Fostering student learning using a complexified educational strategy: A case study in higher education

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Abstract

This paper reports on the design and application of a complexified educational strategy for the administration and delivery of a course in game design at the University of Worcester, UK. We conceived an educational strategy following recommendations provided by Davis and Sumara (2006), aimed at generating conditions key to foster emergence of learning in educational complex-adaptive systems, namely specialisation, trans-level learning and enabling constraints. The strategy was designed through an iterative and adaptive process, informed by evidence and events emerging from the development of the course. The strategy fostered student collaboration, and allowed both students and tutors to deal with complex and unanticipated situations requiring adaptation. Data analysed so far indicates that teamwork was initially challenging for students, but collective learning emerged as the course developed, positively affecting teams' performance. Students felt highly motivated and enjoyed working on the learning activities. Likewise, their progress and expertise levels were always perceived as high. Students' academic performance was on average very good.

Keywords: complexity, education, educational strategies, complex adaptive systems, higher education

1 INTRODUCTION

In 2010 the University of Worcester (UK) commissioned to the authors the design and administration of a new 11-weeks course in game design, to be delivered from October 2011 within the scope of the Worcester Business School "Computer Games Design and Development" BSc.

Our first activity in this academic endeavour was analysing salient aspects of the context of administration and delivery of the course, focusing on both exogenous contextual factors (e.g.; state of the art in the domain of game design; current employability requirements) and endogenous ones (e.g. University of Worcester strategic plan; student entry skills and backgrounds). As a result, we defined general educational objectives for the course which served as a foundation to define an educational strategy. At this stage, systemic complexity entered the scene.

2 THE NEED FOR COMPLEXITY THEORY IN AN EDUCATIONAL STRATEGY

2.1 EDUCATIONAL STRATEGIES

Educational strategies can be regarded as plans aimed at facilitating student achievement of desirable learning objectives within concrete educational systems. Based on the definition of the concept of system provided by Meadows (2008), in this context we define educational systems as wholes composed of interconnected agents (e.g. teachers, students) and elements (e.g. classrooms, books, technology assets), organized and interoperating to achieve educational purposes throughout the lifespan of the system.

Hence, an educational strategy is normally meant to purposefully regulate processes in an educational system. It does so by defining a rationale and modus operandi for the development and organization of contents, infrastructures of the learning environment, assessment approaches and learning activities, and for the actual execution of the learning activities. All this, in compliance with the constraints of the context which the educational system belongs to (e.g. availability of technological infrastructures; logistics; maximum duration of learning activities). Thus, educational strategies must be elaborated depending on the nature of the system they should be applied to, and the context within which they should be enacted.

2.2 THE COURSE AS A COMPLEX SYSTEM

Research into complexity indicates that learning and education are complex phenomena and that educational systems are complex adaptive systems - CAS (Davis & Sumara, 2005, 2006, 2010; Morrison, 2006; Frei, 2011). CAS are "(…) *dynamical and emergent, sometimes unpredictable, non-linear organizations operating in unpredictable and changing external environments* (…) [They] *adapt to macro- and micro-societal change, and, through self-organization, respond to, and shape the environments of which they are a part.*" (Morrison, 2006, p. 3).

CAS adaptive evolution is the result of competition and cooperation dynamics among system agents (Davis & Sumara, 2005, 2006; Mitchell Waldrop, 1992). These dynamics are self-organized and lead to the phenomenon of emergence, whereby "(…) *well-formulated aggregate behaviour arises from local behaviour*" (Miller and Page, 2007, p. 46), and new, unpredictable patterns of organization emerge spontaneously in the system without the intervention of a centralized control (Ottino, 2004; McDaniel and Driebe, 2005; Miller and Page, 2007; Quinn Patton, 2010).

The self-organized adaptive evolution of CAS can be considered the outcome of learning processes. In fact, as Davis and Sumara (2006) maintain, CAS are understood to adapt through events of learning which entail transformations leading to different forms of the same system. For this reason, CAS in general, and educational systems in particular, can be considered proper learning systems (Davis & Sumara, 2005, 2006; Newell, 2008).

A higher education course is a specific instance of the broader concept of educational system, and it can therefore be safely regarded as a complex system, embodying what Frei (2011) defines as micro-level complexity in educational systems.

2.3 WHY COMPLEXIFYING AN EDUCATIONAL STRATEGY

2.3.1 THE PERSPECTIVE OF COMPLEXITY SCIENCE

Research into complexity management indicates that, dealing with CAS, approaches focused on understanding and making use of natural system tendencies and behaviours, supporting and guiding natural self-organization processes generate significantly better results than management approaches requiring centralized control and continuous forcing to try to govern system dynamics (Helbing & Lämmer, 2008; Kempf, 2008). In fact, Bovaird (2008) maintains that "(...) [in CAS] *planners and strategists can hope only to join the game, as players* *themselves, or to take part in the setting of very outline 'meta-rules' within which the game will be played.*" (p.323); and that "(...) *strategic management becomes the set of reactions of an agent by means of which it hopes both to make the most of perceived changes in its environment and also to change the longer-term 'rules of the game' which shape how its environment evolves.*" These ideas promote the adoption of complexified educational strategies, relying on continuous iterative cycles of planning, acting, assessment of results and revision of plans and/or assumptions, based on the concept of double-loop learning proposed by Argyris (1977) (Figure 1).

