Four Questions about Construction Information Technology

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Summary: The problems we are dealing with in construction IT were known in the sixties. In this position paper I claim we are not solving them, because there are things we don't know about construction IT: (1) we don't know very well what construction IT is; (2) whether it has an appropriate scientific method; (3) whether it may be justly labeled "construction" IT, and (4) we don't know how much of construction IT can construction industry absorb at all. Answers to these questions should provide directions and methods for future construction IT research, and means of evaluation of the results and solvability of the current problems.

1. Introduction

More than thirty years ago, Champion(1967) wrote:

> *"One of the problems which is important in relation to the use of computers generally in the building industry is that of finding a satisfactory coding system for information. Whereas individual firms can quite easily devise their own coding systems, the use of computer techniques throughout the industry as a whole will depend to a large extent on all parties agreeing on one generally accepted coding system. One of the difficulties is that different sections of the industry may require different forms of coding; what is ideal for the quantity surveyor for producing Bills may not be satisfactory for the architect for his own use, and vice versa."*

And after 30 years of research and development, particularly intensive in the last 15 years, very little has changed. Are we addressing the wrong problem? Is it solvable at all? If not, what else can be done?

2. What is construction information technology and its role?

Information technology in civil engineering has been developing into a research discipline in its own right. It is also increasing its share in the curricula. Related chairs are being set up in the faculties all over the world. However, IT in civil engineering has many attributes of an immature science because its vocabulary, methodologies, framework and even scope are only loosely defined. It is a subject of influence from the technology push of computer science and technology pull of core civil engineering disciplines and therefore lacking a clear identity of its own.

Historically construction IT emerged form "computing in civil engineering" but after every civil engineering discipline started to use computers, not much was left. Two sets of topics remained affiliated with construction IT:

- technology oriented topics that span over several civil engineering disciplines (e.g. product modeling, integration, concurrent engineering).
- engineering topics that span several disciplines or life cycle phases, such as construction documentation, management and economics.

Few definitions of the construction IT topic were attempted (e.g. Bjoerk, 1999). Another possible approach would be to ask again the old questions: What is design? What is engineering? What are the typical things we do when we design and engineer? What are the atomic activities? Where can technology help us?

In the light of the critique of AI these questions should be revisited. Design is not problem solving, it is not a search of a state space and engineering process is much more than input, processing, output (see Turk, 1998).

3. Is the construction IT research method appropriate?

In the sciences, two kinds of methods are practiced, the so called scientific and a Socratic one. The differences are summarized in the table below (Dye, 1999).

Socratic Method	Scientific Method
1. Wonder. Pose a question (of the "What is *X ?"* form).	*1. Wonder*. Pose a question.
2. *Hypothesis*. Suggest a plausible answer (a definition or *definiens*) from which some conceptually testable hypothetical propositions can be deduced.	2. *Hypothesis*. Suggest a plausible answer (a theory) from which some empirically testable hypothetical propositions can be deduced.
3. *Elenchus* ; "testing," "refutation," or "cross-examination." Perform a thought experiment by imagining a case which conforms to the *definiens* but clearly fails to exemplify the *definiendum*, or vice versa. Such cases, if successful, are called *counterexamples*. If a counterexample is generated, return to step 2, otherwise go to step 4.	3. *Testing*. Construct and perform an experiment which makes it possible to observe whether the consequences specified in one or more of those hypothetical propositions actually follow when the conditions specified in the same proposition(s) pertain. If the experiment fails, return to step 2, otherwise go to step 4.
4. Accept the hypothesis as provisionally true. Return to step 3 if you can conceive any other case which may show the answer to be defective.	4. Accept the hypothesis as provisionally true. Return to step 3 if there other predictable consequences of the theory which have not been experimentally confirmed.
5. Act accordingly.	5. Act accordingly.

The scientific method in construction IT is typically applied like this:

(a) follow the advances in general IT, wonder if some technology is any good in construction and find a problem it can solve; or select the technologies, which seemed appropriate for a problem in the construction industry,
(b) hypothesis: "this" is a good approach, it can be used ...
(c) model the construction industry's products, processes or whatever in a way fit for the selected technology, do system analysis and design, produce diagrams ...
(d) write the software an prove the hypothesis with a prototype.

There appear to be three major faults in this process:

Firstly, the hypothesis is not well defined, measurable and verifiable. It is vague and inprovable with methods used in natural sciences. With corrent approach, it is impossible to objectively prove right or wrong. Why?

Schutz (1962) distinguishes between first and second order constructs. Natural sciences concern itself with 'first order' constructs. They are not changed or influenced by observation or intellectual manipulation. The second order constructs are 'constructs of the constructs made by actors' and are therefore influenced and changed by the observer. They are studied by social sciences. Most construction IT constructs are second, not first order.

