When Sustainable Technologies are Ignored. Socio-Technical Systems Thinking, Construction and Sustainable Development

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Abstract
Achieving sustainable environments requires the construction industry to employ digitalization processes, appropriate procurement methods and innovative technologies. However, the benefits of innovative technologies can be missed when construction supply chains are disjointed and procurement methods inappropriate. This paper reflects on the installation and use of a digital technology in the built environment: a Japanese digital toilet installed in a Vietnamese hotel as experienced by a UK tourist. Employing an autoethnographic approach, the paper mobilises socio-technical systems thinking to examine the digital technology to identify factors leading to a negative experience of the technology from the authors` perspective. The analysis leads to a discussion of innovative technologies and construction supply chains, digitalization processes, the project lifecycle and achieving sustainable futures. The retrospective examination of an innovative technology identifies several issues of importance: communicating the innovation function/purpose; cultural barriers to innovation use; value of data for technological innovation; importance of the innovation experience; maximising technology value through the project lifecycle; social benefits of innovations in the built environment: integration of innovations with external stakeholders (government/social services), etc. The socio-technical systems analysis provides a framework for both retrospective review of existing technologies and an assistive tool to improve planning, design and installation of new technologies in the future. The issues explored are relevant for technology innovators, academics and practitioners in the field: achieving a sustainable future requiring both a predictive and retrospective adaptation of technologies in the built environment. The potential business opportunities in such work are also noted.

Keywords: Socio-Technical Systems, Innovation, Construction Supply Chains, Digitalization, Construction Lifecycle

1. Introduction

Whilst it is recognized that digitalization of the construction supply chain, procurement and positive use of technologies are important for achieving sustainable futures that innovations installed in the built environment can be under-utilized or even ignored is much less acknowledged [1]. Unfortunately, despite their positive impact on sustainability, innovations can be ignored, meaning their positive impact on national and global sustainability challenges are missed. For the user, experiencing an innovative technology for the first time can be either a positive or a negative experience. Disappointment often results if the purpose of the technology is unclear, or if there is a misalignment between user knowledge and technology purpose. In truth, a multitude of factors contribute to the final "experience" of a technology by

a user, and whether or not an innovation is used to help address sustainability challenges. However, many issues can be traced back to the construction project design and delivery process, when the idea for an innovation may be discussed for the first time. This paper explores such issues from an appropriate theoretical perspective (socio-technical systems thinking), building on the experience of the author with one such innovative technology: a digital toilet installed in a hotel bathroom. The findings provide both a framework for retrospective review of existing technologies in our built environment and a predictive tool to assist construction professionals and technology innovators in their work. Methodologically, the paper employs an auto-ethnographic approach to provide personal reflections [2]. Theoretically, the use of socio-technical systems thinking is appropriate for examining

innovative technologies in construction management work: the author proposing that a digital toilet constitutes a system initself which lends itself to a socio-technical systems analysis [3]. As an industry, we are tasked with acknowledging problem issues, and (where possible), presenting solutions for them. Therefore, advocating for suitable adaptation of existing technologies in our built environment to maximise our chances of a sustainable future is important. It is argued that the insights and issues discussed are relevant to achieving sustainable futures.

The paper begins by introducing socio-technical systems thinking and the framework of to be deployed in the paper [3,4]. A methodology section describes the autoethnographic approach employed before a description of the technology encountered and the user experience is provided [2]. A following section uses concepts from to analyse the digital technology itself; a following discussion provides a reflective review of the issues identified [3]. A final conclusions draws the insights of the paper together.

2. Socio-Technical Systems Thinking

Socio-technical systems thinking recognizes that productivity, human well-being and optimal performance of work tasks may be achieved via a joint optimization of the social with the technical [4]; such a joint optimization being possible through a harmonisaton and balance that optimises worker satisfaction and safety [5].

Socio-technical systems theory has over 70 years of research and development, contributing to practical advances in a wide variety of work environments, including coal mining, accident analysis and causation [6,7]. Called for a wider application of socio-technical systems thinking to multiple problems, maintaining that many problem issues in society are systemic in nature, requiring systemic solutions [3].

