Higher education in a complex world: nurturing "chaordic" influencers

Dr. Carlo Fabricatore, University of Huddersfield, Huddersfield, UK
c.fabricatore@hud.ac.uk

Dr. Ximena López, Pontifical Catholic University of Chile, Santiago, Chile
ximena@ing.puc.cl

Prologue - *Ordo ab chao*: actors in the drama of complexity

We live in a world driven by dynamics that challenge and very often defeat traditional reductionist approaches to ethics and problem solving (Weaver, 1948; Rittel & Webber, 1973). This is a world constantly animated by global changes resulting from the interplay of local events. No matter how apparently small, limited, and insignificant the local events may seem, the effects emerging from their interplay are often massive, and seldom predictable and controllable (McDaniel & Driebe, 2005; Miller & Page, 2007). We live in a world permeated by complexity.

This world, our world, is the realm of wicked problems, which cannot be fully described, have no "stopping rule", no "template solution", nor definitive description. In fact, wicked problems defy resolution, because of interdependencies, uncertainties, circularities, and conflicting stakeholders, and because they are often symptoms of other problems (Rittel & Webber, 1973).

The inability to cope with complexity leads inevitably to succumbing to wicked problems, with tragic consequences for human development. Those consequences include environmental emergencies, geopolitical crises, cultural decline, epidemics, and more. Ebola outbreaks, migration control problems, the rise of Islamic State, global warming, and more. These and other issues are part of the drama of complexity, within which we play as key actors, willing or not. A drama that becomes stark tragedy whenever we fail to timely identify and act upon complex dynamics that may lead to chaotic consequences, and are irreversibly detrimental to the future of our global community.

The plot of the drama of complexity is not set. It unfolds based on a dynamic, constantly changing script — but it is one that we can co-author. As actors and co-authors, we can lead the drama to favourable outcomes, influencing complex dynamics to our benefit, as individuals and collectives. This demands the ability to understand and act while "surfing the edge of chaos" (Pascale, 1999); this edge is a dimension in which apparent disorganisation is in fact a manifestation of multiple possibilities to facilitate the emergence of desirable - albeit temporary - order (Beinhocker, 1997). It is here that we have the ability to be "chaordic" influencers. "Chaordic" is a portmanteau word, allying the ideas of *chaos* and *order* into one.

Act 1 - Life in a wicked world

The future of our world and our future in it depend on our ability to cope with its complexities and the wicked problems originating from them. Such ability is not a given, nor an "asset" that can be acquired, once and for all, through some type of "subject-specific" formal educational programme. Rather, it should be viewed as a "living result" of a lifelong learning process, wherein worldviews are constantly transformed at individual and collective levels, in order to adapt to changing contexts, react to external stimuli, and pursue meaningful aims (Jonassen & Rohrer-Murphy, 1999; Mezirow, 2000; Davis & Sumara, 2006). Within this process, worldviews and capabilities are developed as a result of people interacting with each other and their environment, facing challenges, constraints, mechanics and circumstances that cannot always be fully understood, predicted nor controlled

Cite as: Fabricatore, C., & López, X. (2015). Higher education in a complex world: nurturing "chaordic" influencers. *Proceedings of the Sixth Advanced International Colloquium on Building the Scientific Mind (BtSM2015)*.

(Fraser & Greenhalgh, 2001; Davis & Sumara, 2006). Thus, in conditions of complexity deep learning can be viewed as an interpersonal process developing across individual and collective levels (Davis & Sumara, 2006), and framed by contexts that demand adaptation and define the meaningfulness of learning outcomes (Jonassen & Rohrer-Murphy, 1999). The context triggers the need to adapt, and the consequent development of individual knowledge, worldviews and capabilities. Then, the interplay of different individuals' worldviews and knowledge leads to the emergence of new or updated worldviews and knowledge at a collective level, which ultimately feed back into individual ones, enhancing them and the related capabilities above and beyond what individuals alone could do.

Learning to cope with complexity is only possible through holistic engagement in complex dynamics and problems, supported by a mindset geared to cope with complexity (Fabricatore & López, 2014a). Holistic engagement consists of affective, cognitive and operational involvement in complex scenarios affecting human development at individual and collective levels (Tilbury & Wortman, 2004; Sipos, Battisti & Grimm, 2008). People should think and care about matters in order to develop awareness of relevant issues and identify related complex problems to address. Then, the origins of problems and the underpinning mechanics should be comprehended as thoroughly as possible. Consequently, people should strategize and act responsibly to influence complex dynamics and facilitate the emergence of new equilibria, making situations favourable to our global community and the generations that will succeed us.

