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PERSONALIZATION, ADAPTIVITY, ATTUNEMENT

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The complexity of the current educational context, that is, the fragmentation of knowledge and the diversity which characterizes the students in our schools requires new competences. One of the answer is certainly to think about personalized path. The personalization of paths is a hard task for the teacher and, thus, the efficacy and also the sustainability of this choice need to be examined. For what concerns sustainability a solution has been provided by the interaction between the educational world and the world of knowledge engineering. The focus on the user, on intelligent systems for personalization, the adaptive and responsive design are proposals that were born with a different objective, but that have opened new perspectives also in the educational context.

Besides, such processes have linked different research fields, the one of education and the one of knowledge engineering, such connection needs a common languages and meanings to be able to produce solutions. The paper

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is aimed at investigating possible solutions to foster the convergence and the dialogue between the two sectors and wants to verify if the complexity of the current situation is changing the concept itself of personalization.

1 Introduction

The educational world faces today two problems connected with the complexity and, thus, to the current context.

The first one is represented by the fragmentation and the plurality of knowledge, the huge amount of information available. This requires the need for the learner to develop new competences both to access knowledge and to organize it. The second problem is caused by the diversity among the subjects involved in the learning processes. Today the differences among the learners are wider than in the past since students shows their own characteristics that can vary a lot according to the culture (see the migration process), to abilities (special needs), to knowledge (the chance to access information and its multiple sources both in formal, informal and non-formal contexts).

This situation creates a *super diversity* (O'Neil, 2014) among the learners' knowledge and requires that the teacher develop paths able to valorize the personal knowledge of every learner taking into account the learning styles, the potentialities and the difficulties.

Personalized paths seem to be the answer to the problems connected the current context even if it's not always easy for the teacher to build and manage them.

Sustainability has fostered a strong relationship between the researches about personalization and inclusion in the educational field, and the researches about personalization and adaptivity in the field of knowledge engineering. The analysis developed in the following sections takes into account just solutions in the educational field that imply a significant use of technologies. It's thus clear that every path gathers the contribution of researchers in different disciplines: pedagogy, psychology, information technology. When the research develops in border sectors each researcher participates from his/her epistemology viewpoint, so reference languages, meanings and axioms are not always consistent to each other (Rossi & Fedeli, 2014).

The same words "personalization" and "adaptivity" show different meanings in different authors.

There seem to be two options to reach a wider consistence. The first one is to create a common definition. But it's a hard choice (from what common backgrounds shall we start if the reference epistemologies are different?) the papers aims at exploring a different solution. It tries to identify the indicators and the family of problems that characterize the personalized and adaptive

solutions. The reference to common practices can be a starting point to build sharable meanings.

2 Some definitions

We consider a useful strategy to present some current definitions extrapolated from the last years researches.

Adaptive learning appears in the Sixties and Seventies "as a consequence of such an educational approach, wider ranges of abilities can be accommodated and capabilities for learning and motivation can be developed and utilized" (Glaser, 1977, p. 122) and opposes itself to the one-size fits all approach that was common in many educational actions. (Cohen *et al.*, 1982; Kadiyala & Crynes, 1998; Kulik *et al.*, 1990; Waxman, 1983).

Brusilosky and Millán (2007) use the word "personalization" as an umbrella concept that gathers various processes. The main processes are the "user modeling", that is the modeling of the user according to his/her knowledge and/or behaviours and the "adaptation", that is the answer to the requests and needs of the user. User modeling and adaptation are two sides of the same coin, that is of personalization.

Soylu *et al.* (2011, p. 100) state that "the learning system shall not only provide a user-tailored experience through personalization but also adapt to the setting, in which the learner is engaged, through context-awareness."

Adaptivity is defined "as the capability of a system to alter its behaviour according to the learner's needs and other characteristics" (p. 101).

Personalization and adaptivity are seen as two distinct processes that offer different solutions.

They also propose the following categorizations of adaptivity (p.104):

> (1) context based filtering and recommendation of information and services (2) context based presentation and access of information and services: e.g. multimodal and dynamic user interfaces (3) context based information and service searching: e.g., query rewriting for a search for available learning items, (4) context adaptive navigation and task sequencing, (5) context based service and application modification/configuration: e.g., disabling particular features depending on the capabilities of the target device, (6) context based actions: manual, semi-automatic, and automatic, (7) context based resource allocation (digital / non-digital).