The socio-technical system framework of (figure 1) shows the inter-connected relationship between people, goals, processes, buildings, culture and technology: the initial schema of being extended into a framework by to represent how systems are embedded within external environments (consisting of stakeholders; regulatory frameworks; financial/economic circumstances) [3,8]. As noted by the core idea is that any complex system may be represented in the form of a socio-technical hexagon, with several inter-connected concepts being fundamental to its' functioning [3]. Illustrate their framework through several worked examples (crowd events; workplace environmental sustainability): the framework being a simple yet powerful representation of the interdependent nature of work systems. The framework provides a schema for analyzing the linkages and relationships between social and technical issues, whilst providing a systematic way of analyzing a variety of complex systems, problems and events. As noted by, the method lends itself to both retrospective and predictive work [3].
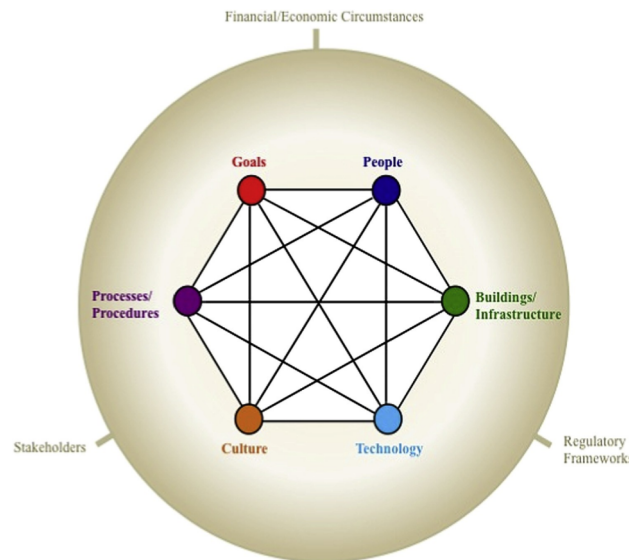

Figure 1: Socio-Technical System [3]

[3] provide a 10-step method for analyzing a socio-technical system, including data collection, analysis and relationship identification. Fully worked examples of the framework in action may be found in [9-11]. This paper does not report such detailed work, but is rather a first-step in proposing socio-technical systems thinking as a useful approach for planning and review of innovative technologies in our environment.

3. Methodology

As noted, the paper employs a socio-technical system schema (figure

1) to examine an existing technology in the built environment. The author uses his own thoughts to reflect on the technology: no interviews were undertaken. Such an autoethnographic approach is an established research method [2]: autoethnography providing a useful approach for reviewing events, discussions and work situations that can provide useful reflections in multiple contexts [12-15]. By combining autoethnography with a socio-technical systems thinking, the paper provides both a retrospective examination of an existing technology and a predictive analysis tool for future technology integration into the built environment.

Moreover, the analysis leads to a discussion of relevant issues for construction professionals and practitioners active in construction project management.

4. Digital Toilet in Hotel

In December 2023, the author visited Hanoi, Vietnam, and stayed in a number of hotels. One hotel had a digital "intelligent" toilet technology installed in the bathroom (figures 2-4). This "smart" technology may be defined as a toilet with the added enhancement of SMART home technology [16]. This positive surprise (this being the first time the author had seen the technology) turned to disappointment: the printed instructions were in Japanese; the hotel had not provided any guidance; nor was I signposted to any information online. As a result, I could not make use of the technology, nor expand my understanding of it. As a result, my encounter was negative in that I left the hotel ignorant of what the technology could do for me. From a sustainability perspective, such a fully functioning technology could make a positive impact for the individual, the hotel and the city authorities. However, encountering the redundant technology felt like a missed opportunity. I was left to think over the experience – what did my negative experience tell me about innovative technologies used in construction work? Could anything be learned from the experience? Following further thought, the author decided to conduct a socio-technical systems analysis of the technology, as encountered in the hotel.

Figure 2: Digital Toilet in Hotel

Figure 3: Control Pad

Figure 4: Manufacturer Information (Japanese)

4.1 Analysis

The following section presents an analysis of the technology using socio-technical systems thinking. An Accompanying Table 1 lists the author insights.