The contexts that give rise to and frame wicked problems are complex systems. These are wholes comprising large numbers of elements interacting and interconnected in ways that may change over time. Complex systems are characterised by the phenomenon of emergence, whereby aggregate behaviour stems from the interplay of local behaviours, generating dynamics and effects that cannot be predicted examining individual parts and the laws that govern their interactions (McDaniel & Driebe 2005; Miller & Page 2007). Consequently, non-linear strategies are required in order to operate in conditions of complexity. Examining, planning and acting should be regarded as a single iterative and adaptive process, pivoting around the constant monitoring of interim results of various actions, and new changes to the context of such actions, along with consequent revision (if need be) of the objectives, strategies and techniques. Those techniques are the ones involved in the particular plan, and the underpinning assumptions. (Argyris, 1977; Beinhocker, 1997; Cohn, 2005). A species of this method has been called "double loop learning", as opposed to "single loop learning"; the former leads to "deep change", whereas the latter brings only "surface change" (Kantamara & Ractham, 2014).

Because of the traits of uncertainty, unpredictability, unknowability and uncontrollability typically exhibited by complex systems, and the iterative/adaptive nature of the examining-planning-acting process, holistic engagement in wicked problems requires "complexivist" mindsets involving key capabilities (Figure 1, adapted from Fabricatore & López, 2104a), which we have identified in our past work (Fabricatore & López, 2011, 2104a).

Cite as: Fabricatore, C., & López, X. (2015). Higher education in a complex world: nurturing "chaordic" influencers. *Proceedings of the Sixth Advanced International Colloquium on Building the Scientific Mind (BtSM2015)*.

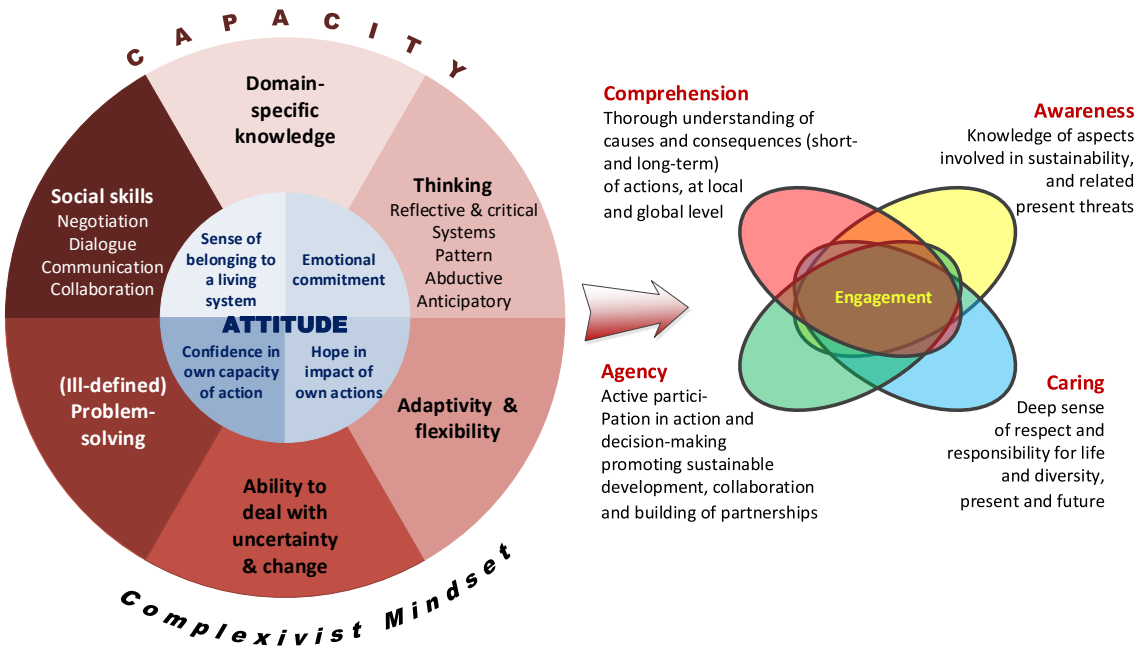

Figure 1: Complexivist mindset and holistic engagement

In this context, it is essential to question the role that higher education can play in building foundations to support the autonomous, lifelong process of learning to cope with complexity and engage with wicked problems. How can universities nurture "chaordic" influencers?