Corno (2008, p.161) states that "in teaching adaptively, teachers respond to learners as they work. Teachers read student signals to diagnose needs on the fly and tap previous experience with similar learners to respond productively.

Teaching adaptively is intellectual as well as technical, requiring quick response to learner variation".

Even from the limited number of the references here proposed it seems to be clear that personalization and adaptivity are used in a different way.

In this paper we will use the generic phrase "personalized paths" as a macro concept to refer to both personalized and adaptive processes in which technologies are used.

Contexts and connected possible variables will be identified. In the final section of the paper we will try to answer to the following question, taking into account the above mentioned variables: the personalization and adaptivity processes were present since the Fifties, but what changes occur when they are used to face the complexity of the current context?

3 The subject and the product

Brusilovsky and Millán (2007) identify two processes in the personalized paths: the user modeling and the adaptivity. How does profiling work? The authors highlight two main characteristics: from one side behaviours and interests, on the other side knowledge. The tracking of what occurs in the online environment helps identifying the user's wishes and perspectives. In the educational field we have two options: starting from the student's physical and cognitive characteristics, and starting from student's knowledge.

Corno, moving from Stenberg, makes reference to "learning styles", that is, stereotypes that describe the basic modalities with which students approach the study (2008).

On one hand Brusilovsky and Millán identify the background for the profiling in the interests and behaviours of the students, on the other side, taking ITS (Intelligent Tutoring Systems) as a reference, highlight as "the user model in ITS is known as a student model and represents mostly the user's knowledge of the subject in relation to expert-level domain knowledge" (2007, p. 4).

If we refer to the product, adaptivity can be connected to different aspects. Brusilovsky and Peylo (2003) suggest to focus on various issues tied to the different techniques used: (1) Adaptive Hypermedia (navigation Support or adaptive presentation, curriculum sequencing technology, intelligent solution analysis), (2) Adaptive information filtering (AIF), (3) Intelligent class monitoring, (4) Intelligent collaborative learning, (5) Intelligent Tutoring.

The range moves from the physical characteristics of the product (format, media used such as texts, images, and videos (Mayer, 2003; McLoughlin & Lee, 2008), to the filtering of resources according to perspective, structure, typology of the provided support (as the structure of the text or of the concepts highlight, Laurillard, 2014). The design choices generate two main solutions:

either to consider the user's profile or to consider the expert knowledge as an independent variable.

4 The subject and the objectives

A second family of variables is connected to the relationship between the subject and the objectives. Differently from the previous paragraph the focus is on the autonomy of the subject in the learning process, a concept that made authors in the educational fields create the words "individualization" and "personalization". Also in this case different definitions are present.

The two concepts are meant, by some authors, as synonyms (Montedoro, 2011) and by others as different (Baldacci, 2005; Calvani & Rotta, 2000).

In this last case personalization implies "a reference to the subject who doesn't decide just the path to follow within more options already set; the subject is co-author of the learning process, h/she has space and voice also in setting and organize the objectives of learning" (Calvani & Rotta, 2000, p. 49).

Individualization is meant, instead, as a process in which the objectives are predetermined and according to them the learning paths are organized either by the teacher or by an automated system (Calvani & Rotta, 2000).

An attempt to overcome such dichotomy, keeping the dialectics equality/dissimilarity, is the proposal by Baldacci (2005) to adopt the phrase "convergent personalization" (that is individualization: different paths to reach common objectives), and "divergent personalization" (that is personalization: different paths to reach different objectives for each leaner).

Chiosso (2010), Kennedy (2008) and, before them Hoz *et al.* (1997), have highlighted the limitations of a dichotomic vision between personalization and individualization since, if individualization doesn't imply the autonomy of students it won't have any didactical efficacy. In the same way if personalization doesn't offer the option for a feedback of the teacher it will lose its educational value.

5 One-to-one approach and the class

An additional variable is connected to the typology of relationship between the teacher (in face to face settings and in automated systems) and the learner.

Personalization, as seen in the Eighties and Nineties, used to believe that the one-to-one model, that is one teacher for each student as in the educational settings of the past centuries, could guarantee a better quality of the teaching process. The class for those authors is just a matter of economical needs to be able to face the mass education. Starting from this conception the one-to-one relationship is a guarantee of personalization.