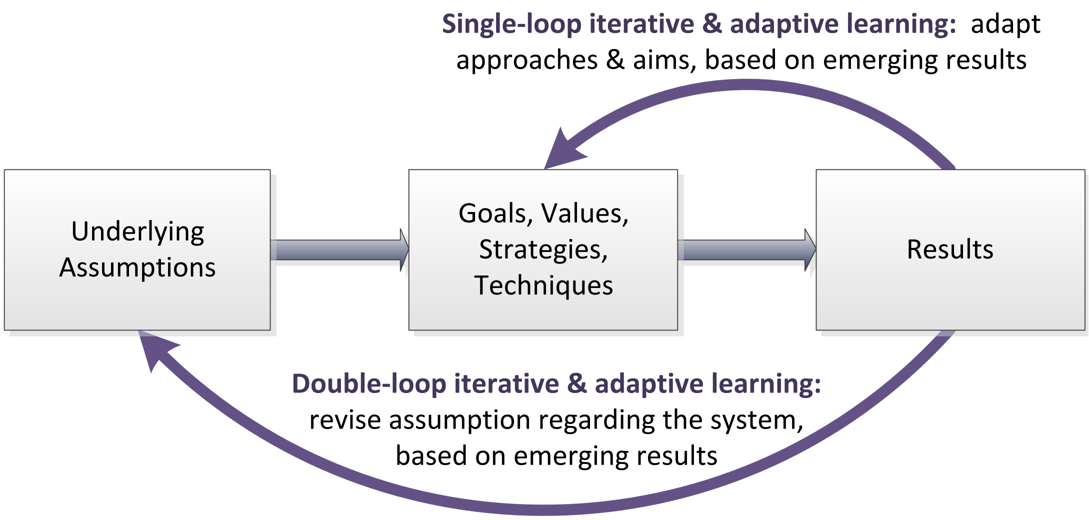

Figure 1 - Double loop learning

2.4 THE PERSPECTIVE OF EDUCATIONAL OUTCOMES

In the domain of complexity science cognition is regarded as an on-going process of adaptive activities involving agents which can be either autonomous or coupled (Davis and Sumara, 2005, 2006, 2010; Kempf, 2008; Newell, 2008). Hence, within a given system learning is a trans-level process, happening both at the level of individuals and collectives intended as wholes, proper learning entities (Davis and Sumara, 2005, 2006; Miller and Page, 2007; Newell, 2008). Collective learning reshapes the system as a whole and transcends individual learning, although it arises from the interplay of individual understandings and knowledge (Davis and Sumara, 2005, 2006; Newell, 2008). Emerging collective learning, in turn, feeds back into individual learning, enhancing it beyond what could be achieved by individuals on their own (Figure 2). Thus, in a CAS individual learning evolves adapting to collective learning, and vice-versa.

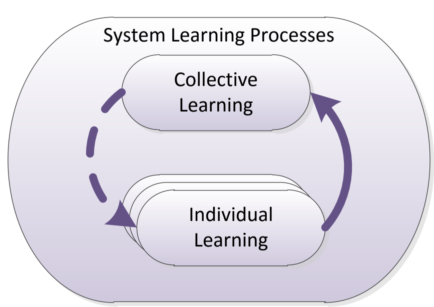

Figure 2: Learning processes in CAS

Disregarding the importance of collective learning would mean confining the development of individuals within the boundaries of what is afforded by compartmentalised individual learning, and only through complexified educational strategies it is possible to fully take into account the impact of the interplay between individual and collective learning (Davis and Sumara, 2006; Frei, 2011).

Student heterogeneity is another important reason to promote the adoption of complexified educational strategies. Adaptive and iterative methods are, in fact, best suited to support different learning styles and levels of skills as they emerge from the learning processes (Mainemelis et al., 2002; Coffield et al., 2004).

Finally, embracing a complexified approach is the best way to prepare individuals for an increasingly complex and intertwined world. Rapid and unpredictable change is one of the major challenges of today's world, as societies expand and become more connected. Global issues such as sustainability, economical exchange and social development requires individuals able to decide and act with responsibility, which is only achieved if individuals are capable to see the complexity of the whole and not only the parts. Capabilities such as the ability to adapt to change, to understand phenomena in context, to make connections between aspects that are not evidently linked, to face non-linear and ill-defined situations and to work in collaboration with others who may not share ideas or interests should be promoted by contemporary education (Davis & Sumara, 2005, 2006; Frei, 2011). A complexity approach provides not only a theoretical sound approach but also a methodology that supports a complexified educational practice (Phelps, 2005; Davis & Sumara, 2006).

3 A COMPLEXIFIED EDUCATIONAL STRATEGY FOR A GAME DESIGN COURSE

Our educational strategy pursued the generation of conditions key to fostering emergence in educational CAS, mirrored by Davis and Sumara's (2006) model (Figure 3).