Act 2 – The making and rise of the chaordic influencer: the failure

Formal education should nurture chaordic influencers through fostering the development of complexivist mindsets, and promoting learners' holistic engagement in complex contexts and wicked problems. Higher education should play a paramount role in this scenario. Universities have the key responsibility of preparing professionals to define our society through developing, leading, influencing and working in its institutions. Furthermore, higher education targets a population of learners who, because of their cognitive, social and emotional developmental stage, present a formidable combination of potentialities to promote the development of the core capacities of the complexivist mindsets and the attitudes required to engage in complex wicked problems.

Therefore, universities should focus on developing self-reliance in students, and provide to them instruments to prosper and act purposively and collectively in an uncertain and ever-changing world. By the same token, contemporary higher education programmes should promote students' engagement in socially-relevant contexts and wicked problems, and foster abilities such as: adapting to change; understanding phenomena in context; making connections between aspects that are not evidently linked; facing non-linear and ill-defined situations; and working in collaboration with others who may not share the same ideas or interests (Fabricatore & López, 2014c).

However, the reality of universities is different, and contemporary higher education systems are frequently criticised for key shortfalls that compromise the possibility of nurturing chaordic influencers within formal higher education environments. Excessive emphasis on subject-oriented performativity, valuing students' ability to carry out specific taught behaviours and assimilate specific knowledge over the development of transferable capabilities which, creativity first amongst them, are key to engage in complex scenarios (Barnett, 2000; Jackson, 2008; Mili, 2015). Teaching

Cite as: Fabricatore, C., & López, X. (2015). Higher education in a complex world: nurturing "chaordic" influencers. *Proceedings of the Sixth Advanced International Colloquium on Building the Scientific Mind (BtSM2015)*.

strategies overly driven by reductionist causal logics, leading to efforts towards quality control, achievement of planned outcomes, cost efficiency, customer satisfaction and resource management that do not map to the actual quality of students' deep learning, and its meaningfulness in relation to the needs of our contemporary world (Davis & Sumara, 2008; Mili, 2015). Curricula promoting fragmentation of knowledge and isolation of disciplines, rather than integration of domains and cross-disciplinary pollination and collaborations (Mili, 2015). Programmes promoting and valuing competition, individual achievement and high-stake assessment, rather than collaboration and focus on collective solutions for the social and environmental challenges we face (Sterling, 2001).

Many of these and further related issues are the product of organisational logics and market mechanics that give rise to boundaries and constraints that are difficult to change. Far too often, these boundaries and constraints frustrate the efforts of educators attempting to contribute to the evolution of higher education systems towards a greater compliance with the needs of our complex global world. Constraints and boundaries can then become insurmountable barriers, leading to the crystallisation of higher education systems into entities arguably useful to promote and serve societal development. Or, they can be embraced as a guiding lantern, a beacon that sheds light on what is not bounded, and the changes that can be effected regardless of boundaries and constraints, working "within the box" in order to transcend it. This dichotomy calls for a critical reflection on the boundaries and constraints imposed by modern higher education systems. If these cannot be changed, what can be done to nurture the development of complexivist mindsets and promote students' engagement with wicked problems within the daily routine of formal higher education environments?

Act 3 – The making of the chaordic influencer: through gameful complexity

In order to foster the development of the complexivist mindset, engage students with wicked problems, and enhance their agency and possibilities to promote sustainable human development, we have developed the Engage-Adapt-Learn (EAL) framework. EAL aims at facilitating the adaptive design of learning activities and environments, based on continuous monitoring of the student experience, and students' engagement in complex scenarios and wicked problems through team-based, socially-relevant projects. EAL treats educational programmes as learning activity systems, analogises learning activity systems to game systems, and leverages game design principles and key perspectives of complexity theory on learning to support the definition and organisation of challenging and meaningful learning activities, framed by contexts promoting student engagement with complexity. Accordingly, EAL is intended support the instructional design of higher education courses through the strategies described below.

Courses as systems of project-driven, problem-solving complexity-savvy collaborative activities

Educational courses can be viewed as organised systems of problem-solving activities framed by contexts meaningful to the learner, and whose solution leads to the achievement of desirable goals (Jonassen, 1999; Jonassen & Rohrer-Murphy, 1999). A "problem" is the difference between an initial state, and a new, desirable goal state. Hence, "solving" a problem is a process of generation of changes required to transition from initial to goal state (Ward, 2011). Such process may require the acquisition of knowledge and the development of skills and capabilities, all of which constitutes a problem-based learning process (Savery & Duffy, 1995). The effects and results of this process depend on how engaging and meaningful the problem is to the learner, and the mechanics of challenge and support involved in it (Jonassen, 1999; Jonassen & Rohrer-Murphy, 1999).

