Exploring the Micro, Meso and Macro
Proceedings of the European Distance and E-Learning Network 2018 Annual Conference
Genova, 17-20 June, 2018
ISBN 978-615-5511-23-3
ISSN: 2707-2819
doi: https://doi.org/10.38069/edenconf-2018-ac-0063

ACTIVITY THEORY AS DESIGN TOOL FOR EDUCATIONAL PROJECTS AND DIGITAL ARTIFACTS

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Introduction

The European Community has identified as one of the most important goals of EU 2020, the issue of technological innovation aimed at developing and improving the quality of life of citizens and to enhance the performance of education systems (European Commission, 2012). In particular the Digital Competence Framework 2.0 (DigComp 2.0) states, in the area "Problem Solving", that a key competence is related to resolve conceptual problems and problem situations in digital environments and to use digital tools to innovate processes and products. Following these recommendations, in 2015 we started a Master's program entitled "Digital Innovator" at the FISPPA Department of the University of Padova (now at its 4th edition). Many of the participants came from various public institutions (schools, municipalities, local health authorities). They enrolled in the Master with the aim to acquire technical and methodological skills useful for designing and implementing specific educational digital projects each one in their specific context. In fact, there is the need to train teachers and experts that are able to deal with these issues and the Master wanted to meet these training needs, focusing especially on the planning stage of educational digital projects.

The Activity Theory framework to design digital educational project and artifacts

A flexible, modular framework able to effectively represent the many and complex relationships and processes involved in an educational digital project, can be the "Cultural Historical Activity Theory" (CHAT) (Engeström, 1987). The theory focuses on *activity systems* seen as interactions and changes in learners, social communities, objects, and tools. Technologies in our context are seen as mediators tools of the activities of individuals acting in a coordinated way in order to achieve a specific goal (Kaptelinin & Nardi, 2006). According to this interpretation, we can describe the activities of a complex socio-technical system, such as the planning of educational digital projects, analysing the interrelationships of six elements that contribute to the realization of an *expected outcome*:

- subject(s) – actors engaged in the activities;
- object – the objective of the activity system;
- community – social context;
- tools – the technological artifacts (instruments) used by actors in the system;
- division of labour – the division of activities among actors in the system;

- rules-conventions, guidelines and rules regulating activities in the system;

Among the various elements, some critical issues often emerge, that in the Activity Theory are defined as *contradictions* (Engeström, 2001). The concept of contradictions between two elements of the triangle (Figure 1) is the starting point for the recognition of the principal stresses (seen as problems) in a system, but also a possible direction for the evolution of the activity system itself. It's important to note that the contradictions are intended not as occasional problems that may or may not influence the Subject, but they represent a real structural component of the system that affects all the elements. Engeström also defines multiple levels of contradictions, starting from the internal ones (for example, between the subject and the community or between the Community and the Rules) until you reach the outer ones that may occur between different activity systems.

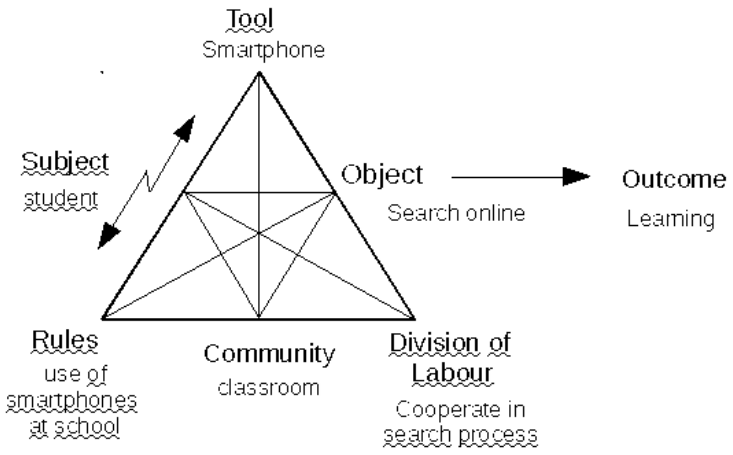

Figure 5. Interrelationships of elements of an educational activity system according to the Cultural Historical Activity Theory (CHAT) (Engeström, 1987). The diagram shows a possible contradiction in the use of smartphones at school.

For example, we can consider the educational use of smartphones in classrooms in order to keep students engaged in an online search for information about a specific learning topic: it can lead to contradictions between Rules and Subject (Students) because smartphones are powerful distractions device and can be an opportunity for cheating, unauthorized socializing, and social isolation (Figure 1). Activity Theory can also offer a methodological perspective where technologies in educational contexts can be analysed in a broader view starting from a micro level (students, teacher, classroom) to a meso level (school networks) and finally to a macro level (Núñez, 2009; Jaworski & Potari, 2009). This approach is useful in order to discover how and if an educational technology project can be influenced by cultural and social interactions outside classroom and formal education. Technology itself is not a neutral tool, it becomes a generative force that shapes and change the learners' knowing processes (Su et al., 2013).