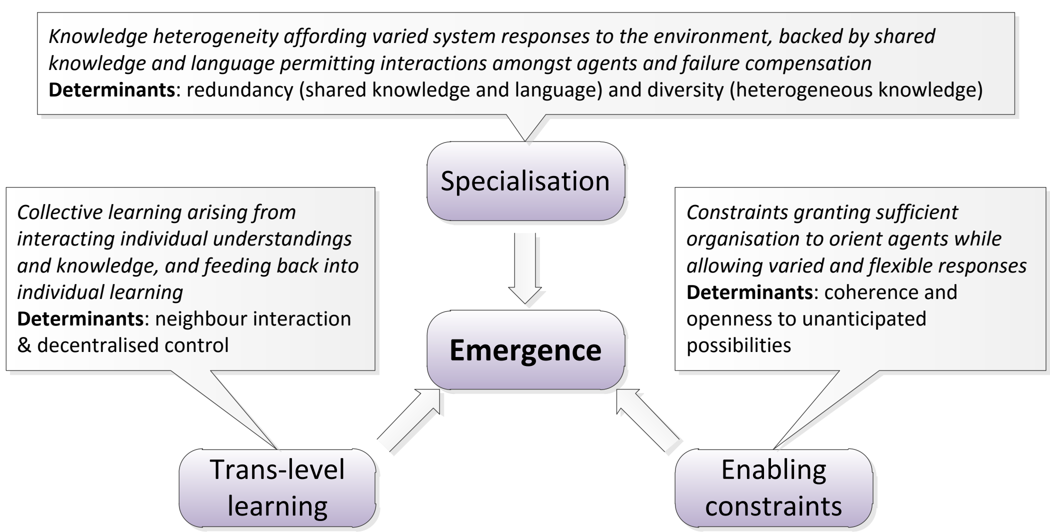

Figure 3: Conditions to foster emergence in educational CAS

Accordingly, our strategy aimed at: i) promoting specialisation, safeguarding redundancy in system agents' knowledge and understandings while at the same time nurturing diversity; ii) fostering trans-level learning, facilitating neighbour interactions and promoting decentralised control; and iii) influence system architecture and dynamics through enabling constraints.

The strategy was not designed upfront. Rather, it emerged from iterative and adaptive design activities, based on evidence and events arising from the development of the course.

3.1 Course system architecture

We conceived an initial distributed system architecture comprising agents embodying the roles of students, tutors, consultants, evaluators and clients.

Students were the key agents of the system, aiming at passing the course through successfully completing a course team project and related individual learning journals. Students were initially required to form teams of 3-4. Within these boundaries, students were allowed to change teams provided that they clearly explained to tutors why they wished to change, and why both the team they were leaving and the one they were joining were comfortable with the change. No rule was imposed as to the internal organisation of each team (e.g. responsibilities and distribution of the workload). Teams were free to discuss and interact throughout the whole course.

Tutors selected contents, prepared learning materials, delivered lectures and defined requirements for the course project. They formed a team of three, coordinated by a course leader, and were able to talk to each other at any given time.

Consultants provided advice to teams through project workshops. They formed a team of three with no formal leadership. Consultants had different backgrounds and expertise, and engaged with student teams providing independent advice (often on the same issue). Advice was provided only when required, mostly based on what teams reported as being their state of progress, and on specific needs reported by each team.

Evaluators initially constituted a panel of three for the evaluation of project milestones. They also evaluated individual learning journals related to project milestones.

Tutors embodied the role of consultants and evaluators in the case discussed in this paper.

Clients provided aims and core requirements for the course project. In our case, they were representative of the Elgar Birthplace Museum (Worcester, UK).

3.1.1 Adaptations

In the early stages of the course, before the start of the project, the maximum team size was increased to six. This was done in response to requests of students who clearly explained how they intended to organise larger teams, and why this would be beneficial to their learning achievements.

The milestone evaluation panel was extended to five members for the most important project milestone, to include museum representatives. This was done in response to the Museum’s interest in proactively providing feedback to the teams, and the teams’ positive reaction to this possibility.

3.2 Contents and pedagogical materials

Tutors initially identified a core set of contents whose knowledge would be essential to pass the course. Tutors agreed that further contents would be added as the course unfolded, based on emerging events. Accordingly, pedagogical materials were planned to study core contents iteratively, through different approaches and means (e.g. books, slideshows, videos, guided tours).

3.2.1 Adaptation

Contents were broadened after the first project milestone, to study narrative in games and the contextualisation of game worlds and explore with other core topics. This was done in reaction to students’ interests and the approaches they chose to develop their team projects.

3.3 Learning activities

We articulated the course through four key types of learning activities: lectures; formative tasks; project milestone presentations; project workshops.

Lectures aimed at studying core contents from an abstract perspective, independent of specific contexts. Lectures explored contents iteratively, proposing, at each iteration, alternative perspectives, contexts, integrations and mode of study. Tutors initially designed and planned a minimal set of lectures sufficient to cover the core contents, leaving the possibility open to adding further lectures to cover new topics and/or revisit core contents.

Formative tasks aimed at presenting to students problems closely related to what explored in the lectures, requiring them to conceive and discuss solutions. At the beginning of the course formative task included both problem solving activities and step-by-step tutorials, to boost students' confidence. Later on, only collaborative problem-solving activities were proposed.

The **course project** required students to design an educational game for the Edward Elgar Birthplace Museum, based on aims and specifications provided by museum representatives integrated with requirements provided by tutors. It was agreed that a core set of requirements would be provided at the beginning of the course, allowing the addition/modification of requirements as the project unfolded, mimicking real-world scenarios.

