An Innovative Approach to Technology Mediated Architectural Design Education

A framework for a web-based socio-cognitive eco-system

Tuba Kocaturk[1], Riccardo Balbo[2], Benachir Medjdoub[3], Alejandro Veliz[4]
University of Salford, School of the Built Environment, United Kingdom.
[1]T.Kocaturk@salford.ac.uk, [2]R.Balbo@salford.ac.uk, [3]B.Medjdoub@salford.ac.uk
[4]A.A.Veliz@edu.salford.ac.uk

Abstract. *Learning in architecture has shifted from an individual focused approach to a larger system of interacting individuals in a situated, tool-mediated and socio-technical context. In addition to developing essential skills to work with diverse design software and taking part in collaborative design activities, learners also need to be equipped with competencies that will allow them to operate intelligently outside of situations of distributed cognitions. The challenge in present educational climate is to develop pedagogical approaches where situations of distributed cognition are not the ends themselves but are the means for improving mastery of solo competencies. The paper contributes to the current discussion about the need to re-orient architectural education and proposes a pedagogical framework for the development of a new web-based teaching/learning environment (socio-cognitive eco-system) as an integrated platform to support both autonomous and distributed learning.*
Keywords. *Technology-mediated learning; distributed cognition; design pedagogy; digital design education.*

INTRODUCTION

The context of this paper lies within the subject areas of "innovative teaching/learning" and "technology mediated learning" in Architectural education. The proposed paper aims to report on an ongoing research project which has recently been developed by the Mediated Intelligence in Design (MInD) research group, at the School of the Built Environment, in the University of Salford.

Our work has its origins in the recognition of the limitations of existing technology-mediated learning environments used in project-based (or design-based) courses. The ongoing research emphasizes the need to identify both context and content specific changes in architectural practice and education - which needs to be addressed in the design of technologies to support design learning. The proposed research makes an intellectual contribution to the growing body of literature on "constructivist learning" by taking the "distributed intelligence" perspective. Such perspective emphasizes the distributed nature of knowledge across individuals, social groups, and media, and therefore proposes the need to integrate individual, socio-cognitive and tool-dependent dimensions of learning and meaning making in Architectural education.

In the specific context of Architectural education "technology mediated learning" has two distinct dimensions. One is the *didactic* use of web-based technologies to aid the learning process of the individual learner. The second dimension relates to the highly technology mediated *disciplinary* content of the architectural design process itself, due to the new emphasis on integration of technology into all phases of design from conception through to production. In this research, new themes and additional knowledge content introduced by the *disciplinary* dimension are considered to be closely linked to the utilization of the *didactic* dimension. This paper aims to discuss the extent to which these two dimensions can be embedded, stabilized and sustained within the educational context.

Therefore we aim to contribute to the discussion about the need to re-orient architectural education and propose a pedagogical framework for the development of a new web-based environment (socio-cognitive eco-system) with a special emphasis on providing support for personalized, self-directed and distributed learning in Architecture. This emphasis is grounded on the recognition of emerging modes of informal learning through socio-technical networks, which have started to become an integral part of student experience in higher education. The potentials of diverse media and informal web-based knowledge acquisition have already been acknowledged to facilitate diverse and innovative kinds of communication. Although the highly fragmented informal web-based knowledge acquisition and sharing (through blogs, facebook, online tutorials, webinars, twitter, youTube, wikis, etc.) provides powerful inputs to knowledge/skill building, the process is highly learner centric, bottom-up and usually motivated by the needs and aspirations of the individual learners. This contradicts with the existing top-down and controlled course structures and delivery methods with pre-defined learning outcomes that currently exist. The main challenge the students face today is making sense of the highly complex, at times contradictory and very contextual knowledge they encounter without relevant frames of reference, and for the educator to balance the freedom/autonomy of individual learner with the critical interpretation of the captured information (Siemens, 2010). We are currently in the process of developing an innovative "curatorial approach" to technology mediated learning and aim to develop a framework for a web-based environment (socio-cognitive eco-system) based on this approach which supports innovative teaching/learning experience and course delivery. In this paper, we will first present a discussion to ground the motivation and the rationale for the development of such an environment. This includes the identification of the combined socio-technical, cultural and knowledge-based change in architectural practice and education as well as the global factors that are driving this change. We will then reflect on the utilization of virtual learning environments and e-learning in current architectural education. Both discussions will help identify the relevant elements of our pedagogical framework to be implemented in the development of the proposed socio-cognitive eco-system. While doing so, we will draw from multiple disciplines, including; design-education, cognitive science, developmental psychology, learning sciences and intelligent/adaptive learning technologies.