Cite as: Fabricatore, C., & López, X. (2015). Higher education in a complex world: nurturing "chaordic" influencers. *Proceedings of the Sixth Advanced International Colloquium on Building the Scientific Mind (BtSM2015)*.

In conditions of complexity, learning is a trans-level process, happening both at the level of individuals and whole collectives. The interplay of individual understandings and knowledge produces collective learning. This, in turn, feeds back into individual learning, enhancing it beyond what would be attainable by individuals alone (Davis & Sumara, 2005, 2006).

According to the concept articulated above, courses can be designed as systems of interdependent problem-solving activities purposeful to the completion of an overarching collaborative project.

Davis and Sumara (2006) identified conditions fostering the emergence of learning in complex scenarios, summarised in Figure 2 (adapted from Fabricatore & López, 2014c).

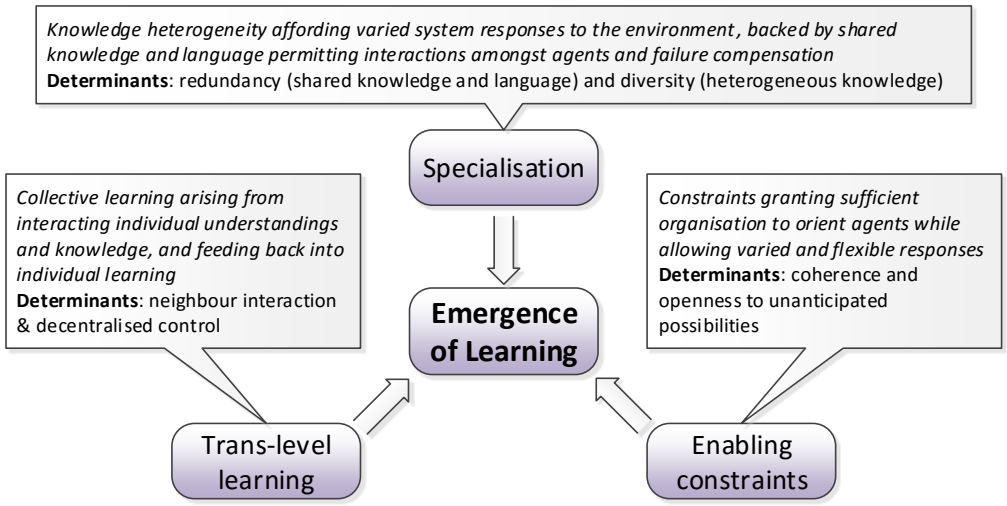

Figure 2. Conditions fostering learning in complexity

Accordingly, learning activities should be designed to: i) foster trans-level learning, through supporting interactions between students, promoting decentralised control, minimising passive learning activities (e.g. passive lectures), and appraising progression through collaborative results, and individual contributions to them; ii) promote student specialisation, through facilitating the development of shared knowledge while fostering diversity, and supporting collaborative activities with individual activities; iii) leverage enabling constraints to provide sources of challenge, disruption and randomness while maintaining coherence and focus.

In conditions of complexity learning is not a linear process. Rather, it develops iteratively, in ways and with outcomes varying from one student to another, and depending on interim outcomes of each learner's process. Accordingly, to support engagement and achievement across a broad spectrum of students, learning activities should be designed iteratively, (re)defining them based on evidence and events arising at key stages the course. Furthermore, a core set of activities (e.g., core lectures) should be pre-defined specifically to ensure access to shared knowledge (Fabricatore & López, 2014c).

Finally, the problems underpinning the learning activities primarily should require empirical and holistic-adaptive resolution approaches, involving the study of relationships, and to combine different perspectives on the same phenomenon to understand what needs to be done and when (Weaver 1948). Furthermore, highest challenges should correspond to ill-defined problems, wherein: initial and/or goal state are not clearly defined a priori; the number of possible solutions is

Cite as: Fabricatore, C., & López, X. (2015). Higher education in a complex world: nurturing "chaordic" influencers. *Proceedings of the Sixth Advanced International Colloquium on Building the Scientific Mind (BtSM2015)*.

undefined; solutions cannot be shaped as a fixed procedure; valid solution approaches emerge and are shaped throughout the problem-solving process.