Project milestone presentations required teams to present their project advancement state, and were the opportunity for evaluators to provide related feedback, just-in-time. There were three core project milestones: pitch, requiring an initial game concept compliant with the project requirements; pre-production, requiring a preliminary design and proof of concept illustrating key game mechanics; production, requiring the final game design, and a playable prototype implementing the core game features. A fourth milestone (post-production) was also included for finishing touches or late-minute fixes. Milestone deadlines were initially scheduled every three weeks. However, it was agreed by tutors that milestones could be postponed, depending upon emerging events.

Project workshops allowed teams to work receiving consultant advice. Consultants "visited" teams if requested, and worked with within constrained time windows, ensuring that all teams had a chance of receiving support.

3.3.1 Adaptation

The project production milestone was postponed by one week, to allow museum representatives to participate in the evaluation panel.

3.4 Assessment

The course was assessed through a portfolio comprising the team project and an individual learning journal.

The **course project** was assessed through the milestone presentations. Evaluators provided independent scores, not necessarily coinciding. After each presentation teams were asked to report on the team members' contributions. Members adequately engaged were awarded the full milestone score earned by the team. Contributions of students not adequately engaged were assessed individually, receiving a percentage of the team's grade.

Learning journals were structured to help students to reflect on and critically analyse specific aspects of their learning experience, and comprised both open entries/questions and closed questions. Students were required to compile a learning journal entry after the completion of each project milestone. A typical entry comprised evaluations of and reflections on: i) project milestone outcomes; ii) team dynamics; iii) personal learning experience; iv) learning activities.

3.5 RATIONALE

3.5.1 COURSE PROJECT TO COALESCE SYSTEM DYNAMICS

The project integrated, guided and gave meaningfulness to all the learning activities of the course. In fact: i) lectures, formative tasks and project workshops were designed/planned based upon events emerging from the development of projects; ii) lectures always covered contents immediately applicable to produce/enhance projects outcomes, possibly in response to the evolution of projects; iii) project workshops served to provide contextualised, timely support, strengthening students' understandings in relation to their concrete experiences with the course project; iv) milestone presentations triggered reflection processes as to the project progress.

3.5.2 DECENTRALISED CONTROL AND SELF-ORGANISATION WITHIN TEAMS

We created a decentralised framework and allowed teams to self-organise, to facilitate the emergence of a decentralised architecture which is the most suited to foster specialisation and trans-level learning (Davis and Sumara, 2006; Newell, 2008). The project goals and requirements were intrinsically multidisciplinary and could be fulfilled through numerous alternative solutions, none of which was discussed with students a priori. Hence, we wanted teams to freely define their approaches, and each student's role and responsibilities to emerge and reshape through a student/team dialogic relationship, based on the student's skills and interests, and on what the whole team considered to be suitable for the pursuit of a common interest (i.e. succeeding in the project). We expected all this to favour the emergence of both specialization and trans-level learning (Davis and Sumara, 2005, 2006; Newell, 2008).

3.5.3 ESSENTIAL KNOWLEDGE AND SHARED UNDERSTANDINGS

Core contents represented an essential knowledge base that students had to assimilate to be able to contribute to project teamwork activities. Thus, they were the object of the shared (redundant) understandings and the language necessary to permit fruitful and purposeful collaborative dynamics within each team and across teams (Davis and Sumara 2005, 2006).

3.5.4 SUPPORT FOR HETEROGENEITY IN LEARNING

The adoption of redundant and heterogeneous pedagogical materials was aimed at supporting different learning styles (Mainemelis et al., 2002; Coffield et al., 2004), thus promoting heterogeneity among students to further foster the emergence of specialisation (Davis and Sumara, 2006; Newell, 2008).

3.5.5 PERTURBATIONS TRIGGERING ADAPTIVE DYNAMICS

We leveraged consultant advice, evaluations and project requirements to expose students to frequent and often unexpected perturbations, requiring teams to continuously adapt to a dynamic context.

Consultants provided advice which was never prescriptive, and aimed at scaffolding team learning, acting as enabling constraints (Davis and Sumara, 2006). Consultant advice was independently provided and reflected consultants' heterogeneous perspectives. Therefore, student teams had the final responsibility as to what to accept and how to synthesise sometime divergent recommendations.

Evaluators provided just-in-time qualitative feedback for interim outcomes of each team project. Furthermore, through the evaluation of individual learning journals they provided qualitative feedback regarding individual progress, reflections and ideas that students proposed in relation to their team project. Evaluators' feedback was never prescriptive. Rather, evaluations proscribed undesirable approaches/decisions and emphasized critical weaknesses of the project being evaluated.

Project requirements implicitly promoted collaborative dynamics through requiring a workload that was hardly affordable without appropriate team organisation. They were never prescriptive, specifying objectives but not ways to achieve them. Furthermore, frequent moderate changes in project specifications required teams to adapt their approaches on a regular basis.

Thus, consultant advice, evaluator feedback and project requirements served as forms of enabling constraints, fostering coherence while enabling the emergence of diverse responses (Dennis and Sumara, 2006).

3.5.6 Relevance and feasibility of contents

The definition of the core contents was driven by the ethos of 'thinking globally and acting locally' (Frei, 2011). To promote meaningfulness and relevance, core contents were selected based on analyses of exogenous contextual factors (e.g. game industry state of the art; employability requirements). At the same time we took into account important endogenous factors (e.g. time constraints) to safeguard feasibility.