THE NEED FOR A NEW PEDAGOGICAL AGENDA IN ARCHITECTURAL EDUCATION

Architectural profession is going through an enormous transformation. The commercial availability of complex software technologies have led to a new and diverse design culture. Additionally, the new emphasis on integration of technology into all phases of design and the growing importance of climate change, energy and sustainability placed an emphasis on new roles/skills for all parties, and new methods of collaboration. The professional market today demands a reorientation in theoretical, conceptual understanding and skills in the architectural profession (Oxman, 2008; Kalay, 2006). Practices are increasingly demanding the need for educating the "new digital architect". In order to meet current de-

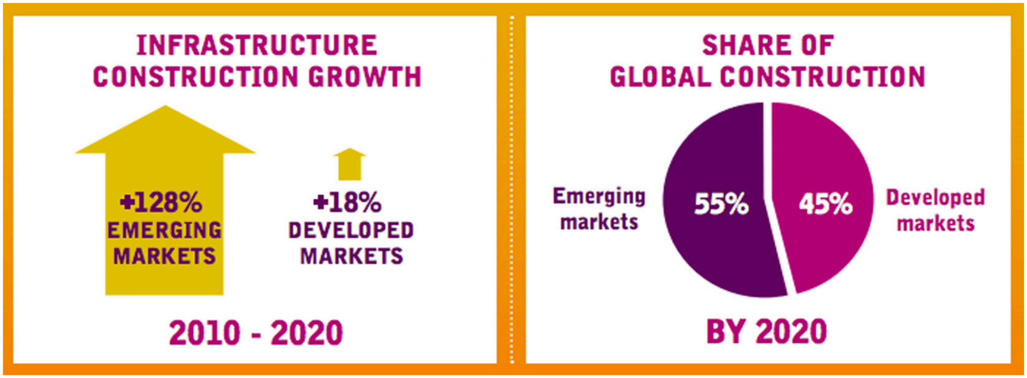

Figure 1
The Emerging markets and the potentials for the Construction Industry by 2020 (Jamieson, 2010).

mands for new methods of professional specializations, leading architectural schools in the world are currently exploring and experimenting with new ideas, theories, methods and techniques of educating the new generation of digital designers. Various conferences and publications stress the need to develop new curriculum and new pedagogical approaches to remain relevant to changing global demands and the changing profession (Kvan, 2004; Oxman, 2008; Allen, 2012). There is an urgent need to accommodate this combined socio-technical, cultural and knowledge-based change with a re-orientation of the curriculum, new methods of delivery and pedagogical agenda.

Global trends and profiling the architect of the future

According to a recent study into the Future of Architectural Profession, conducted by the Building Futures group of RIBA there is a reduction/decline in demand for traditional architectural services in UK since 2008 by 40% (Jamieson, 2010). However, according to the same study, there is still a considerable increase in demand to study architecture in the UK. This means more qualified architects are graduating every year than the profession can accommodate in traditional roles. In order for the UK architects to take leading roles in global markets it is crucial that architectural education responds to the new challenges and demands in the industry. According to the same study, the global population growth is predicted at 46%, and 70% of the population is expected to live in Urban Areas by 2050. This means more emphasis on urbanism, more construction, and a bigger demand for construction professionals, including architects. Although the growth of construction is reported as 18% in developed markets, this rate is 128% in emerging/developing markets (Jamieson, 2010). Considering that the share of global construction for the developed markets is 45%, if this trends continues, architects educated in developed countries will opt more for the challenges and opportunities in the global markets, implying a growing tendency for architects to work in a more networked manner (Figure 1).