Game-based interaction design for the organisation of gameplay activities and support progression

Games are systems in which gamers engage in activities aimed at achieving desirable goals through tackling challenges requiring interaction with each other and other game elements - e.g. virtual objects and entities (Salen & Zimmerman, 2003; Fabricatore, 2007; Fabricatore & López, 2014a). Gameplay activities are framed by a context that allows players to define/understand the meaning and relationships of gameplay activities and involved game elements (Gee, 2007; Schell, 2008). Game challenges require the development of mastery through learning about game elements and mechanics, which is an essential determinant of player enjoyment (Fabricatore & López, 2012).

Gameplay activities can be therefore regarded as contextualised problem-solving processes, and games can be conceptualised as systems of problem-solving activities underpinned by engaging learning processes, regardless of specific game contents (Fabricatore & López, 2014b).

Analogising games and educational courses as systems of contextualised problem-solving activities allows approaching instructional design as a form of gamified interaction design. Consequently, game design principles and strategies can be leveraged to promote learners' engagement and achievement through learning activities, based on the effects that they have in entertainment games (Fabricatore & López, 2014b).

Through our past work, we defined and empirically tested game design patterns that could be useful in the design of higher education courses, as a system of problem-solving quests. These patterns, described in table 1 (adapted from Fabricatore & López, 2014b, p. 112), are compliant with the key conditions facilitating the emergence of learning in complexity (Davis & Sumara, 2006). They complement the strategies previously described, in order to enhance the structure of learning activities, and generate affordances to promote learners' engagement in and progression through learning quests.

Table 1. Game design patterns for the definition of courses as problem-solving quests systems

Cite as: Fabricatore, C., & López, X. (2015). Higher education in a complex world: nurturing "chaordic" influencers. *Proceedings of the Sixth Advanced International Colloquium on Building the Scientific Mind (BtSM2015)*.

Game design Pattern	Description
Quest structure	Quests are defined by: • An objective requiring the accomplishment of victory conditions through tasks to be completed within each quest. Core victory conditions are sometime accompanied by optional conditions, usually entailing additional challenges engendering additional positive outcomes (e.g. enhanced tools to engage in further quests). • Means required or beneficial for the fulfilment of the objective • A motivation, explaining the importance of the quest to progress in the game. Quests are usually structured as a sequence of briefing, action and debriefing activities. Briefing and debriefing activities provide information necessary to engage in a quest and understand the outcomes of a quest, respectively. Action stages allow players to act to fulfil a quest goal. At least one briefing activity precedes player action, and one debriefing activity follows the completion of all the quest action stages. Briefing and debriefing information is usually expressed through concrete and contextualised game elements (e.g. storyline, game entities) rather than through abstract concepts (e.g. progress percentages).
Strategic open-endedness	Quest goals can be achieved through alternative strategies, allowing players to "do more" or "differently". This allows players to embrace alternative play approaches, and motivates them to explore increasingly challenging approaches as their confidence increases.
Non-linear progression	The organisation of quests generally allows them to decide when to engage in specific quests. When this is not allowed, it is usually related to quest narrative articulation or functional dependencies. Briefing and debriefing feedback provide the information regarding quest engagement and functional dependencies.
Orientation	The game delivers briefing information that is available to the player at any time through orientation artefacts (e.g. maps), to support decisions in relation to when, how and in what to engage.
Challenge-based reward	Rewards are normally granted based on a "the more you achieve, the more you receive" rationale. The fulfilment of core victory conditions earns a baseline reward. Success achieved through more challenging strategies earns additional rewards (e.g. additional resources), and a recognition of increased mastery (e.g. enhancement of the formal role of the player). Rewards in collaborative quests depend on the contribution of each participant.

Finally, the context that frames learning quests should be closely related to the wicked problems that students are led to engage, so that learners' engagement in learning activities will trigger meaning-making processes enhancing awareness, comprehension and agency in relation to these.

Act 4 - The rise of the chaordic influencer?

This paper discussed the necessity to learn to cope with complexity in order to address the wicked problems that affect human development at individual and societal level. Learning to cope with complexity requires the development of complexivist mindsets, capable of dealing with change, uncertainty, unpredictability, unknowability and uncontrollability, and holistic engagement in/with the wicked problems to be tackled. This is essential to become chaordic influencers, agents capable

of channeling chaotic dynamics to facilitate the emergence of equilibria favourable to our global society.