People: People can be defined as the construction project team (i.e. the internal stakeholders: hotel client; designers, principal contractor; subcontractors; etc.) and the hotel users (part of the external stakeholders). It may be concluded that internal stakeholders are not now focused on technology value; whether this was true during hotel design and construction is an empirical question. During construction, the contractor may have been simply focused on installation of the physical toilet, and not mobilizing its' digital capabilities (again, this is an empirical question). What can be said with certainty is that the full value of the technology (as envisaged by the Japanese designers) is not now being met. For hotel users of today, the technology is a missed opportunity. When I asked about the technology to the hotel front desk, my question was met with incomprehension. The lack of current end-user engagement is evidenced by poor communication between hotel owners and guests regarding the technology. As a result, there is a failure to enhance the hotel experience for guests.

Goals: The goal of the technology is not being met: the positive benefits of the technology on sustainable issues are not being realized. Although guidance is clearly written on the device (figure 4), this is incomprehensible to UK and Vietnamese users. The full extent of how the technology may contribute to sustainability is unclear, but it may be argued that it would positively contribute to city, regional and national environmental targets and health service needs and challenges. The possible personal health needs of individuals should also be noted as part of the bigger Goal picture.

Technology: Whilst the affordances and benefits of the technology are being missed, it can be noted that the hotel was fitted with efficient wifi services, enabling such a technology to work if required. The relation of the digital toilet to mobile device apps. was not investigated, but this would be intrinsic to effective functioning of such a technology.

Culture: the culture of Vietnam and UK is not aligned to regular use of such a technology, whereas the culture of Japan is. Changing cultural behaviours is a major task (c.f. mask wearing and Covid pandemic). A primary driver for cultural change is government, through education and financial incentives. Personal digital technologies in the built environment, such as the digital toilet, have a definite role to play in achieving sustainable environments. The author would have communicated a positive first-time experience of using the techynology to friends, family and colleagues in the UK if he had experienced it.

Processes: Because the technology was dormant, there was no evidence of any processes being in place to mobilize the technology, although the Japanaese guidance (figure 4) should be considered part of the process. The void in processes/procedures contributes to the benefits of this technology being completely missed.

Buildings/Infrastructure: each hotel room was fitted with the technology (as confirmed by the hotel desk). Despite the hotel having good wifi connectivity, the technologies were not mobilized through any interactive user interface (UI). The bigger supporting infrastructure of Hanoi city region in supporting these technologies was not investigated, but would be significant in the overall effectiveness of such devices to address sustainability challenges.

External Issues: Stakeholders: The influence and power of external stakeholders to make this technology active would be significant. City authorities could use data from such technologies to inform environmental services management; health services could use the data positively to improve patient care, etc. The absence of such stakeholder interest in the technologies is a negative force. Securement of such stakeholder support would be important in mobilizing currently installed devices and future digital innovations in the built environment.

Regulatory Frameworks: The technology will have a regulatory framework for its' safe use and operation, but it was unclear whether or not the hotel (or Hanoi city) complied with these. Certainly, regulatory compliance would be required for any retrospective upgrade work.

Financial/Economic Circumstances: Presumably the digital technology is more expensive to buy than a regular toilet, but the financial circumstances of their purchase is unclear. Technology re-activation would be an option for the hotel, and a certain cost would be required for this, but this did not seem to be a priority for the hotel. Any city effort to re-activate such technologies would have a financial cost: the role of the construction industry here is potentially important (see Discussion).

Concept	Description
People	Ignorance of technology value Lack of end-user involvement No communication about the technology Failure to enhance hotel experience
Goals	Unclear goal of technology use Failure to connect with individual and govt. goals
Technology	Failure to mobilise the technology affordances Wifi connectivity present
Culture	Cultural mismatch between technology and users
Processes/Procedures	No clear processes in place
Buildings/Infrastructure	Wifi services provided No supporting infrastructure

Table 1: Socio-Technical Analysis

The same concepts which help explain why the technology is not functioning through a retrospective review can also be used as a planning tool for future technology innovations in the built environment. It should be noted that each concept may open up significant work tasks to be completed, although some elements may already be in place (e.g. the Hanoi hotel already had wifi services installed). The paper now discusses the issues raised by the analysis further.