Secondly, the value of research prototypes is also very doubtful. Some talk of them like of hiding mice and elephants. They prove little until implemented by a CAD vendor and actually used industrially. If this does not happen very soon after the research, it is very likely that the problem will be solved by the advances of general computing. But because most of point (c) and (as illustration) point (d) is very useful for scientific publishing, there has been a tendency of a growing complexity of models invented, rather than applying the Occam's principle.

Finally, the interpretation of the models and prototypes is done by intelligent and flexible humans. The Socratic approach of cross-examination and refutation is almost non-existent. It seems, however, very useful in discussing phenomena that do not have physical existence, in particular product and process models that model human conventions and not some physical 'first order constructs'. This is manifested by a multitude of different, correct solutions and almost zero failures. The zero failure rate, however, does not prove construction IT research successful.

4. How is construction IT different from plain vanilla IT?

We read often that construction industry is different from other engineering disciplines as follows:

- it is involved in one-of-a-kind products; buildings and other facilities are usually unique;
- they are designed, built and maintained in a one-of-a-kind processes;
- the process is carried out by a one-of-a-kind team of contractors an subcontractors;
- team members vary in size, budget and level of IT expertise and are typically small to medium enterprises (SME).

Nevertheless, have we ever drawn any consequences from them? Doesn't all this say that modeling tools should be designed in such a way that they are easily adaptable for one-of-a-kind products; would not this argue for relatively minimalistic models composed of very generic items? Should't we shift the focus to handling data efficiently and not insist on having every bit of data "in a formation" (in-formation!). Processing power and data mining techniques could be applied to get the right data at the right moment.

The processes are unique and typically assemble a unique set of partners. Are the approaches that were conceived for the modeling of certain bureaucratic processes in banks and administrations, that are repeating millions of times, really suitable for something as chaotic as construction? What does hapen in construction a million of times? The speech act theory and the communication workflow approach have not been sufficiently addressed so far.

A particular problem in the implementation of IT is the varying IT capability of the team members. The co-called state-of-the-art could be available to some best practice firms, but how about the rest of them. In particular if the goal is computer integrated construction, the benefits come when the entire virtual enterprise can use them.

In summary, construction IT is different in the following ways:

- it should support products that cannot be described by standardized product models.
- it should encourage the transparency of the private models used in various applications more than the use of unified, standardized models (e.g. XML data exchange, publicly available EXPRESS files or component definitions).
- in "process" support it should focus on human-human communication and acknowledge improvisation as an important way of working in construction
- it should build a thin layer over a moderate technical and human-resource infrastructure. Web and browser based solutions that work with little overhead over phone lines seems the lowest common denominator.

5. How much IT can construction companies absorb?

It has been often noted that the intake of information technology in the construction industry has been slow, slower than in other industries. Researchers seem to live under the impression that they have all these fantastic solutions and that all that is lacking is a way to make the construction industry use them. Several research projects have tackled this issue from the perspective of educating the practitioners and tried to bring research results closer to the practice (e.g. SCENIC) or asking the practice what it wants (ELSEWISE). Generally, I'm not sure that the studies that question the industry ask the right question. The do not know how much more will the use email or if they need product models.

What they should know, and what would be very useful for the researchers in the field would be, how much are they capable and have time, to learn in a given period of time. Suppose that an upgrade from Word 6 to Word 7 is a unit of technology enhancement effort (TEE). How many TEEs a year can their staff afford. How many TEEs is worth an introduction of a commercial document management system? How many TEEs is the implementation of a state of the art integrated environment created in a multimillion EU project? How much overhead can they swallow to adopt a new technology? What should be investment return rate e.g. after how much time would the time invested in installing and learning a new technology return in time savings due to using the technology? Yes, computer assisted learning can speed up the learning process but without clear answers to the above questions, we don't know by how much.

Intuitively it seems that due to the nature of the work, construction industry is very demanding in these matters. Evolutionary technologies, that would build on existing knowledge and ones that would have a clear upgrade path would have an edge over revolutionary ones.

6. Conclusion - towards human orientation

Current directions of construction IT have been focusing on products, processes and state of the art technology. Research methodology was shaped on that of the natural sciences.

Future directions of construction IT should focus on the human - the engineer, the architect, the technician - who is supposed to be assisted by the technology and who designs, engineers, learns and interacts with other humans. Research methodology should be influenced by that of the social sciences. It should be taken into account that the objects of study are a second order entities.

7. Acknowledgemnt

The citation of Champion was brought to my attention by S. Fridquist from Lund University, Sweden.

8. References

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