Learning to cope with complexity is a lifelong process, and universities should play a key role in fostering it. However, boundaries and constraints imposed by contemporary higher education systems compromise the possibilities of nurturing chaordic influencers.

In this context, we proposed a framework for the design of educational courses to nurture chaordic influencers while working within the constraints and boundaries imposed by ordinary higher education programmes and curricula. The EAL framework proposes strategies informed by complexity science, play and game design theories. These are aimed at fostering the development of complexivist mindsets, and promoting learners' holistc engagement in/with wicked problems and complex scenarios.

We developed and tested the EAL framework through five years of action research, using it to design fourteen courses (subjects: game design, software engineering and game development) involving over 300 students. The data analysed so far suggests that the framework generates positive impacts on students, in line with its aims (e.g. Fabricatore & López, 2014b, 2014c).

When engaging in learning activities, students tend to adopt strategies based on high order thinking skills and other capabilities key to the complexivist mindset. Students tend to consider learning activities interesting, despite judging them difficult and challenging. Students generally acknowledge sufficient autonomy to define their own goals and strategies, recognise that the definition and organisation of learning activities is helpful to understand type of work to be done, and the expected outcomes, and that the mechanics implemented are appropriate to promote student motivation, engagement and progression. Overall, students tend to consider the systems of learning activities designed based on the EAL as attractive, meaningful, and valuable from an academic perspective.

With regards to engagement in wicked problems and related themes, we have recently completed a research project exploring the impacts of engaging students with the ideal of peace through a game design project, based on a quasi-experimental design. The course did not include any teaching focussed on peace. The capstone project required students to: work in a team: identify 1-3 core ideas related to peace; design a game to allow players to explore and learn about the identified ideas.

Epilogue – Designs towards Peace

A preliminary qualitative analysis of the design produced by students revealed, so far, that the vast majority of student teams identified and explored peace-related ideals current and highly relevant from a social perspective (e.g. tolerance, equality, power, social acceptance, redemption, compassion, loyalty, poverty, morality/ethics, etc.) and avoided clichés (e.g. no game was designed that focused on warfare).

As a part of the research, we administered a questionnaire to evaluate attitudes toward peace. The questionnaire was not related to the coursework, and aimed at exploring the impact that working on a peace-related project can have on students' attitude towards, knowledge and understanding of peace-related ideas and conjectures. The questionnaire was administered to a treatment group (students involved in the team-related game design project) and a control group (not involved), at the beginning (pre-) and at the end of the course (post-). We found that the students in the

Cite as: Fabricatore, C., & López, X. (2015). Higher education in a complex world: nurturing "chaordic" influencers. *Proceedings of the Sixth Advanced International Colloquium on Building the Scientific Mind (BtSM2015)*.

treatment group are more interested in exploring initiatives to preserve peace, and engaging in those initiatives (table 2; figure 3).

Table 2. Attitudes towards exploration of and engagement in peace-preservation initiatives

	Group	N	Mean	Std. Deviation	Std. Error Mean	Effect size (Cohen's d)
Initiative to preserve peace: how interested would you be in finding out more about it? (1=Not at all; 5=Very much)	Exp	36	3.944	.8262	.1377	.5200
	Control	62	3.484	.9364	.1189	
Initiative to preserve peace: how likely are you to engage in it? (1=Not at all; 5=Very much)	Exp	36	3.500	.9710	.1618	.4800
	Control	65	3.046	.8915	.1106	