3.5.7 Iterative and incremental teaching

Learning activities were organised to iteratively study and apply concepts and frameworks at different levels of depth, complexity and integration. This aimed at promoting the redefinition of ideas and concepts at increasingly sophisticated levels through a spiral process, requiring to learners "(…) *a continual deepening of one's understandings of them* [ideas and concepts] *that comes from learning to use them in progressively more complex forms*." (Bruner, 1960, p13)

3.5.8 Assessment portfolio as a facilitator of specialisation

A portfolio comprising a multi-disciplinary self-organised project was an appropriate choice to both assess standard skills and promote the development of emerging skills (Frei, 2011). We planned the portfolio to foster skill heterogeneity and allow students to specialise and develop along diversified paths, decentralising control and allowing team self-organisation to make specialisation possible (Davis and Sumara, 2006; Newell, 2008).

3.5.9 Compound assessment to nurture collaborative dynamics

Our strategy defined the grade of each student as the result of his/her engagement in team activities, and hence in collective system dynamics. In fact, although learning journals were individual, they were based on the outcomes of team activities (milestones), and it was impossible to earn significant credits through the learning journals without properly engaging in the project. Furthermore, team as a whole ultimately decided whether its members adequately contributed to team dynamics or not, being consequently entitled (or not) to share the team's score. All this was planned to nurture collaborative dynamics, minimising the risk of students "leeching on team performance".

3.5.10 Assessment as a "window onto the system"

Assessment activities were planned to generate a constant flow of information regarding system dynamics, necessary to adapt the educational strategy based upon emerging events.

4 Outcomes and discussion

What impact did the complexified educational strategy have on students? From complexity perspective, impact is seen as a process of change that is adaptive in nature. This means that the process, and not only the outcomes, should be looked at, trying to understand how individuals continuously interact with their context, leading to knowledge production at micro and macro levels (Davis and Sumara, 2005). Embracing a complexity perspective also means describing impact in terms of the evolution of processes and outcomes, feelings, skills and knowledge that could be affecting the overall development of the course as a learning system.

Thus, in order to answer the initial question, we decided to evaluate the impact in terms of both process and outcomes, and at different levels. For this, we analysed data provided by students through the learning journals. These learning journals allowed us to explore the students' opinions, feelings and perceptions regarding:

1. Teamwork
2. Perception of the activities (level of difficulty, relevance to the module, perceived quality of performance, motivation, enjoyment)
3. Perception of progress and expertise, defined by feelings of autonomy and development of abilities and confidence with the course topics.

Closed items of the learning journals were formulated as propositions to be rated on a 5-point Likert scale. Averages were calculated to summarise the main trends found in the course.

Learning journal entries were evaluated based on items requiring students to reflect and deal with problems requiring to apply knowledge and skills used for the milestones. Scores were categorised in a 5-point scale.

Evaluators assessed project milestone presentations using a 5-point scale. The teams' total score was calculated by averaging the scores given by the different tutors.

4.1 EVOLUTION OF TEAMWORK

There was a surprising difference between the evolution patterns across the different aspects of the work done by teams (Figure 4). From the beginning, teams perceived that their ability to agree on key decisions regarding their projects was very good, and this perception remained constant for the next milestones. Collaborative problem solving and team communication were initially perceived by students as "good", and increased to "very good" as they approached the production milestone. This did not happen with other teamwork aspects. On average, workload distribution was always perceived as good, showing some fluctuations between milestones but never increasing or decreasing too much. Time management skills presented the greatest variation throughout the course. In the beginning students had some difficulties in organising their time to work in groups and reconcile the course demands with their other academic activities. Good time management was achieved by the teams after the first milestone, and it remained constant for the rest of the course.

When analysing team performance in light of the scores obtained by students in each milestone, it appeared that team communication, collaborative problem solving, time management and ability to agree on key decisions were correlated to the teams' scores on the tasks ($r=0.25$, $r=0.24$, $r=0.28$, $r=0.22$ respectively). Interestingly, no correlations were found between teamwork and the students' individual scores. Despite the small strength of the correlations, these results are coherent with the literature indicating the importance of participatory, collective, and ongoing engagements that, in the process of adaptation to the requirements and constrains of the context, enable the emergence of collective cognition and knowledge production (Davis & Sumara, 2006; Newell, 2008; Davis & Sumara, 2010). Discussion plays an active role in the creation and improvement of knowledge, especially when it is oriented towards a collective understanding (Jordan, 2010).

It is important to note that, beyond the complex nature of the strategy, teams had to face other situations that were not foreseen (e.g. sickness of a member before a deadline; members' disengagement), affecting the team dynamics at different stages of the course. Students had to learn to adapt to these changes and organise in ways that would enable them to continue their work. These situations were highly valuable to make new learning emerge - a kind of learning not directly related to the course topics, but very relevant in terms of the capabilities required to engage with the "real-world".

