design methods among architects, but this interest soon died away when such methods became generally regarded as being rather sterile. This left a legacy of distrust of systematic methods. Against this difficult background of, at best indifference, at worst hostility, to systematic design methods, it is very difficult to introduce such methods into the architectural design curriculum, except incidentally. The authors describe how the TRIZ method was introduced on an *ad-hoc* basis to a number of postgraduate Architecture students, by means of a limited number of tutorials and self-study, as the subject of a research-based dissertation project. In most cases TRIZ generated a great deal of enthusiasm and creative output on the part of the students, who applied TRIZ to a variety of tasks, including planning, detailed design and façade design. The projects reported here were undertaken in the belief that it is not necessary to be very experienced in the use of TRIZ in order to produce valuable results. The results of the students' work are briefly discussed and are shown to support this hypothesis.

1. Introduction

Despite its rapid spread across a wide spectrum of different industries and disciplines, the Soviet-originated Theory of Inventive Problem Solving, TRIZ, has yet to have any impact on architecture. One reason why appears to be the lack of any significant catalogue of success stories in areas relevant to architects, and a consequent lack of teaching material. Furthermore, in the second half of the twentieth century there was a sudden burst of interest in design methods among architects, but this soon died away when such methods began to be generally regarded as being rather sterile. This left a legacy of distrust of systematic methods and such methods are no longer taught on architecture courses. Ironically, the abandonment of formal design methods occurred at around the same time that people commissioning new buildings began to demand a more professional approach to risk and quality management (see for example Ó Catháin 1993 and 1995).

Against this background it was decided to introduce TRIZ to selected individual postgraduate architecture students working on a research-based dissertation project where they had a choice of topic. The typical duration of each project was 4 months. The aims were:

a) to ascertain whether architecture students could internalise the main philosophies and concepts of TRIZ and put them to work, without formal teaching;

b) to create a number of mini case-study applications;

c) to provide foundation experience to guide the formulation of future education materials and teaching strategies

The projects were undertaken in the belief that it is not necessary to be very experienced in the use of TRIZ in order to produce valuable results. None of the students received formal training in TRIZ. As postgraduates, they were expected to explore the available literature in order to establish whether they might benefit from some or all of the various tools and strategies. The rationale behind this strategy of self-organisation and self-motivation was that the level of interest in the method would become directly tied to the benefits obtained; if a person tried and failed with any part of TRIZ, then the motivation to try other parts would be diminished. On the other hand, any early successes with the method would tend to lead to a desire to learn other tools. Thus it was our hope that we would gain a useful perspective on which parts – if any – of TRIZ would offer an appropriate combination of ease of learning and ability to deliver tangible benefits.

2. Outcomes

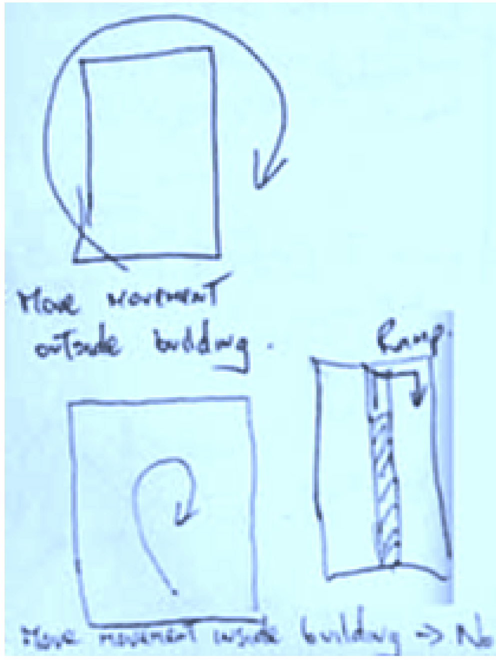
The following sections briefly summarise some of the largely self-directed activities of three different postgraduate architecture students.