The Activity Theory and the Project Work

Activity Theory can provide a good framework for project work design (Hung & Wong, 2000), so participants were invited to design their proposals for educational technologies projects

ISBN 978-615-5511-23-3

using this framework. It was not too difficult for them to identify concrete elements at play in their specific Activities Systems and recognize the potential *contradictions* emerging in each System. This historical-cultural analysis process of the various organizations has led to many participants in the Masters to develop a deep understanding of how each organizational context in which they belong to can evolve positively, and in this way solving one or more contradictions present, thanks to proposed changes and innovations introduced in the project. Use of the Activity Theory, however, has required us to pay special attention to the items *Outcome* and *Tools*: most of the projects in fact wanted to have as *Outcome*, an App to install on a Smartphone or tablet, to be used by students or citizens, but the analysis has also highlighted the need to consider this App as part of two Activities Systems and in which it takes on two different roles.

In the first role, the App is conceived as the *Outcome* for the Design System and in the second role instead intended as a *Tool* of another Activity System; The broadening of the design perspective that involves two Systems, one of production and one of use, then drove us to elaborate an ad hoc model, useful for the participants in order to improve their understanding and the design of project. We referred to the PAM (Project Activity Model) model, which enabled us to transform the learning experience of the Masters into a real organizational project, which was set out through a project-based learning approach (Krajcik & Blumenfeld, 2006; Bell, 2010). As we have seen, the first step required the reconstruction of the current Activity System from which one could begin the plan design. Subsequently the relationship between two systems in which the key elements are the design and the use of application software that are able to resolve some of the contradictions emerging from the analysis of the Activity System and can help it evolve effectively was outlined. All the projects proposed have had to review the information systems related to their Activity System.

Two connected systems: *production* and *use*

Many projects written and realized in the master "Digital Innovator" involved the participants drawing two connected activity systems. The first one refers to the production of an App or a digital instrument and the other one showed its use and therefore the changes occurred in the initial activity system (before the project). Therefore, the design model PAM (see a first formulation called SAM that concerned only Smart Cities projects, in Petrucco and Ferranti, 2017) allows the integration of the Production and the Use systems to innovate the intervention in real educational contexts (Uden, 2006). After the representational rebuilding of the two systems, in order to complete the design, we proposed to follow some steps called PAM DESIGN STEPS (making explicit the information needs for the digital tool or app design), which are shown below:

- the analysis with AT triangle related to the current context, before the project;
- the emergence of the main CONTRADICTIONS - identification of the most important contradictions in order to design an information system that meets the needs of the evolution of the System (van Amstel et al., 2016);

ISBN 978-615-5511-23-3

- the creation of KEY QUESTIONS - leading questions that help to identify key information elements used for shared planning (their nature, form, value and timing, ...);
- the draw of connected two systems: production system and use system of digital tool or App);
- the use of a DOCUMENT MODEL for the descriptive part of the project document, namely a format of logical design sequences.

The PAM model has many strengths, but also some limitations. It is suitable to identify the main directions of evolution of the system and it is particularly profitable for the macro-design processes. Nevertheless, it does not appear to be the most appropriate instrument to manage the micro-planning level of the App and the specific information flows. For these processes the project team should make use other design tools. Especially for App development aspects, it should make use specialized and technical knowledge, which also take into account the vision of any participatory planning systems that allow to respond to the needs of students.

Projects based on designing model

The experiences of project work of the participants are clear examples of how the PAM design model can help one to focus on the fundamental directions for thinking in an evolutionary manner about the project in a specific context (seen from inside a public institution or a school system). During the first three editions, the participants designed several educational projects with our model. It is interesting to report these projects because they are the result of an entire process. The analysis of the context, the activities system and the roles of the involved stakeholders and the contradictions within the system itself have outlined, in a socio-culturally founded way, the specific elements of the educational design actions. Many ideas were presented with the support of PAM, among which here we mention four examples, and at the end we represent only one of them.

The first one is "The alphabet of dots": the project, with inclusive educational objectives, has realized a path with tactile laboratories and sensory deprivation exercises in order to allow children to better understand the condition of a blind person. In addition, has been created an app, specially designed for sighted children, that allows to learn and practice alphabet Braille in an intuitive and fun way. The second one is "Dante's Inferno", a playful-educational application for an interactive game; the project led to the design of *Dante's Inferno*, an app for tablets and smartphones, that allows to create dynamic activities starting from the creation of a team game structured as the "Game of goose". The third one is "OpenLab", a participated project of creative atelier, a sort of fab lab, realized in a secondary school. The analysis of the activity system showed the need to involve the territory (interest groups and associations) in the design and organization of the atelier. The creation of an App made possible to manage the organizational and consultation phase.

The last one is "Augmented Museum", the project led to the construction of an educational path, through an *ad hoc* Augmented Reality App, modifies the approach of students, but also general visitors, to the Museum of Natural Sciences of Legnago. The outcome of the project was

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the creation of a visit experience where students can "touch" the artifacts and interact with 3D digital objects. During the first step of design process, it was fundamental to bring out the contradictions of the current system. They turned out to be: difficulty in the representation of museum artifacts, lack of structured paths designed for visitor categories, weak involvement of the local community. Afterward the "production system" connected to "use system" was outlined, a core step to have a good initial representation and then to develop the entire project and facilitates the descriptive phase of educational project work (Figure 2).