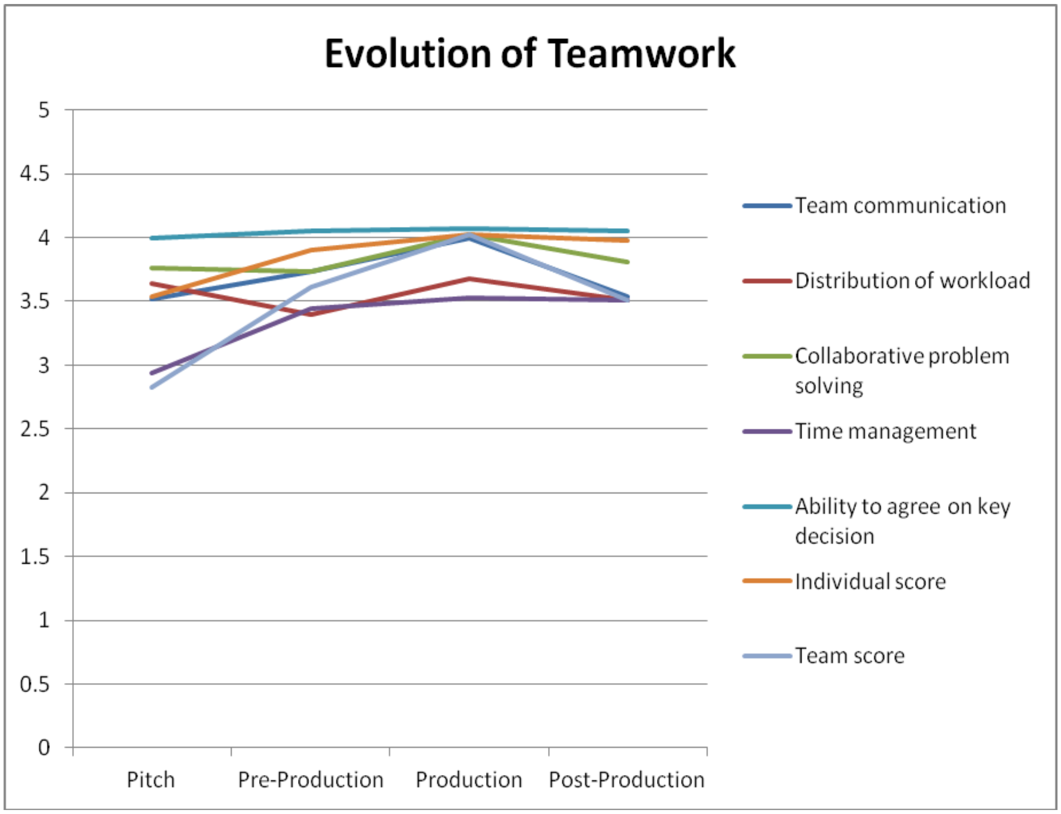

Figure 4 Evolution of Teamwork

4.2 STUDENT PERCEPTION OF THE ACTIVITIES

Students considered learning activities relevant to better understand the topics of the course. Production and post-productions milestones were perceived as the most relevant activities, nonetheless very close to the pitch and pre-production activities done before.

In general, students perceived an almost ever-increasing level of difficulty. The pitch milestone was perceived as neutral (“neither easy nor difficult”). Perceived difficulty increased until the production milestone, which was mainly considered as difficult. The post-production milestone was perceived as less difficult than the production, but more difficult than the pitch and pre-production.

Despite the progressive increase in milestones’ difficulty, from the beginning students felt very motivated to work on the different learning activities proposed by the course. Notably, this motivation remained mostly stable across the activities, slightly peaking in the production milestone. It is thus not surprising that the level of enjoyment reported by students was very high as well, and stable across the different activities.

In summary, the increasing difficulty of milestones did not overwhelm students. On the contrary, most students found the activities challenging, motivating, relevant to their learning and enjoyable to perform.