The same report also addresses a growing shift towards those trained in architecture moving into other parts of the construction industry. The number of trained architects holding senior positions across the industry seems to be gathering pace, while there is a decreasing emphasis on the "star architect", but an increasing trend on "multi-disciplinary design practices". Previously, personal success and fame in architecture was impossible to attain before e relatively older age; nowadays it is quite common to come across relatively young and successful architectural firms. These firms are design-driven, technology adept and agile, capable of making rapid adjustments as the project or the market requires it (Allen, 2012). They use new technologies and strategic collaborations to leverage their expertise to respond to larger and more complex projects. In other words, "the habits of mind and ways of working once associated with experimental practice or the academy have been re-contextualized in this new climate of practice" (Allen, 2012, p.226). Creativity and innovation are no longer on the product nor is design solely judged by it. The new emphasis is on the means and methods of creating, manufacturing, communicating and taking tadvantage of global interconnectivity.

The emerging technology-mediated design and management processes such as Building Information Modelling, and Parametric Design as well as the emerging visions for an "Integrated Practice" in building industry also carry potentials to fundamentally transform the way in which architectural education engages with issues of design, technology, representations; questioning the roles and rules of traditional architectural conventions. (Ambrose et al., 2008). There is a growing interest in a new profile of architect, who can *work globally, interdisciplinary, technically capable, who not only can design but can also adapt to different cultural and social contexts, can network and respond to the global themes and challenges creatively.*

We are also experiencing the emergence of additional profiles, new specializations and consultancy services high in demand in building industry. For example specialist consultants who provide coordination mechanism between design and production processes, in-house specialist modelling groups within the architectural offices who provide customized tools, techniques and workflows per project, or BIM specialists. In such expanded modes of practice, one size doesn't fit all. Is it sustainable or even possible to reproduce "architects" with exactly the same profile? How do we address the emerging roles and profiles for architects through effective provisions of the curriculum and delivery methods? Architectural expertise is being re-aligned. More importantly, the question that is of paramount importance for the profession is *how architectural education is responding to these emerging modes of practices and global developments*.

HOW IS ARCHITECTURAL EDUCATION RESPONDING SO FAR IN TERMS OF CONTENT/PEDAGOGY AND DELIVERY

When we look back over the past two decades of architectural education, we distinguish three distinct and interconnected tendencies and their consequent repercussions in educational agendas, especially in the developed and developing countries. The first is a new approach of learning through social and technological networks due to the emergence of new intellectual consortiums developed among (design)tool builders, practices and academy. Through various workshops real design scenarios are collectively developed, modelled, computed, simulated and fabricated, opening paths to new agendas as well as experimenting with new ideas, theories, methods and techniques of educating the new digital designer. An increasing emphasis is placed on architecture's instrumentality and ability to confront actual problems and integration of technology and multi-disciplinary values into the design education.

The second is the expansion of the profession's knowledge-base and skill sets. Integration of technology into all phases of design and the growing importance of climate change, energy issues and ethics and environmental sustainability placed an emphasis on new roles/skills for all parties, ability to integrate cross-disciplinary value systems, and new methods of collaboration. Such an expansion has also led to a diversity of skill sets and pluralist tendencies. There is not a single dominating design direction or agenda, but a series of diverse intellectual agendas multiplying the possibilities and points of views. This can be confusing to a student in the process of cultivating his/her intellectual independence which has become a major challenge to attain in such plural climate. This pluralism is contributed by the intrinsic methodologies implicitly embedded in the commercially available "digital design tools". A student working with Rhinoceros, Grasshopper, Generative Components, Autodesk Revit or Digital Project develop both complimentary and at times contradictory approaches to "design tasks", and develop context and technology-bound and situated perceptions of the problem at hand. These ubiquitous mediating structures that both organize and constrain activity include not only tools, and new forms of representations, but also other learners, teachers and other users distributed in social relations. The influence of tools on the way we think and design has never been of this magnitude and variety.