2.1 Student 1

This student applied TRIZ to three aspects of a library design project: planning and movement in the building, development of its bookshelf structure and the book storage area. Describing his approach, he states,

> "The first step of analysing the problem was always done in 4 stages. I would map the problem under the headings Contradiction (between uses), Ideality (ideal system), Functionality (positive and negative functions), and Use of Resources (making full use of something). I would often find that, by the time I had written these out, I would have almost 10 solutions in mind (hence 10 principles). Testing these solutions was all that was left to do. In using TRIZ, I found at many stages that the same proposed solution could be reached by means of several different principles."

Figure 1 shows one of numerous examples, with the student's commentary.



Principle 16:
Partial or Excessive Actions.

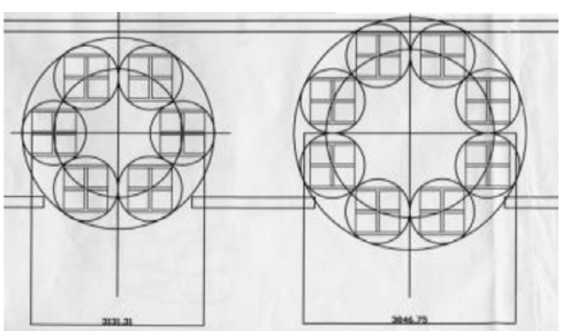
“Move all circulation [of people] outside the building? This would give space for the ramp to be sure. Another idea here was a mechanical lift that moved on exterior structural framework, allowing the user to go where ever he or she wanted. The alternative was to concentrate the ramp circulation to the main atrium area. This is what I did in the end.”
(Ahern, 2004)

Schematic plan view sketches

Fig. 1. Conceptual application of Inventive Principle 16 to Library circulation design (reproduced from Aherne 2004 with permission).

He found the classical TRIZ Contradiction Matrix to be of no use, but was not daunted, employing contradiction-elimination tools to produce numerous elegant solutions. In the case of the Archive/High Book Shelving design, the student also deployed a small number of the ‘trends of evolution’ tools to good effect. As may be seen in Figure 2, the trend towards increasing use of curvature and dynamic structures led to the generation of several novel ideas to improve the book quantity versus ease-of-access conflict.

We observe that TRIZ is here being used to augment and structure the normal ideation process, provoking the generation of large numbers of ideas. Highly effective during this activity was the strategy whereby if no solutions were generated from one solution trigger, the student simply moved on to the next.



Plan view:
Each circle represents a rotating column of books. By arranging the rotating columns inside a bigger ring of columns, storage density is maximised without compromising reader accessibility.
(In later variations on the theme, opening the ring of columns into a horseshoe-shape further increases the accessibility options.)

Fig. 2. Conceptual TRIZ Solution for Library Archive/High Book Shelving (reproduced from Aherne 2004 with permission).

2.2 Student 2

The second student focused her dissertation on integration of wind technology and buildings. Again without formal TRIZ training, she did some excellent work using a wide variety of different tools from the toolkit. The combination of architectural domain knowledge and, for example, the TRIZ trends of evolution, knowledge database and resource identification tools have influenced the creation of a very high number of novel ideas and concepts. At least a handful of these ideas appear to offer a sufficient degree of immediate practicality that they could be considered as candidates for patent applications. This prevents us from presenting them here. What we can observe, however, are some of the connections to the TRIZ tools and how they have revealed new insights into the wind energy problem.