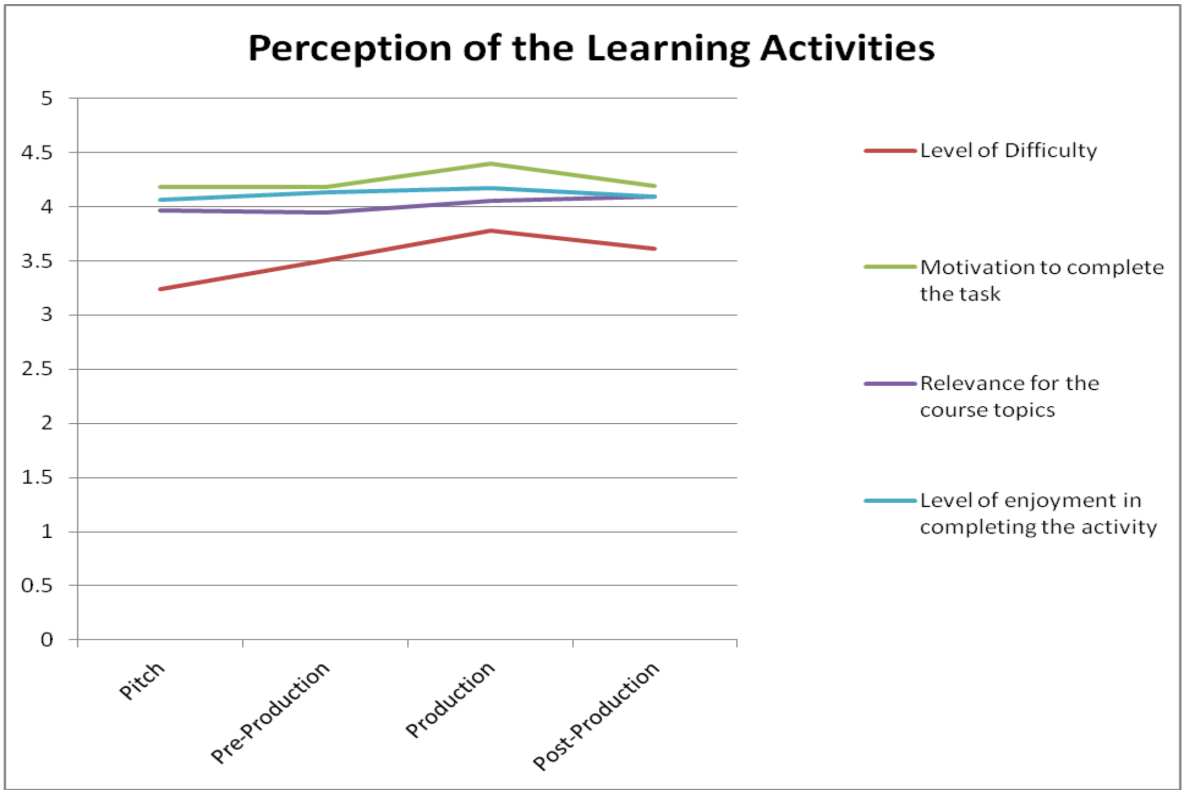

Figure 5: Students' perception of Learning Activities

4.3 PROGRESS AND EXPERTISE

Overall, students perceived that they were making progress and increasing their expertise in the topics related to the course (Figure 6). Students strongly perceived that they were improving the abilities required to deal with the topics of the course and that they were gaining more confidence. These perceptions were reported from the beginning of the course and evolved positively during the semester.

From the beginning students also rated as “good” their level of understanding of the course topics and their level of confidence in successfully accomplishing the tasks related to the topics seen so far, working both in teams and autonomously. Their perceived level of understanding remained constant throughout the course, while their level of confidence increased slightly.

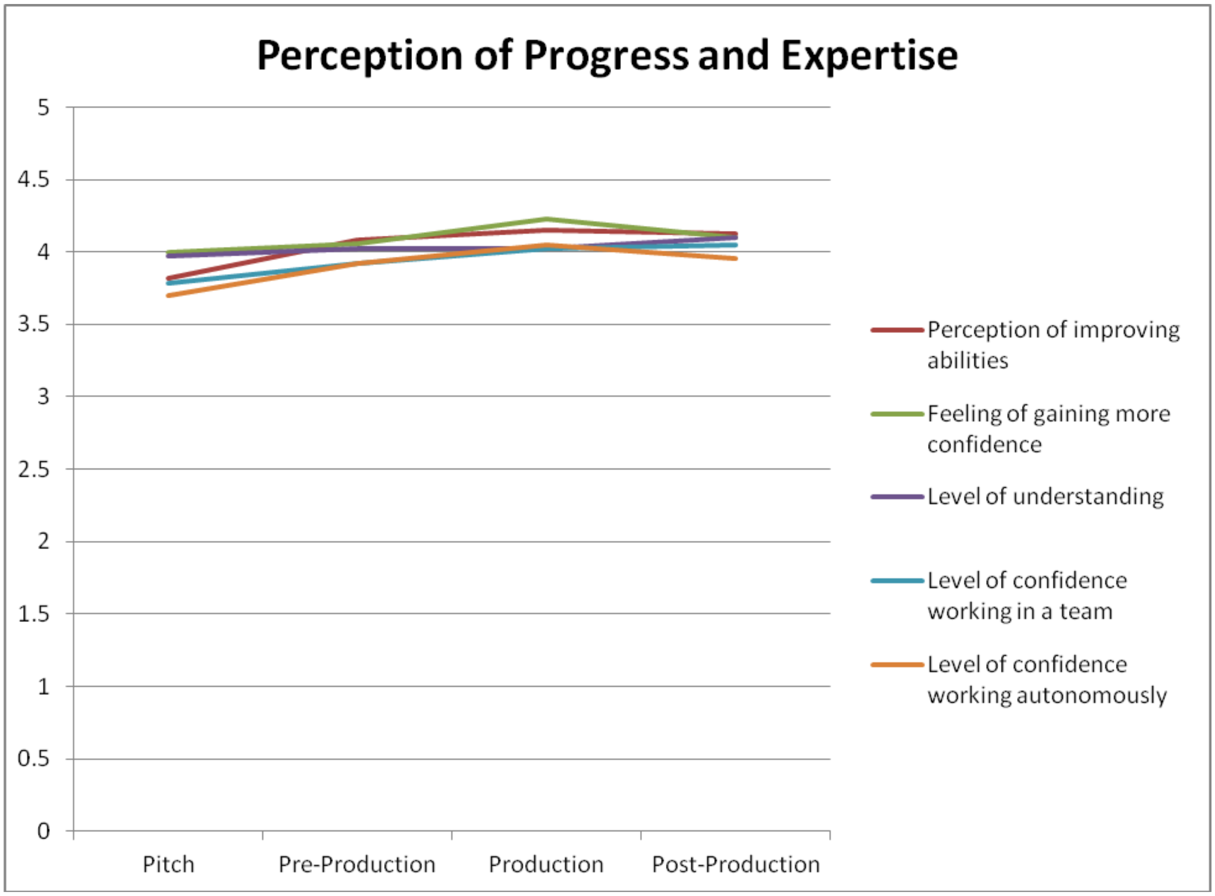

Figure 6: Perception of Progress and Expertise

Evident differences appear between the perceived performance in the course and the scores in team and individual work (Figure 7). Average team performance was "fair" in the pitch and rapidly increased to "good" in the following milestones. Average individual scores always remained in the "good" category. Interestingly, team scores increased to level up with the individual scores. Considering the results presented in section 4.1, it is possible that students initially perceived that their individual work was sufficient to produce a good team result. After realising that their performance was not as good as expected, they probably recognised that they needed to work more and better with their teams, interacting more and producing more collective knowledge. Team self-organisation is not automatic, even more if students are not used to work in teams and face complex group dynamics. Time and continuity of interaction is needed in order to create the clash of ideas and the interplay of individual and collective learning, leading to the transformation of team knowledge into something that transcends the sum of the student individual knowledge (Newell, 2008).