The third is the effect of socio-technical networks on knowledge acquisition and blurring the distinction between local and global dimensions of design knowledge. Architects today work in distant locations, students are highly mobile and are exposed to varying approaches. The student enrolling in an architectural school in Tokyo, Los Angeles, or London is drawn to that city less for its local design culture than by a desire to join into the global network (Allen, 2012). Many tool builders/vendors provide skill building activities and travelling workshops (on a global scale) in collaboration with architectural schools, giving access to learners (both experienced and novice) from academy and practice. Similarly, many online websites and blogs provide online training and open-source design scripts, 3D models and other forms of information accessible by a global network of designers. In order to support the development of students' competences and skills for the emergent architectural knowledge content, the role of the teacher is shifting from "delivering knowledge" to organizing, guiding and assessing student's learning experience (Lakkala et al. 2008).

INDIVIDUAL COGNITION VERSUS DISTRIBUTED COGNITION

These recent trends in education today point out to a common tendency across many schools of architecture in the developed countries: aiding the learner development through both social and technological scaffolds to achieve more than the learner and the instructor could do alone. In this respect, we identify the emergence of a dominant 'tool-aided', 'socially shared', contextual and highly situated forms of cognition commonly referred to in literature by developmental psychologists and learning theorists as "distributed cognition" (Hutchins et al., 1986) and "distributed intelligence" (Pea, 1993). The central idea in both theories is that the resources that shape and enable activity are distributed in configuration across people, environments, situations and artefacts (tools). In pointing out the mind-environment interface, Simon (1996), in his seminal work, The Sciences of the Artificial, questions whether what we often consider the complexity of some act of thought may have more to do with the complexity of the environment in which action takes place than the intrinsic mental complexity of the activity. He then suggests looking at problem solving as distributed between mind and the meditational structures that the world offers. This is a very distinct departure from earlier models and approaches in design education and definitions of "design cognition" which has traditionally been perceived as residing in the head of the designers and traditional architectural education had commonly geared towards the development of such "individual cognition". Therefore one of the main pedagogical dilemmas today can be grounded on the gap between the distributed and the individual levels of intelligence that students are building through diverse methods of knowledge acquisition and methods of delivery without any explicit recipes of how to build the link between the two.

Salomon (1993) introduces two kinds of cognitive effects of technologies on intelligence:

- *Effects with* technology is obtained during intellectual partnership with it, and
- *Effects of* it in terms of the transferable cognitive residue that this partnership leaves behind in the form of better mastery of skills and strategies.

While *effects with* refers to the development of Distributed Cognition, *effects of* is attributed to the development of Individual Cognition and solo intelligence which are essential for the learner to develop an autonomous response as a residue to interaction with the social and technological scaffolds. Today, the special emphasis on the use of a variety of digital design software in architectural studios and skill building workshops offered by many tool builders provide the necessary social and technical scaffold to the learner. However, a disproportionate emphasis placed on the "tools" present a risk of promoting design as solely a tool-driven activity, especially for the novice learner, displacing the innermost values of architecture, and as a consequence, weakening and changing the role of designer in the society.

In addition to developing essential skills to work with diverse design software and take part in collaborative design activities, learners also need to be equipped with competencies that will allow them to operate intelligently outside of situations of distributed cognitions. The challenge in present educational climate is to develop pedagogical approaches where situations of distributed cognition are not the ends themselves but are the means for improving mastery of solo competencies. This has been referred to as "the higher order knowledge" by Perkins (1993) which not only informs the construction of an understanding of content-level knowledge (of the domain), but also provides a base for executive function. In sum, two extremes – the psychology of individual competencies and that of distributed cognitions – ought to be accommodated within the same theoretical framework. "No theory of distributed cognition can do justice to the understanding of human activity and the informed design of education without taking into consideration individuals' cognitions. The same applies to the flip-side of this argument: No theory of individuals' cognitions would be satisfactory without taking into consideration their reciprocal interplay with situations of distributed cognitions" (Salomon, 1993, pp.135) (Figure 2).

Hence, a central goal is to facilitate students not only be a part of "distributed intelligence" presented to them, but also contribute to the creation of such intelligence in different contexts.

Technology enables new kind of practices; can it also be integrated to serve advanced ways of learning as well?