5. Discussion

The socio-technical systems findings largely align with more detailed studies into sanitation innovations in the built environment and their functionality [16,17]. Whilst the insights are limited (being the authors` own), they are informative in noting how combinations of social and technical issues impact sustainable technology use now and in the future. The highlighted issues lead to a broader discussion of sustainable development and the role of the construction industry in addressing such challenges.

It has been noted by that sustainable development research is moving from the margins to the mainstream of management studies: sustainable development being "a research paradigm that assumes a normative outcome (social equity) and a theoretical perspective (systems)" [18]. A socio-technical systems thinking approach to sustainability challenges embraces the complexity and interconnection between technical and social systems over time. The author contends that sustainable development should consider dormant and under-utitilized technologies in the built environment as part of the solution to the sustainable challenges facing us all. Such a proposition aligns with the conference theme that challenges us to think how innovation technology shapes the sustainable built environment beyond the limits for research and industry. A non-functioning digital toilet in a Vietnam hotel is relevant and may be taken as a prime example of the challenges we face as a construction community in addressing environmental and sustainable development challenges. As noted by [3], most problems in society are systemic, requiring systemic analysis and solutions. Also note the need to take more predictive work that help identify problems and solutions in advance. It is beyond the scope of this paper to provide detailed solutions to the specific problems identified in Table 1. Instead, the paper will note issues of interest for the construction industry that stem from the study.

Construction professionals (architects, designers, contractors, etc.) are bound by the procurement routes and contractual set-up of any project, and these must necessarily impact each parties input into design, delivery and maintenance of any innovative sustainable technology in the built environment. Clearly, technology suppliers have an interest in ensuring the optimal use of their equipment, so effective communication to the project client and construction supply chain is in their interests. In the hotel in Hanoi, there had been a breakdown in communication between parties. However, the technology itself remained intact, and with wifi services available, so it would be possible to reactivate the technology. Does the construction industry have a role to play in any such technology "resurrection"? The answer is "yes", if we accept that technologies will continue to evolve beyond the time of their installation, no matter how "innovative" they may be. Therefore, our approach to sustainable technologies should also be shaped this reality. In a Smart city of the future, such technologies would be part of our built environment experience.

Construction professionals should be ready to advise the project client accordingly if a sustainable technology can be adjusted to a new environment, or whether disposal is the best option. That decision can be informed by a socio-technical systems analysis of the sustainable technologies in question: the concepts presented in the paper being useful in this respect. Of those concepts, the construction industry may be able to exert more control and influence over some more than others. For example, the concept of Buildings/Infrastructure to support sustainable technologies

in the built environment should be a concept where construction professionals can exert a direct influence through professional associations, such as the Chartered Institute of Buildings (CIOB), or through industry networks and contacts with local and regional government. As sustainability is now a subject of regional and national concern, the views of construction industry professionals concerning the built environment will be increasingly considered as important. Other concepts of the socio-technical systems hexagon would not be as easy to influence, such as Culture. However, understanding any sustainable technology in the built environment holistically as a system in itself will assist planners, designers and construction professionals in delivering better value for the client in delivering a project that achieves sustainability targets. A socio-technical systems analysis contributes positively to such an aim.

6. Conclusion
The paper provided an autoethnographic account of one innovative digital technology in the built environment: a digital toilet in a hotel. The socio-technical systems analysis of the technology helps to explain its' non-functioning today, whilst also assisting in the identification of work tasks that will re-activate the technology so that it contributes positively to a sustainable future. Those same socio-technical concepts may be used by future innovation technology developers and construction project designers and planners in scoping out the factors which determine whether or not a technology in the built environment will be successful or not when delivered through a construction project and then used by the client in the operation and maintenance of a facility. Understanding sustainable technologies in the built environment from a systems perspective helps to clarify their working and functionality. For construction industry professionals, such a systems view of a technology will assist in their work to deliver better value for the client.

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