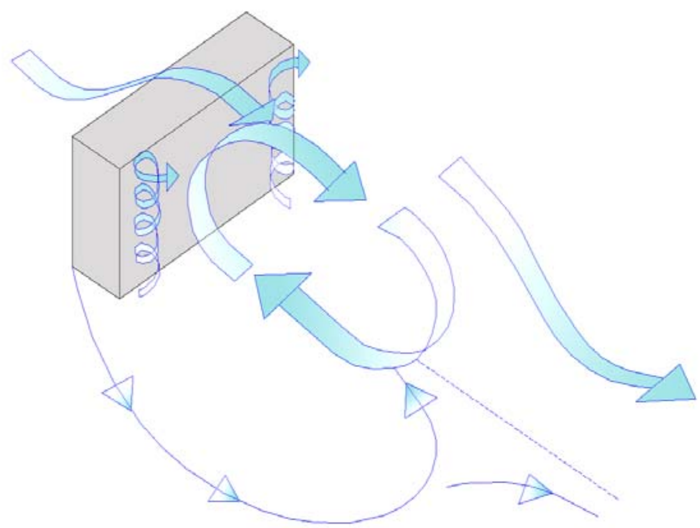


Fig. 3. Available sources of Wind Energy around Buildings
(reproduced from McGee 2005 with permission).

Firstly, the resources part of the method prompted the student to think, "the ideal final result is to design, invent or discover a system where one can use the free moving air in or around a building to produce energy for the building and its occupants … " and from here to identify a string of already existing resources that the neither the building industry nor the wind energy industry have realized can be used. Amongst these untapped resources – as shown in Figure 3 – are the presence of macro-scale boundary layer wind effects, and local-scale separation regions and vortices from which a wind turbine could be designed to extract energy.

The dissertation moves on to compare both building and wind-turbine technology with the trends of evolution part of TRIZ. The space available here prevents us from doing justice to this part of TRIZ. According to TRIZ, technology evolution trends are highly predictable in the sense that there are a number of discontinuous evolution stages that repeat across different industries (Mann, 2002a). The student first conducted a comparison of current wind-turbine technology against these known trends to reveal how many of the evolutionary jumps made in other industries have not yet been exploited in the wind turbine sector. The result is shown in Figure 4.