STATE OF THE ART IN TECHNOLOGY MEDIATED LEARNING IN ARCHITECTURAL EDUCATION

Teaching Architecture is not primarily an instructional process but rather a process of interaction and experience (Kipcak, 2007) and, as described in the previous sections, should comprise of elements to support both distributed and individual cognition. This approach is in sharp contrast with the "instructionist" approaches to learning where content is overvalued and the learner is made the main target of instruction. Many online distance learning environments are developed based on "instructionist" principles. Portals, instructional management systems, computer assisted instruction and most online courses are artifacts of instructionism (Cannings and Stager, 2003). It is no wonder why "distance learning" is not a popular approach in design studio education in architecture, as the current commercially available virtual learning environments (VLEs) do not have the necessary features to address the necessary cognitive demands. However, distance learning and e-learning is rapidly becoming a key element in higher education to produce new educational systems that support a flexible access to the educational programs and broadening the geographical boundaries of universities, supporting life-long learning and continuous professional development (Littlejohn and Higgison, 2003). Commonly, architectural schools support e-learning through virtual learning environments (VLEs) which provide students with access to single and multimedia course materials, online collaboration and computer-aided assessment of the taught modules (Mizban and Roberts, 2008). The implementations so far do not go much further than the replication of conventional course content and delivery techniques within the web-based environment (Oliver and Herrington, 2003).

When learning shifts from the individual to a larger system of the individual's participation in a community of practice, it is more relevant to consider e-learning as a situative context of interaction in which individuals participate and coordinate their

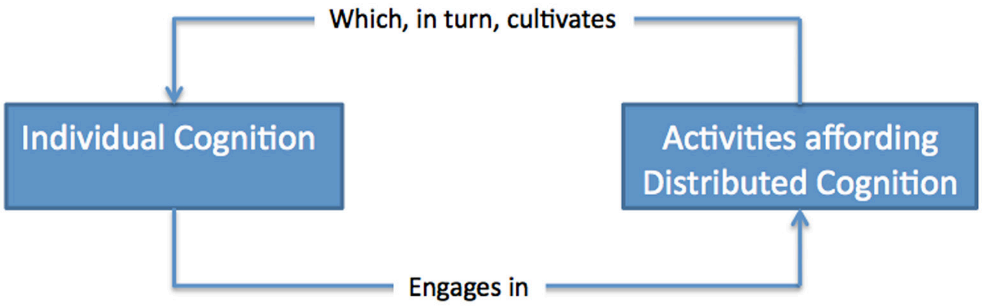

Figure 2
The reciprocal interplay between individual and distributed cognition.

activities to achieve meaningful objectives (Greeno, 1998). There have been some bespoke implementations in the design studio context to achieve this. Majority of the reviewed cases, in the context of Architectural education, have related to the development of possible new ways to design using new technology, with the design studio being used as a "test bed" for new practices (Mizban and Roberts 2008). Other reasons for implementing e-learning have been to develop students' skills, facilitate cross-cultural exchange, and support students' design thinking through the provision of digital repositories and design support system. Mizban and Roberts (2008) identified two key approaches: 1) to augment existing teaching and learning activities and/or 2) to generate new design environments. The benefits have varied, such as allowing schools to develop new teaching methods, promote different types of collaboration, enhance students' skills and facilitate a flexible access to multimedia data and educational resources. However, these web-based applications have proved to be too generic to support the reflective and dynamic knowledge building process of the learner(s) which are among the core issues in design learning. Similarly, the inclusion of the "industry" in these applications as an active participant in the social scaffolding of the learning is either non-existent or very limited, and the extensive potential of web-based learning is left under-explored. There is very little evidence to suggest that e-learning has been introduced to support any particular pedagogic or cognitive need or agenda (Mizban and Roberts, 2008).

INTRODUCING A DISTRIBUTED INTELLIGENCE FRAMEWORK – THE SOCIO-COGNITIVE ECO-SYSTEM

Our proposed approach will be manifested through an online learning environment (socio-cognitive eco-system). An eco-system is described as a community of users together viewed as a system of interacting and in(ter)dependent relationships. What we are proposing is not a substitute to the new modes of architectural education (*effects with*), but an essential support and a complementary activity for building an *integrated autonomous and distributed learning* experience for the learner, by combining *effects with* and *effects of* technology within the same environment (Figure 3).