According to Koschmann (1996, p. 7) "since one-on-one tutoring is considered the gold standard against which other methods of instruction are measured (Bloom, 1984), the paradigm is founded on the proposition that education could be globally improved by providing every student with a personal (albeit machine-based) tutor" (Lepper *et al.*, 1993). The creation of ITS is an application of such approach until the Nineties in which the tutoring is meant as superior to classroom learning (Graesser *et al.*, 1995). For example, for what concerns Andes, one of the most used ITS and the one considered as a theoretical and practical reference, Schulze *et al.* (2000) state that a primary objective is "to provide a tutoring environment that allowed the same kind of student/tutor interaction that might be experienced in a one-on-one session with a professor" (p. 3).

The second model is framed in the researches by Vygotskij and, then, in the constructivist vision. This model highlights the social aspect of knowledge and underlines the relevance of the active role of the student in the learning process and his/her continuous interaction with peers to validate the knowledge construction. In addition, the role of the class as a collective subject is relevant. After 2000, this second model is being discussed by several authors, also in the field of knowledge engineering. For example in the call for papers of the ITS conference in 2006 one of the topic was: "Teamwork and peers collaboration (Collaboration: The use of peer-collaboration within ill-defined domains, e.g., to ameliorate modeling issues)". This issue is significant because it underlines a shift from the one- to-one approach of the ITS of first generation.

Pedagogically the two models support different learning processes: the first is focused on the tutor role as a guide and on step-by-step pre-structured paths. The second one requires that the teacher set the learning materials and possible paths that are, then, developed by the student/s in an autonomous way according to their own strategy.

6 Personalization and complexity. The attunement

The search for personalized solutions has ancient roots. Corno (2008) sees the origins of such strategies already in Quintiliano and describes its evolution till today (Mangione, 2013). The question that we ask is how the concept of personalization is changing in the society of complexity. Complexity implies the need for solutions that are non-reductionist that take into account a systemic vision in which the various components interact and generate autopoietic processes.

What does it mean in the educational field? And how personalized and adaptive systems could evolve?

Corno (2008) counterposes the micro one to the macro adaptation, he states

that:

> Macro adaptation refers to programs planned for groups of similar students based on formal assessments of qualities such as intellectual ability (as in "gifted" education), or sociocultural background another factor that influences response to instruction (as in teaching for cultural congruence).[…] Practicing teachers, however, make micro-adaptations all the time—in the ongoing course of instruction and in response to particular students. They interpret the to and from of classroom life, and intercede. In fact, with respect to classroom teaching, the term micro-adaptation might be defined as continually assessing and learning as one teaches—thought and action intertwined. Micro-adaptations are critically important for the nuanced line of theory we care about today (p.163).

The perspective of micro-adaptation brings back the focus on the level of the didactical action, of the complex didactical practices and this is in line with the current researches in the educational field that put the attention to the lesson and to the class practices (Ferrari, 2014; Giaconi, 2015; Rossi, 2011) and rethink didactics starting from this level. But in Corno's words the key word is still "in response to particular student" where response makes you think to a direction that is not biunivocal in the process.

In the educational field the trend seems to be today the overcoming of the behaviourist approaches (focussed on the teacher and on teaching) and of the constructivist approach (focussed on the student and on learning).

In the field of educational technology the cognitivist approach had its results in the ITS built in the Nineties (Graesser *et al.*, 1999; Van Lehen *et al.*, 2005), while the constructivist approach can be connected with the adaptivity based on the user. Reighelut (1999) identified a new paradigm characterized by the shift from the standardization to customization, from the centralisation of autonomy, the centralisation of CEO to the centrality of the user.

The overcoming of the two approaches, behaviourist and constructivist, seems to foster a vision that came after the advent of the new millennium that could be defined post-constructivist that puts the teaching-learning process at the centre.

Even if didactics's goal is learning it reifies such goal by actualizing as the space-time of mediation (Damiano, 2013) and interaction.

In such space-time it develops an alignment (Giaconi, 2015; Laurillard, 2014), a structural coupling (Proulx, 2004; Rossi, 2011; Varela *et al.*, 1991), an empathic process (Berthoz, 2004; Rossi & Fedeli, 2015; Sibilio, 2014) a co-activity process (Vinatier & Numa Bocage, 2007), an attunement (Lutzker, 2014) between the teacher and the student/s. The attunement process is validated also by the recent discoveries in neuroscience (Rivoltella, 2012). From

now on we will use the word "attunement" to characterize this perspective.