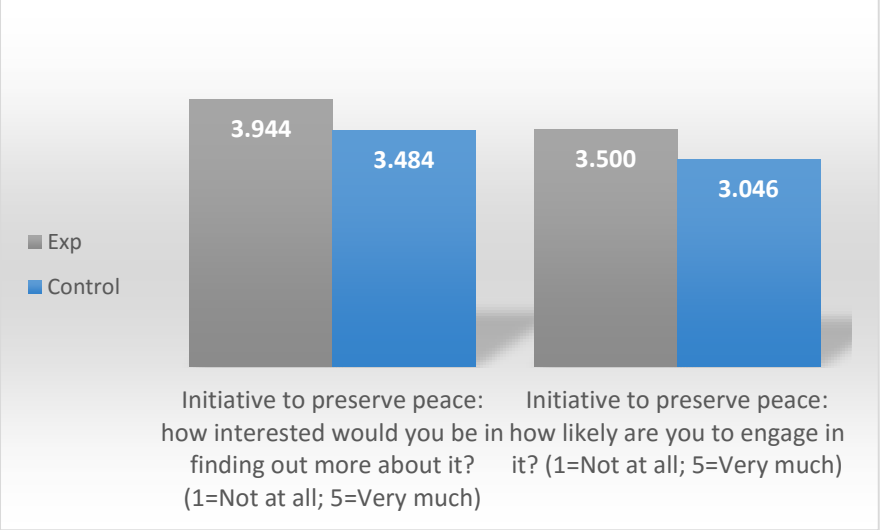

Figure 3. Attitudes towards exploration of and engagement in peace-preservation initiatives

All things considered, the results that we have formulated concerning the application of the EAL framework suggest the following: *developing complexivist mindsets and promoting student engagement with wicked problems and related social issues within the boundaries and constraints of formal higher education environments is indeed feasible*. Further research is needed to explore in greater detail the impacts that the framework has on the students' learning experience and development. Further research will also reveal methods of application, in terms of designing courses in other subject areas; this, finally, will allow the corroboration and generalisation of the results obtained so far.

References

Argyris, C. (1977). Double loop learning in organizations. *Harvard Business Review*, *55*(5), 115–125.

Barnett, R. (2000). Supercomplexity and the Curriculum. *Studies in Higher Education*, *25*(3), 255–265. http://doi.org/10.1080/713696156

Beinhocker, E. D. (1997). Strategy at the edge of chaos. *McKinsey Quarterly*, (1), 109–118. Retrieved from www.mckinseyquarterly.com/strategy/sted97.asp

Bruner, J. (1999). *The Process of Education*. Cambridge, MA: Harvard University Press.

Cohn, M. (2005). *Agile Estimating and Planning*. Courier in Stoughton, MA: Prentice Hall.

Cite as: Fabricatore, C., & López, X. (2015). Higher education in a complex world: nurturing "chaordic" influencers. *Proceedings of the Sixth Advanced International Colloquium on Building the Scientific Mind (BtSM2015)*.

Davis, B., & Sumara, D. (2006). *Complexity and Education: Inquiries into Learning, Teaching, and Research*. Mahwah, NJ: Lawrence Erlbaum.

Davis, B., & Sumara, D. (2008). *Engaging Minds: Changing Teaching in Complex Times*. New York: Routledge.

Dewey, J. (1998). *Experience and Education* (The 60th A). Indianapolis, IN: Kappa Delta Pi.

Espinosa, A., and Porter, T. (2011) "Sustainability, complexity and learning: insights from complex systems approaches", The Learning Organization, Vol18, No.1, pp 54–72.

Fabricatore, C. (2007). Gameplay and game mechanics design: a key to quality in video games. In *Proceedings of the OECD-CERI Expert Meeting on Videogames and Education* (pp. 1–18). Santiago, Chile: OECD. Retrieved from http://www.oecd.org/dataoecd/44/17/39414829.pdf

Fabricatore, C., & López, X. (2011). Gaming for Sustainability: an Overview. In D. Gouscos & M. Meimaris (Eds.), *Proceedings of the 5th European Conference on Game Based Learning* (pp. 159–167). Reading, UK: Academic Publishing Limited.

Fabricatore, C., & López, X. (2012). Sustainability Learning through Gaming: An Exploratory Study. *Electronic Journal of E-Learning (EJEL)*, *10*(2), 209–222.

Fabricatore, C., & López, X. (2014a). A Model to Identify Affordances for Game-Based Sustainability Learning. In C. Busch (Ed.), *Proceedings of the 8th European Conference on Game Based Learning* (pp. 99–109). Reading, UK: Academic Conferences and Publishing International Limited.

Fabricatore, C., & López, X. (2014b). Using Gameplay Patterns to Gamify Learning Experiences. In C. Busch (Ed.), *Proceedings of the 8th European Conference on Game Based Learning* (pp. 110–117). Reading, UK: Academic Conferences and Publishing International Limited.

Fabricatore, C., & López, M. X. (2014c). Complexity-based learning and teaching: a case study in higher education. *Innovations in Education and Teaching International*, *51*(6), 618–630.

Fraser, S. W., & Greenhalgh, T. (2001). Coping with Complexity: Educating for Capability. *BMJ (Clinical Research Ed.)*, *323*(7316), 799–803.