The online learning environment is envisaged as a dynamic and interactive logbook, where different learned elements can be compiled, organized (structured), represented and shared selectively. The structure and organization will be guided (not enforced) by the instructors, but steered by the learners. It will allow personalization of its content and its interface by each individual user and will have an embedded intelligent system to guide such personalization that would best suit its user's learning style and personal preference. The system will have a flexible interface and infrastructure that could be re-modified to expand and allow new interconnections between its

	Effects with Technology	Effects of Technology
Impact on Cognition and Domain Knowledge	Situated, artifact mediated activity, focus on context	Metacognition, residue left by thinking and reflection
	Social and technical scaffolding	Autonomous, self-directed activity
	Distributed Cognition	Individual Cognition / Solo intelligence
	Being a part of the socially distributed Intelligence	Contributing to the design of Distributed Intelligence
	Content level knowledge - facts, procedures	Higher order knowledge, problem solving,executive skills
	INTEGRATING AUTONOMOUS and DISTRIBUTED LEARNING (*Effects with* + *effects of*)	

Figure 3
Integrating Autonomous and Distributed learning, by combining "effects with" and "effects of" technology.

modules/elements. Therefore the emphasis will not be solely on "compiling" but also on the active contribution to knowledge construction and delivery.

The system will be composed of modules/features where individual, collaborative and guided learning will be distinguished yet interlinked. The guidance will be provided by the instructors who will be acting as "curators". Instead of dispensing knowledge, the curatorial teacher is expected to create spaces where knowledge can be created, explored and connected. Thus, the curatorial teacher acknowledges the autonomy of the learners (and users of the system) and provide interpretation, direction, provocation and guidance. At the same time, he/she is not the dominant expert and relies (and also learns from) the talent and knowledge of his/her students (Siemens, 2010). This implies instructors with a flexible approach and an adaptable methodology, capable to provide tasks that are "checkpoints" rather than full paths. On the distributed side, creative, technical and intellectual expertise will be distributed among the community of its users and will provide support and inspiration for peers engaged in a common learning adventure. On the individual side, students will steer their own learning process and become self-aware of their own learning experiences. They will exercise and build a *metacognition* through constant monitoring and reflection on their learning process. If the individual learning adventure takes an unexpected turn into a new goal/agenda, there must be adequate flexibility to allow students to take the time they need to learn, build, grow and reflect. This requires getting personalized feedback and support to develop their specialization not according to "pre-specified learning outcomes" of the modules, but according to their individually chosen field of focus.

Lakkala et al. (2008) provide an outline of 4 essential infrastructures to support collaborative online learning (social infrastructure, epistemological infrastructure, cognitive infrastructure, and technical infrastructure). We interpret and specify the specific characteristics of these infrastructures within the proposed integrated environment as described below:

- *Social infrastructure*: to facilitate new and alternative modes of online collaboration to maximize contact with different types of users (peers, instructors and other users such as academic/industry partners).
- *Epistemological infrastructure*: directing students to diverse sources for knowledge acquisition, creation and categorization. Different learned elements can be compiled, organized (structured) and shared selectively with other users.
- *Cognitive infrastructure*: ensuring that students (learners) get a conscious understanding of ends and means, underlying foundations of design methods/strategies and gradually learn to work in an expert-like way, by supporting the development of both individual and distributed cognitions simultaneously.
- *Technical infrastructure*: to support the above listed infrastructures technically and to facilitate intelligent tutoring as well as personalization of its interface and content according to user needs, learning styles and preference.