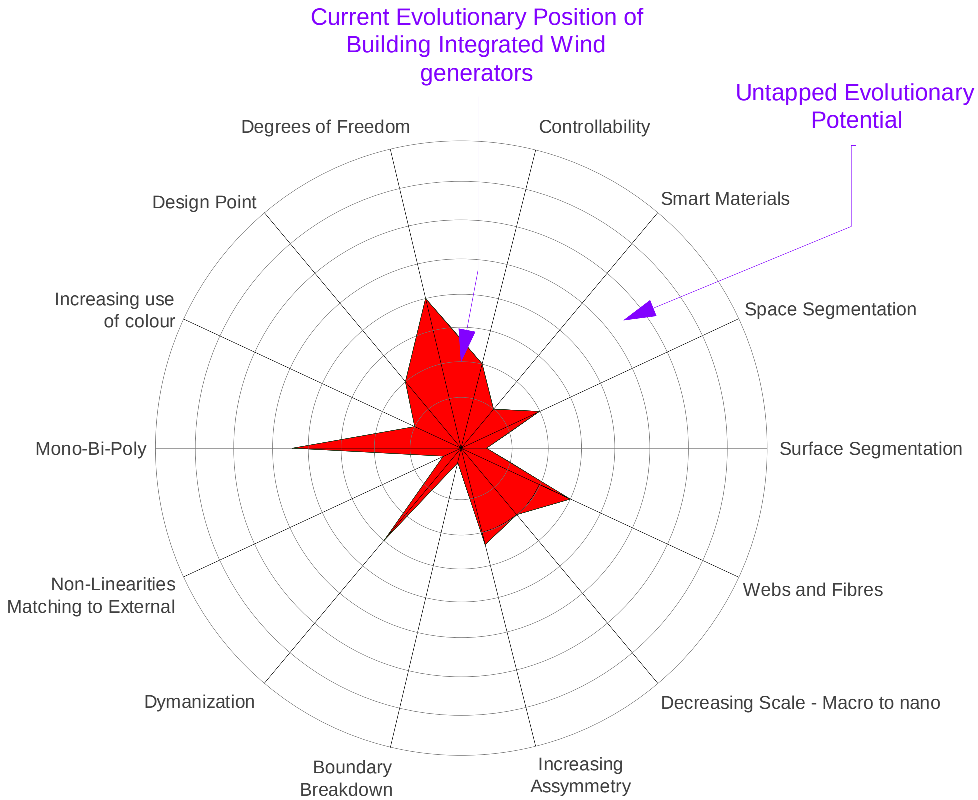


Fig. 4. Untapped Evolution Potential in integration of Wind Energy into Buildings (reproduced from McGee 2005 with permission).

Each spoke on the plot represents one of the known trends of evolution. As per Evolution Potential convention, the coloured region represents how far integration of wind energy has progressed. The figure thus indicates that there is considerable untapped potential in the field at present. Certainly that would seem to be the case when we examine the quantity and breadth of ideas the student was able to generate in exploiting that untapped potential.

The student also explored the function database part of TRIZ, observing, that the basic function of a wind-turbine is to extract energy from moving air. TRIZ research has sought to look across all industries in order to collate all the different ways of delivering useful functions like ‘move air’. By working through the list of other ways of achieving the function, the student was able to suggest a host of different means by which wind energy could be extracted and exploited in a building. A key motivation behind this work was the recognition that energy extraction through use of rotating aerodynamic surfaces had the inherent problem of being difficult to integrate into a static structure without having a considerable negative impact on the overall appearance. With another elegant deployment of the TRIZ trend – this time the evolution of systems to the micro-scale and beyond – the student found a host of conceptual design solutions in which micro-generation systems could be incorporated into various parts of the structure of a building project. In the student’s ‘intelligent air-screen panel’ solution, for example, the combination of available resources, in the form of conventional façade pressure equalization strategies, are used to convert air movement inside a controlled cavity into electricity. Although specific details of the energy conversion mechanism devised cannot be discussed for confidentiality reasons,

Figure 5 is able to present elements of the overall concept relating to the use of natural resources – in this case deploying the system into the corner structure of a building. Subsequent matching of the natural pressure difference resource to already existing façade weather-proofing design strategies to then a known means of energy conversion identified from a TRIZ knowledge database appears to have created a practically viable design solution that provides a sum greater than the total of its individual parts.