Gee, J. P. (2007). *What Video Games Have to Teach Us About Learning and Literacy* (2nd ed.). New York, NY: Palgrave Macmillan.

Helbing, D., & Lämmer, S. (2008). Managing Complexity: An Introduction. In D. Helbing (Ed.), *Managing Complexity: Insights, Concepts, Applications* (pp. 1–16). Berlin: Springer.

Jackson, N. (2008). Tackling the wicked problem of creativity in higher education. In *Creating Value: Between Commerce and Commons*. Retrieved from http://normanjackson.pbworks.com/f/TACKLING THE WICKED PROBLEM mod.pdf

Jonassen, D. H. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), *Instructional-design theories and models* (2nd ed., pp. 215–240). Mahwah, NJ: Lawrence Erlbaum Associates.

Jonassen, D. H., & Rohrer-Murphy, L. (1999). Activity theory as a framework for designing constructivist learning environments. *Educational Technology Research & Development*, *47*(1), 61–79.

Leont'ev, A. N. (1978). *Activity, Consciousness, and Personality*. Englewood Cliffs, NJ: Prentice-Hall.

McDaniel, Jr., R. R., & Driebe, D. J. (2005). Uncertainty and Surprise: and Introduction. In R. R. McDaniel Jr. & D. J. Driebe (Eds.), *Uncertainty and Surprise in Complex Systems* (pp. 3–11). Heidelberg: Springer.

Mezirow, J. (2000). Learning to Think Like an Adult Core Concepts of Transformation Theory. In J. Mezirow (Ed.), *Learning as Transformation. Critical Perspectives on a Theory in Progress.* (pp. 3–33). San Francisco, CA: Jossey-Bass.

Mili, F. (2015). The "Wicked" Problem of Transforming Higher Education. Retrieved from http://evolllution.com/opinions/wicked-problem-transforming-higher-education/

Miller, J. H., & Page, S. E. (2007). *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*. Princeton, NJ: Princeton University Press.

Cite as: Fabricatore, C., & López, X. (2015). Higher education in a complex world: nurturing "chaordic" influencers. *Proceedings of the Sixth Advanced International Colloquium on Building the Scientific Mind (BtSM2015)*.

Moore, J. (2005). Is Higher Education Ready for Transformative Learning? A Question Explored in the Study of Sustainability. *Journal of Transformative Education*, *3*(1), 76–91. http://doi.org/10.1177/1541344604270862

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, *4*(2), 155–169.

Pascale, R. T. (1999). Surfing the Edge of Chaos. *Sloan Management Review*, *40*(3). Retrieved from https://www.questia.com/library/journal/1G1-20389918/strategy-at-the-edge-of-chaos

Kantamara, P., & Ractham, V. (2014). Single Loop vs. Double Loop Learning: An Obstacle or Success Factor for Organizational Learning. *International Journal of Education and Research*, *2*(7), 55–62.

Salen, K., & Zimmerman, E. (2003). *Rules of Play: Game Design Fundamentals*. Cambridge, MA: MIT Press.

Savery, J. R., & Duffy, T. M. (1995). Problem based learning: An instructional model and its constructivist framework. *Educational Technology*, *35*, 31–38.

Sipos, Y., Battisti, B., & Grimm, K. (2008). Achieving transformative sustainability learning: engaging head, hands and heart. *International Journal of Sustainability in Higher Education*, *9*(1), 68–86.

Sterling, S. R. (2001). *Sustainable Education: Re-visioning Learning and Change*. Dartington, UK: Green Books.

Tilbury, D., and Wortman, D. (2004) *Engaging People in Sustainability*, IUCN, Gland, Switzerland and Cambridge, UK.

Vygotsky, L. S. (2012). *Thought and Language*. Cambridge, MA: MIT Press.

Wals, A. (2009). *Review of Contexts and Structures for Learning for a Sustainable World*. Paris: UNESCO.

Ward, T. B. (2011). Problem Solving. In M. A. Runco & S. R. Pritzker (Eds.), *Encyclopedia of Creativity, vol. 2* (2nd ed., pp. 254–260). Burlington, MA: Elsevier.

Weaver, W. (1948). Science and complexity. *American Scientist*, *36*(4), 536–544.

Cite as: Fabricatore, C., & López, X. (2015). Higher education in a complex world: nurturing "chaordic" influencers. *Proceedings of the Sixth Advanced International Colloquium on Building the Scientific Mind (BtSM2015)*.