All projects are the result of definition of the interaction between different activity systems where some contradictions connote the existing context and activities. From the reciprocal relationship of elements of old activity system, the participants design a new and prospective system, imagined for the future and reachable through the app's production system.

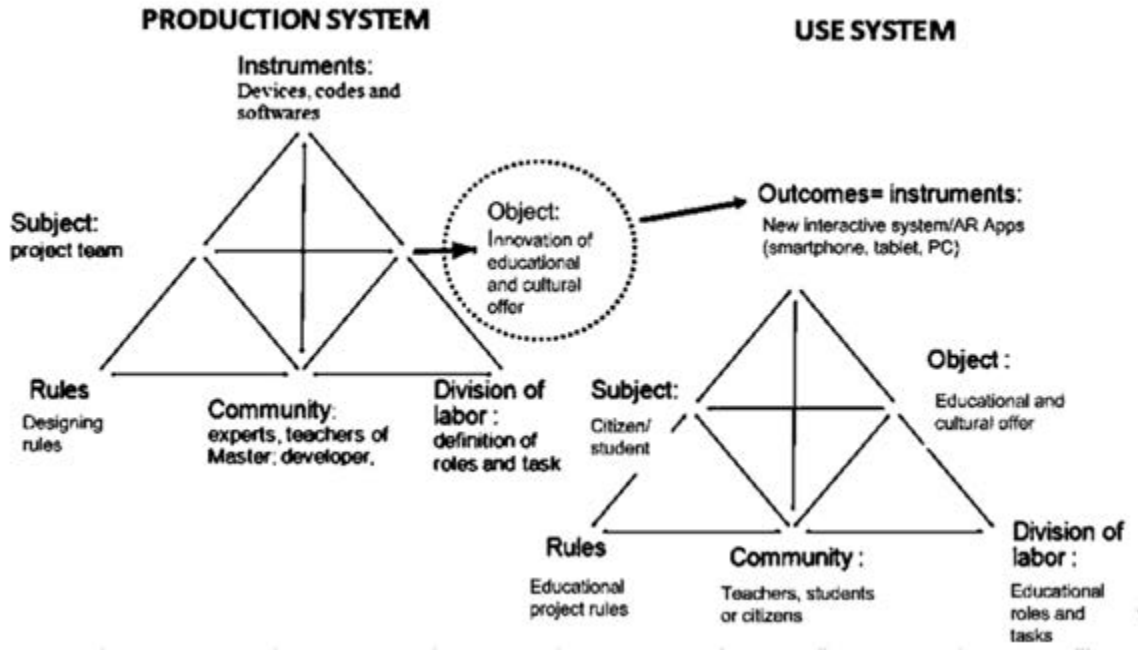

Figure 2. The connection between production and use systems (project "Augmented Museum")

Participants perceptions of PAM model

To test the usefulness of the model in the projects design we analysed the perceptions of participants (N = 40) at the end of the Masters activities, through a short questionnaire. In particular, in 2015, there are 20 participants (M = 9, F = 11); in 2016, 11 participants (M = 2, F = 7); and in 2017, 9 participants (M = 2, F = 7). The results were encouraging: more than about 90% of the participants considered it *useful* or *very useful* to use the model in the initial design stage, compared to a conventional design they used in past, confirming a previous result in Petrucco and Ferranti (2017), with data referring only to 2015. Also the distributions reported in Table 1, although different, do not change much the substance of the participants' perceptions. It's interesting to analyse the reasons for these findings (Table 1): the majority of participants see the model as a concept tool that is capable of representing effectively and comprehensively all the elements and their interactions (79%), especially between different activity systems (61%) (for example, Public institution and citizens or School and students).

ISBN 978-615-5511-23-3

Also to note, but to a lesser extent, is the perception of the model as a tool that facilitates communication of the project to politicians or administrators (28 %). Finally, more than 80% of the participants believe they can use this model in the future into their professional practice.

Table 1: Perceived usefulness of the PAM model (more than one answer)

It has effectively represented all the elements and their interactions.	79 %
It made it possible to understand the interaction between the two different systems involved (e.g.: my institution and the targets of project).	61 %
I have been able to easily explain my project to others or to the administrators and / or politicians.	28 %
I have been able to clearly define the problem that the app had to deal with.	18 %

Conclusion

All the participants considered the PAM model very useful in particular because it made possible to understand the interaction and solve contradictions between different stakeholders and systems involved. In particular, the PAM model has enabled participants to consider the development of technologies, such as the App, not only as a mere product, but also as part of multiple different systems of activities that can adequately represent the requests and the points of view of all the social stakeholders involved in the production and in their use. From a broader point of view, using the Activity Theory (AT) framework as a project/reflection tool proved to be particularly effective, both as a reference framework for the design of specific educational technologies projects and as a training tool capable of creating a bridge between formal learning conveyed in academia and real world contexts. The participants highly appreciated the characteristic of the AT to foster a systemic vision which clearly represents the various elements involved and identifies technologies as important mediators of the innovation processes.

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