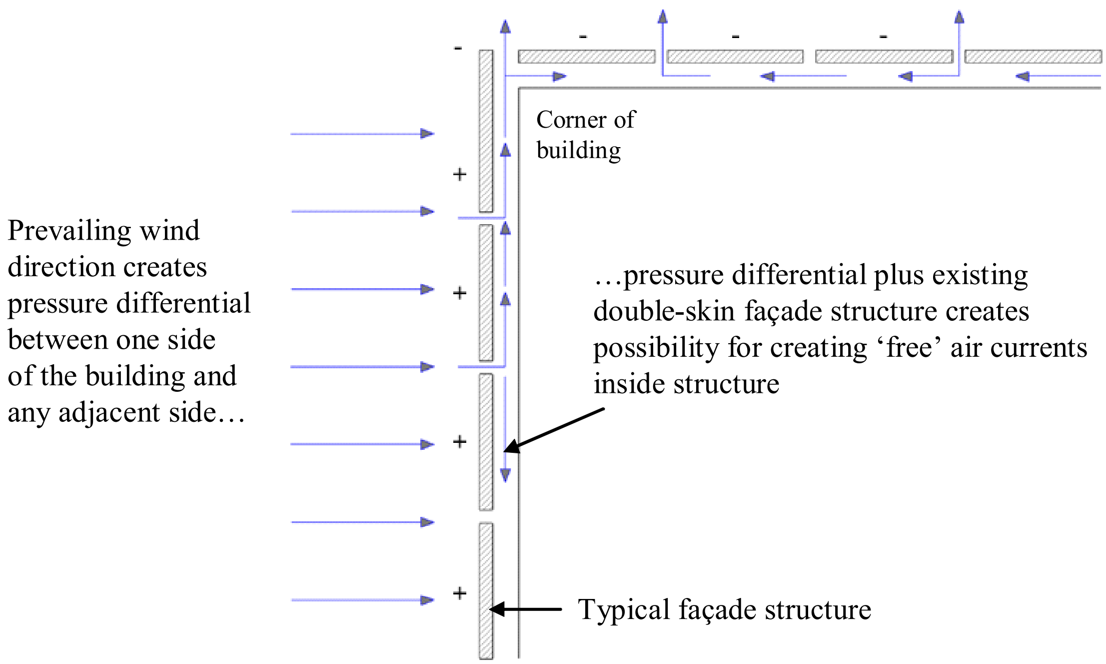


Fig. 5 Airflow within a pressure equalized cavity at the corner of a building due to natural pressure differentials(reproduced from McGee 2005 with permission).

2.3 Student 3

The third student started by examining a number of published facade problem case studies, showing how TRIZ might have been used to avoid or eliminate those problems. This student appeared to find his way into the subject through the '5Ws and an H' paper (Apte et al., 2001), an excellent means of understanding the root causes of a wide variety of problem types. This analysis revealed a number of key contradictions in the design of the existing systems. These were then used as inputs into the TRIZ toolkit.

Again it appears clear from some of the solutions proposed that seeing the design problem from the perspective of contradiction-elimination as opposed to traditional design strategies has revealed some highly elegant solution concepts that appear both novel and practical. Figure 6 describes one of the contradiction-eliminating solutions suggested for the façade of Cité International, Lyon.

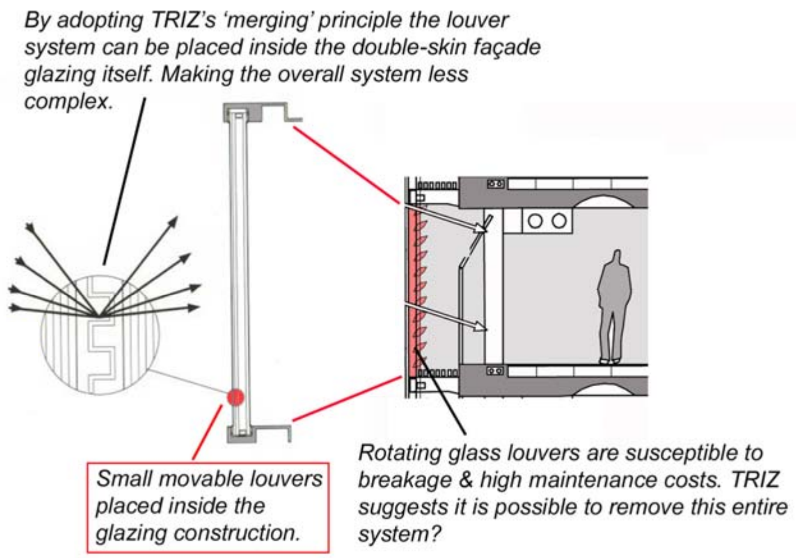
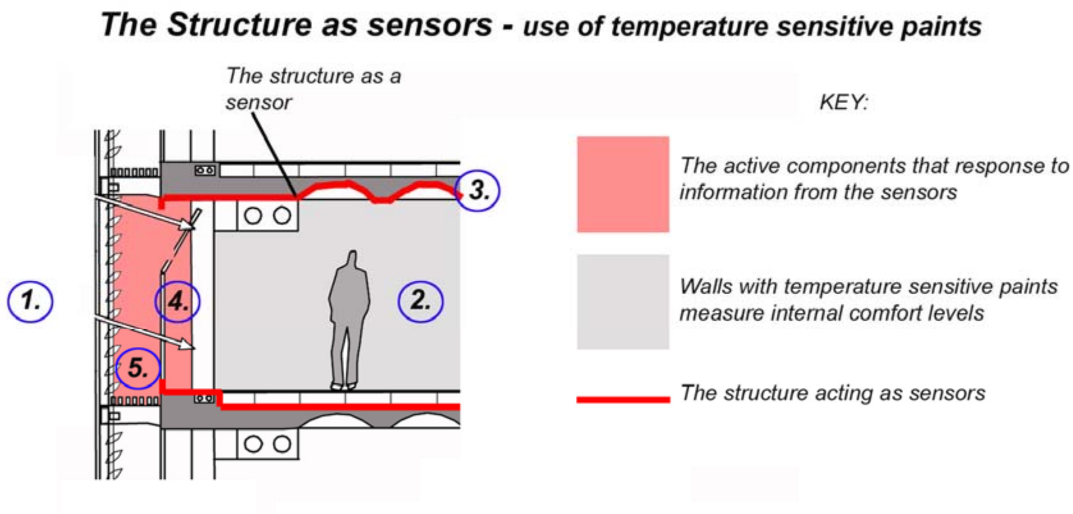