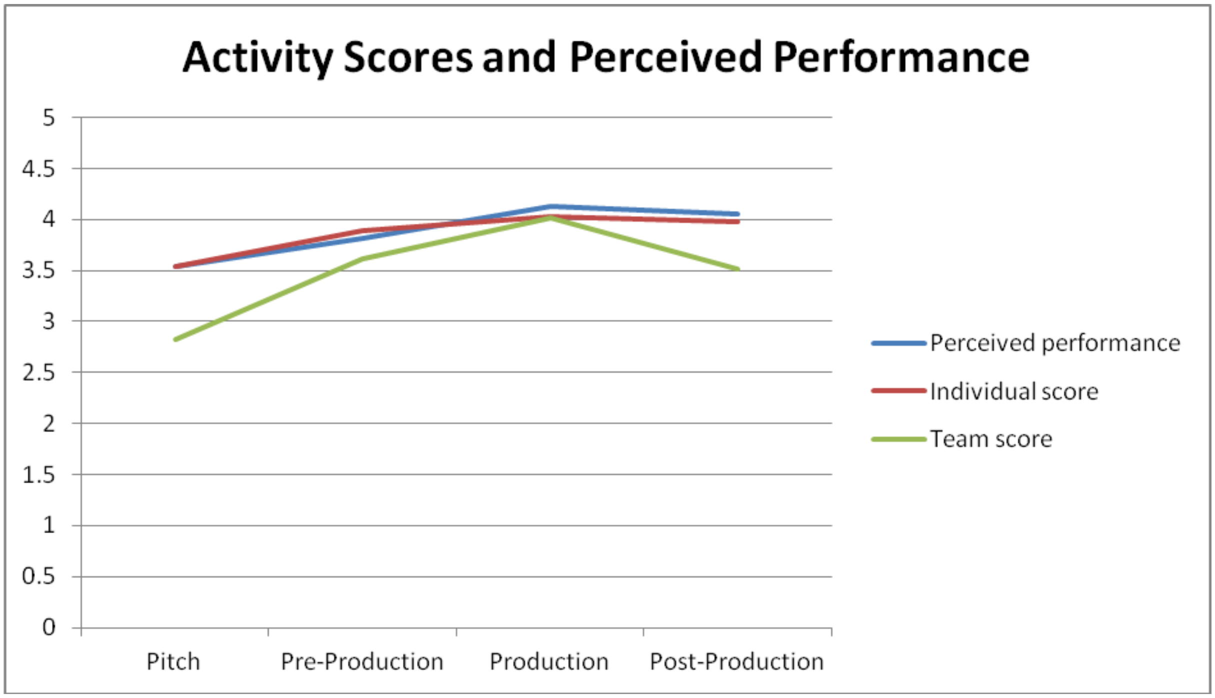

Figure 7: Perceived and Real Performance

5 PRELIMINARY CONCLUSIONS

The aim of this paper was to report an experience in a higher education course which used a complexified educational approach. As complexity science leads us to focus on processes and on different levels, a huge variety of information was collected in different moments and involving different actors. This paper only presented the general design of the strategy and some preliminary results regarding the development of the course as a CAS. Our research is ongoing and there is still much information to be analysed and integrated in the general picture. Nonetheless, we believe that the experience analysed so far allows us to advance some preliminary conclusions and reflections:

- The development of complex thinking requires not only to learn about complex systems, but also to participate in situations requiring to face the challenges of complex systems. Adaptation to change and self-organisation cannot be learned if not by being part(icipants) of situations that require them. In our experience, we witnessed how students had to deal with complex situations and how they managed to self-organise and give continuity to their work. Likewise, we also "witnessed" our own transformational process, which demanded us to adapt and change our plans, even revising our assumptions regarding certain aspects of the course.
- It is interesting to see how teamwork skills evolved throughout the course, and how they were related to the learning being produced by the collective class. As Jordan (2010) indicates, individual and collective learning are a consequence of the interactions of connected and diverse agents. Both individual and team scores increased as students continued to work collaboratively in teams for the different milestones, but it was the teams' score that presented the greatest improvement throughout the semester.
- We were surprised to see that, from the beginning, students in general gave high ratings to their motivation, learning and progress. It seems that an iterative and adaptive course strategy constantly promotes students' feeling of increasing their abilities and understanding of the topics of the module. It also fosters the idea of being able to accomplish required tasks either autonomously or with a team.
- "*Complexity cannot be scripted*" (Davis & Sumara, 2005, p.460). Since learning is a complex phenomenon, teachers and learning strategy designers can provide students with learning environments rich with possibilities for learning, but they cannot prescribe what will be learnt. Nevertheless, the adoption of complexified learning strategies can promote and nurture complex dynamics facilitating learning processes at different levels.

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