The implementation of these principles and its success also rely on the creation of a robust technical infrastructure in order to support the achievement of the intended outcomes of the epistemological, cognitive and social infrastructures. We are currently investigating the area of "Adaptive and Intelligent Web-based systems" and their implementations in the context of online collaborative learning. The main point of departure of Intelligent Tutoring System than traditional CSCL (computer supported collaborative learning) systems is addressing the issues such as analysing and understanding of learners' activity and production, problem solving and interaction control, which have not been adequately addressed by classical CSCL systems. These systems attempt to be more adaptive than other systems as they are able to build a model of the goals, preferences, and knowledge of each individual user and use this model throughout the interaction with the student and "adapt accordingly to the technological means they are presented with (Tchounikine et al., 2010). In such a scenario, the dialogue and interaction between the user and the system usually facilitates an enhanced display of the subject matter to the learner (presentation adaptation) and links to be followed from the presented information (navigation adaptation).

The proposed socio-cognitive ecosystem is still under development, but aims to distinguish itself from the existing online learning environments on the following principles:

- Integrates top-down and bottom-up teaching/learning.
- Students not as passive recipients but active builders of knowledge.
- The system implements AI and intelligent tutoring approaches.
- Interaction between learner and teachers is extended to include other learners and industry.
- Supporting different learning styles with adaptive personalization of interface and content.
- Encourages path-finding, specialization towards a specific niche of learners' choice (and interest) where they can devote a certain time of their education identifying that niche and developing additional skills and competences in that area.
- Supports curatorial teaching and encourages self-directed learning.

SUMMARY AND CONCLUSION

In this paper, we have introduced an innovative approach and discussed the rationale and motivation for the development of a new web-based learning environment to be used in the context of architectural education. The proposed environment is defined as a "socio-cognitive ecosystem" and is still a work-in-progress. The paper identified two distinct dimensions of "technology mediation" affecting learning in the context of architectural education: *didactic* and *disciplinary* uses of technology. The paper claims that new themes and additional knowledge content introduced by the *disciplinary* dimension – due to the extensive use of digital tools as cognitive instruments - are considered to be closely linked to the utilization of the *didactic* dimension. In other words, extensive use of technology is impacting not only what we know and how we design, but is also opening new directions regarding how we learn on/about/through design. At the intersection of the *disciplinary* and *didactic* dimensions, three distinct and interconnected tendencies have been identified at the intersection of education and practice, namely: the emergence of new socio-technical networks, expansion of the profession's knowledge-base and skill sets, and blurring of the distinction between global and local dimensions of learning which gives way to new knowledge acquisition methods.

Learning in architecture has shifted from an individual focused approach to a larger system of interacting individuals in a situated, tool-mediated and socio-technical context. In addition to developing essential skills to work with diverse design software and take part in collaborative design activities, learners also need to be equipped with competencies that will allow them to operate intelligently outside of situations of distributed cognitions. The challenge in present educational climate is to develop pedagogical approaches where situations of distributed cognition are not the ends themselves but are the means for improving mastery of solo competencies.

We propose a new pedagogical framework for the integration of both autonomous and distributed learning in architectural design. The proposed framework will be used to develop a web-based learning environment (the socio-cognitive eco-system) and for the development of its social, epistemological, cognitive and technical infrastructure. A prototype will be developed and tested iteratively within the context of a masters-level course. The context of implementation and impact study will be in two separate studio modules of this course (Hybrid Architecture and Virtual City studios), focusing on building and urban scales, respectively, and entailing both individual and group working elements.

We anticipate that the proposed output of the research, the web-based *socio-cognitive ecosystem*, will provide an innovative technology-mediated framework for learning that supports autonomy and relatedness, self-regulated learning, encourage awareness and ownership in knowledge building/sharing, and at the same time reflects the key learning outcomes of a course through the curatorial actions of the instructor(s) involved. The main beneficiaries of this research will be educational researchers, educators and technology developers to support learning in Built Environment education and other relevant disciplines. As a long-term impact, we anticipate that these findings will also have significant impact on the development of new strategies for project-based (design-based) teaching/learning and revised educational curricula to support the ever changing and emerging demands of ICT integrated higher education.

REFERENCES

Allen, S 2012, 'The Future is Now', in *Architecture school : three centuries of educating architects in North America*, Ockman, J. and Williamson, R Cambridge (eds), Mass. pp. 204-229.