Fig. 6. Cité International, Lyon: TRIZ-inspired façade concept design (reproduced from Turley 2005 with permission).

Another case study focused on intelligent sensor applications in buildings. This time the inspiration was a problem with the Helicon building, London. The 'intelligent façade' design of this building was seen as the "solution to many of the problems of an energy-efficient office in an urban site" (Loughran, 2003). Inner-city areas with poor air quality dramatically limit the use of natural cross ventilation. The Helicon building's facade consists of a ventilated double skin with electrically controlled shading devices. The building envelope is highly glazed to maximize natural daylight use. Its solar screens double as light shelves preventing excessive heat gain while reflecting daylight deep into the building. A mixed-mode ventilation and air-conditioning strategy, controlled by sensors which test external air quality, determines when natural cross ventilation can be used. However through misuse and tampering with sensors by occupants, the building is not operating as designed, so that, for example, shading control devices do not work above the main entrance. The highly glazed building has problems with overheating in this area resulting in unintended extra use of mechanical cooling (air-conditioning). Therefore the facade is using energy rather than conserving energy which it was designed to do.

The student also went on to use the knowledge database part of the TRIZ toolkit to identify pre-existing technological solutions to the conflicts and trade-offs identified. He was able to make a significant number of useful suggestions to show how the Helicon building problems were readily tackled using off-the-shelf solutions available in other sectors. What is most encouraging about many of these solution concepts is that – thanks to the students' grasp of the 'ideal final result' evolution drive – they offer the desired function without complicating the overall structure. One particularly elegant combination of IFR and contradiction elimination thinking came when the student saw a need for 'large numbers of sensors *and* no sensors', and then set about using the TRIZ knowledge base to see how it might indeed be possible to have sensors everywhere without having the expense of installation and control complexity (Figure 7).



1 - *External environment: solar radiation & air temperature*

2 - *Internal temperature/internal comfort*

3 - *Heat sensitive paint as a 'sensor' device.*

4 - *Signal device (refer to diagram below). Photocells device located at external glazing. Colour filters determine internal temperature levels according to colour of walls and surfaces. This in turn sends an electrical signal to the solar louver blinds to set the optimum position for internal comfort.*