The attunement implies an autopoietic process that involves the two subjects thanks to reciprocal inputs. The process creates a new situation, unique, but consistent with the characteristics of the actors.

If the inputs are reciprocal, the feedback from the teacher is obvious. But what inputs can the student offer to the teacher?

It's possible to identify two possible conceptions of knowledge (Laurillard, 2014). In the first one the assertions, for every conception, are located along a vertical axis that ranges from the correct position (the expert knowledge) to positions that are not correct, the misconceptions. The correct position presents various nuances that depend on the transposition and use "representations", different "mediators" (more than exemplifications) to take into consideration different levels of maturity and knowledge of the learner.

In the vertical axis the relationship teacher-student is asymmetric. A second conception implies the existence of a second axis in addition to the vertical one already described (expert knowledge-misconception), an horizontal one in which different layers are present, all equally significant and each of them valorizes a specific perspective with which the concept is examined. Every subject builds a balanced frame that takes into account the various layers.

This second axis is correlated to complexity and takes into consideration the different perspectives, cultural, social and epistemological, present in the current society. The researches in the ITS field of the last decade seem also to be interested in an open conception of knowledge.

Underwood and Lucking R. (2011) analyze the contributions in AIED from 2000 to 2010 which highlight a shift synthesized in the following table (Tab. 1).

Table1
SHIFT IN AIED RESEARCH 2000-2010

Support for 1-to-1 learning	Support for personal, collaborative and social learning
Support for learning in tightly defined domains and educational contexts	Support for open-ended learning in ill-defined domains across varied physical and social cultural settings and throughout the lifetime
Support for knowledge acquisition	Support for knowledge construction, skills acquisition and meta-cognitive, motivational and affective support
Small-scale systems and laboratory evaluations	Large-scale deployments, evaluations in real settings and learning analytics
Focussed analysis of relatively small quantities of experimental data	Discovery and learning from educational data mining of large amounts of data captured from real use
Constrictive technologies and interfaces	Accessible, ubiquitous, wireless, mobile, tangible and distributed interfaces
Designing educational software	Designing technology-enhanced learning experiences

Besides the shift related to the one-to-one approach the table puts the focus on ill defined problems or domain that can be connected to the model of knowledge made of two axes as previously described. The adaptive and pervasive approach proposed by Soylu *et al.* (2011) is an additional shift towards an adaptive direction which takes into consideration the context/situation.

The authors underline that:

> focus of learning is more on personalization, in order to enhance learning and performance by taking into consideration that, learners differ in prior knowledge, skills, and abilities, have different demographic backgrounds, and show different affective states. Emergence of Pervasive Learning led to a complete understanding of adaptivity by considering that the learning systems shall not only provide a user-tailored experience through personalization but shall also adapt (to) the setting, in which the learner is engaged, through context-awareness (p. 100).

Further in the text they state:

> Once a concrete perception of the computing setting is acquired, dynamics of the setting can be re-organized through adaptation. This can be formally defined as a process of mediation between the computing setting and the individual/common characteristics, capabilities and requirements of the entities available through the setting (e.g., users, devices etc.). We consider adaptivity as a primary relation between context and computing in context-aware computing settings while the user is the primary reference point. Context is an open concept characterizing the situation of an entity. It can encompass infinite number of characteristics and appropriateness of a context dimension is volatile; characteristics being part of the context in one setting could be irrelevant in another (p. 103).

In the conclusion the authors synthesize the goals of their adaptive and pervasive project:

> PerCom vision manifests an unobtrusive, anytime and anywhere user experience which requires expansion of the personalization era to the context-awareness era. Under this unitive vision, learning process should be immersive and contextualized along with the computing process. Contextualization and immersion of computing require new approaches for software development and management (p.113).

In Sixties-Seventies, till the beginning of the current century personalization, also in an adaptive nuance, was meant as a process that connected two impermeable systems. The two systems were the student with his/her cha-

racteristics and, on the other side, according to the model, the set of available resources, the set of didactical strategies, the expert knowledge. The student's behavior and interests and his/her knowledge vary along the time, but they don't affect the expert knowledge and the set of available resources and strategies. This second set exists independently from the student's profile. Adaptivity modifies, also in itinere, the matching between the student and the proposed resource/strategy according to the updating of the profiling.