Ambrose, MA, Lostritto, C., and Wilson, L. 2008, 'Animate Education: Early Design Education Pedagogy', *Proceedings of the CAADRIA 2008 (Computer Aided Architectural Design Research in Asia) Chiang Mai (Thailand)* 9-12 April 2008, pp. 29-35.

Cannings, T and Stager, G 2003. 'Online Constructionism and the Future of Teacher Education', *in ICT and the Teacher of the Future*: Selected papers from the IFIP Working Groups 3.1 and 3.3 Working Conference, McDoughall, Murnane Stacey and Dowling Editors. Vol. 23, Sydney: Australian Computer Society.

Greeno, JG 1998, 'The Situativity of Knowing, Learning, and Research', *Journal of American Psychologist*, Vol. 53, no. 1, pp. 5-26.

Hutchins, EL, Hollan, J. D., and Norman, D. A. 1986, 'Direct Manipulation Interfaces'. In D. A. Norman and S.W Draper (eds), *User Centred system design: New Perspectives on human-computer interaction*, Hillsdale, NJ.

Jamieson, C 2010, *The Future for Architects*, Report prepared by Building Futures (RIBA). Accessible online: www.buildingfutures.org.uk.

Kalay, YE 2006, 'The Impact of Information Technology on Design Methods, Products and Practices, *Design Studies, Vol.* 27, no. 3.

Kipcak, O. 2007, 'The VIPA Project. What is VIPA?', in *VIPA virtual campus for virtual space design provided for european architects* , O. Kipcak (ed), Graz: Edition Mono, pp. 6-9.

Kvan T., Mark, E. Oxman Rivka and Martens, B. 2004, 'Ditching the Dinosaur: Redefining the Role of Digital Media in Education', *International Journal of Design Computing*, Vol. 7, no. 5, MIT Press.

Lakkala, M and Muukkonen, H and Paavola, S and Hakkarainen, K 2008, 'Designing pedagogical infrastructures in university courses for technology-enhanced collaborative inquiry', *Journal of Research and Practice in Technology Enhanced Learning*, Vol. 3, no. 1, 33-64.

Littlejohn, A and Higgison, C 2003, *A Guide for Teachers: LTSN Generic Centre E-learning Series No 3* (online). York, Higher Education Academy. Available: http://www.heacademy.ac.uk/resources/detail/e-Learning_Series_Guides_1-5.

Mizban, N and Roberts, A 2008, *A Review of Experiences of the Implementation of E-Learning in Architectural Design Education*, CEBE working paper No.13, Cardiff University. Available at: http://www.heacademy.ac.uk/assets/cebe/documents/resources /workingpapers/WorkingPaper_13.pdf.

Oliver, R and Herrington, J 2003, 'Exploring technology-mediated learning from a pedagogical perspective', *Journal of Interactive Learning Environments*, Vol. 11, no. 2, pp. 111-126.

Oxman, R 2008, 'Digital architecture as a challenge for design pedagogy: theory, knowledge, models and medium', *Design Studies*, Vol.29, no. 2, pp. 99-120.

Pea, RD 1993, 'Practices of Distributed Intelligence and designs for education', in *Distributed Cognitions, Psychological and Educational Considerations*, G. Salomon (ed), Cambridge University Press, UK.

Perkins, DN 1993, 'Person-Plus: A Distributed view of thinking and learning', in *Distributed Cognitions, Psychological and Educational Considerations*, G. Salomon (ed), Cambridge University Press, UK.

Salomon, G 1993, 'No distribution without Individuals' Cognition: a dynamic interactional view', in *Distributed Cognitions, Psychological and Educational Considerations*, G. Salomon (ed), Cambridge University Press, UK.

Siemens, G 2010, *Connectivism: Teaching in Social and Technological Networks* (online). Available: http://www/connectivism.ca/?p=220. Accessed 5 June 2012.

Simon, HA 1996, *The science of the Artificial*, MIT Press.

Tchounikine, P., Rummel, N., and McLaren, B. M. 2010, 'Computer Supported Collaborative Learning and Intelligent Tutoring Systems', in *Advances in Intelligent Tutoring Systems*, R. Nikambou, J. Bourdeau, R. Mizoguchi (eds), Springer, Warshaw. pp. 447-463.