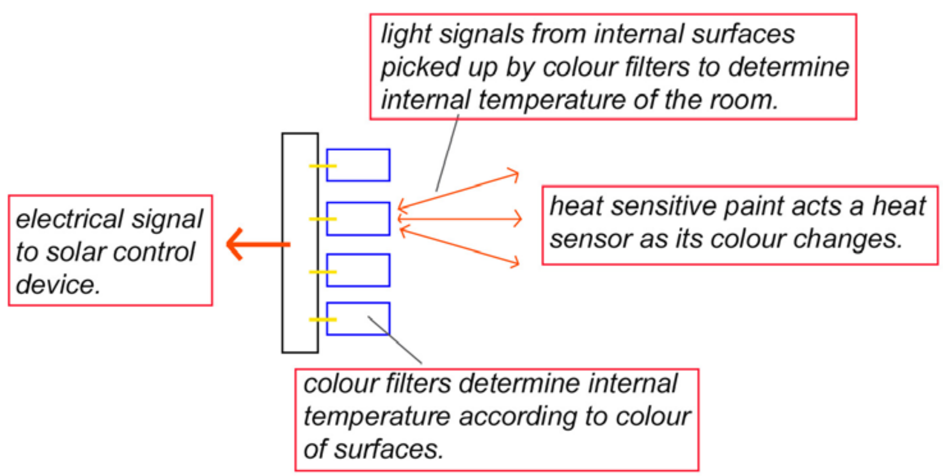


Fig. 7. Sensors everywhere by the use of temperature-sensitive paint

(reproduced from Turley 2005 with permission).

3. Summary & Conclusions

Three case study examples is, of course, a very small number from which to draw conclusions. There are however a number of emerging pointers indicating how to expose architects to TRIZ.

3.1 Lessons Learned

Different students were attracted to quite different parts of the TRIZ toolkit (though the function database was not available to Student 1). The TRIZ community is currently debating how best to teach people the method. Our experience appears to confirm that, by allowing students to find their own way through the available TRIZ tools, they are more likely to find something that will deliver them some benefit. In other words, it is better that TRIZ adapts to the individual rather than the other way around. While this might not deliver a perspective of TRIZ that is either complete or efficient in its application, what it will deliver is some tangible benefit. Once this tangible benefit has occurred then there is motivation to explore other parts of the toolkit. We believe that this is an important pointer to how the subject might best be presented to architects – especially in the light of the profession's rejection of other design methods in the past.

It also appears clear that several of the TRIZ tools would benefit from a re-framing to suit the architecture context better. In many ways, the students in this programme were set an enormous challenge, to find how TRIZ is relevant to them in the absence of any prior architecture case studies and where all of the tools have been configured primarily for engineers. That they were able to make any connection at all is a strong testament to their interest and dedication. Of the TRIZ tools used by the students, it is probably the classical Contradiction Matrix tool that would benefit the most from a re-framing. Here is a tool with instinctive appeal – the idea collapsing all of the world's contradiction elimination experience onto a one-page grid – that subsequently turns into disappointment when the solutions recommendations offered are unable to be connected to the architecture context. When instinctive appeal turns to swift disappointment, the tool is not doing its intended job. This finding is consistent with observations in other new and emerging TRIZ application areas. In areas like software design and business and management, the result has been the construction of a new Matrix tool specifically tailored to the language and context of workers in those fields. We anticipate, therefore, that there is a corresponding context-matching exercise to be carried out for architects.

With TRIZ it is a common occurrence that a solution obtained by the method looks 'obvious'. Beyond the TRIZ boundaries, however, 'obviousness' can be problematic, largely because of poor task definition. All we can say at present in the architecture context is that in each of the student cases, the starting point was the current state of the art of architectural design practice as understood by these postgraduate students. Several solutions that emerged might appear obvious now: they certainly were not obvious beforehand. Perhaps the general lesson here is that, for the first time, the TRIZ knowledge database offers architects simple and ready access to technical solutions that are 'obvious' in other fields of endeavour, that as yet are anything but in the world of architecture.

3.2 Further Work

We are confident that further work is justified on making TRIZ available to architects. Amongst the next steps is the creation of a version of the TRIZ toolkit for architecture. Once such materials become available, we plan to expand our TRIZ education strategy with other postgraduate students in order to establish if and by how much the re-framing helps users to get to the point where they can see real tangible benefit from using the tools in the shortest possible time.

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