An adaptive proposal, that takes into account the attunement, needs to focus on the situation created by the interactions rather than on the subjects and their characteristics. In this way it fosters, on one side, the autonomy and self regulation of the subjects and, on the other side, it provides resources and support that can enrich the development of the interaction and the empathy between the subjects.

7 Some examples and conclusions

Approaches consistent with the attunement have been described in other works (Rossi, 2011; Paviotti *et al.,*, 2013[1]): didactics as mediation (Damiano, 2013), that is, a different relationship between teaching and learning, the attention on regulation (Altet, 1997; Laurillard, 2014), the attention to the active role of the student and his/her autonomy, but also to the presence of the teacher, to his/her ability to listen, to give feedback and support, to his/her ability to re-design in itinere.

The finality in the field of TEL (Technology Enhanced Learning) is to interpret technologies as mediators between the student, the teacher and the context and to develop software agents able to support teacher and tutor work (without replacing them).

Some examples of experimentations to reify what has been said are the ones developed by the research group EDIT (University of Macerata, Department of Education, Cultural Heritage and Tourism).

In the I-TUTOR[2] project tools with AI elements were created within the LMS (Learning Management System) Moodle to support the teacher in the design process, in the management of the complexity and in the in itinere monitoring of the students.

A tool to create maps in an automated way (with intelligent agents) was also created. The map tool works using resources provided by the teacher and with technologies of the semantic web to draw the disciplinary territory in reticular way.

Every node of the map represents a concept been extracted from the do-

[1] Downloadable from http://intelligent-tutor.eu/download/

[2] For an in-depth analysis refer to http://intelligent-tutor.eu

cuments present in the online environment or created in itinere by the teacher and the students. The nodes are located and organized in the space according to the concept's position in the documents (distance/proximity). A new map is being created after each interaction and describes the process in its development more than an ontology of the topic.

During the teaching and learning process the teacher and the students discuss about the map and this creates a process of mirroring that lets each actor to acquire a deeper awareness of the process and of own positions.

We could, thus, describe the artefact as a system that adapts itself to the process and that helps the involved subject to perceive the process itself and their path.

In the PROPIT project (Design for inclusion and personalization)[3], the teacher builds an iconic representation of the lesson to describe his/her educational design. The design artefact (a map) is a mediator used in class and visualized by students. Every node of the map describes a Teaching Learning Activity (Laurillard, 2014) and lets the access to materials in clouds, materials that are set by both the teacher and the students. The map is developed during the process thanks to the materials created by the students and makes it possible to highlight the process in its evolution. There will be nodes created during the lesson, that were not previously set, and nodes that won't be developed even if they were initially set. The map changes during the lesson adapting to the process since the nodes are affected by the products and activities developed in class.

The map is, thus, a way to visualize the initial design made by the teacher and, then, the class activities.

The use of maps has a significant role for the personalization. The map is organized in parallel layouts, that is, it offers multiples paths to groups of students. It would be impossible for the teacher to design and manage different paths without a technological support that helps in giving the proper directions and tasks to all students, guiding single groups in their work, finding and suggesting in itinere to each group proper materials. As mentioned earlier complexity requires the personalization, but personalization is not always sustainable. The support offered by intelligent and adaptive technologies can build the bridge between personalization and sustainability.

If perspective and adaptive technologies aim at putting the attention to the quick development of the system and of the situation during the didactical action and they do not only aim at adapting the system to the learner's characteristics, they will be able to offer an additional support.

The current technologies might support the educational design and they would be consistent with the guidelines previously described, to make the school able to face its complexity.

[3] For an in-depth analysis refer to http://www.editlab.it/dip-design-for-inclusione-and-personalization/

In such direction, a new alliance is needed. An alliance that can respect the different fields in the communities of educators and the community of knowledge engineering. As stated by Laurillard (2014) educational technologies were born outside the school context. If a shared design among teachers is not fostered, if the apps for the design and class management don't come from the need of the educational world, if we don't have co-disciplinary processes between educators and knowledge engineers there will hardly be steps forward and school won't be able to face the challenge of complexity.

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