Adaptivity and adaptation: which possible and desirable complementarities in a learning personalization process?

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Abstract

Within the iClass (Integrated Project n° 507922) and Elektra (Strep n°027986) European projects, LabSET (Support Lab for Telematic Learning) was requested to harness its pedagogical knowledge to the production of educational adaptive systems. The article pinpoints and documents difficulties and limitations of this work as well as the possible fertility of such kinds of interdisciplinary joint research. Identification of pitfalls is a prerequisite for better interdisciplinary approaches in Technology Enhanced Learning (TEL) and safer design of usable and useful e-learning tools. For the authors, the pedagogical added-value of adaptive tools is more likely to be found in the support of human decision-making regarding personalization strategies, autonomy development and metacognitive training than in the provision of highly-technical automatic customization devices.

Keywords

Personalization, adaptivity, pedagogy

Adaptivity – New word, historical concept

Personnalization of learning has become a prominent thrust in the educational field, at various levels: social (Bonal & Rambla, 1999, p. 208), government policy (DfES, 2004; Leadbeater, 2004), school management (Lambert & Lowry, 2004; West-Burnham & Coates, 2005), course/lesson design (Martinez, 2002; Polhemus, Danchak, & Swan, 2004; Tomlinson, 1999; M. Weller, C. Pegler, & R. Mason, 2003). Definitions of personalization varies a lot (Jennings, 2006; Noss, 2006, p. viii), from the perfectly acceptable "the antithesis of impersonal", to the more technically focused "automatically structured to meet the needs of the learner" or proposals which tend to equate the essence of personalization to metacognition which allows the learner understands herself as a learner and, therefore, to assume the responsibility of all aspects of her personalized learning. This last orientation is the one we would gladly embrace. Since the mid-90, the discourse on personalization of learning has been feeding the development of Adaptive Hypermedia Systems (AHS) (Primus, 2005), the most recent metamorphosis of Artificial Intelligence's vision on education, embodied successively by the Intelligent Tutoring Systems (ITS), programmed instruction and Computer-Aided Learning (CAI). The core idea remains the production, by a learning system, of automatic educational adjustments to learner's profile. If we take for granted that personalization will improve the efficacy of education and if we assume that e-learning technologies have a major role to play in providing such a personalised experience, the production of personalized learning paths can possibly be left to three agents: the teacher, the learner and the machine. We refer to the teacher/student-led process as "adaptation" and to the machine-led process as "adaptivity". Both terms contend that learning might be tuned to characteristics of learners (age, knowledge level, need, objective, preferences, styles, modalities…) but the latest assumes user-driven adaptation.

Problems, reminders and reservations

Usually coming from the technical side, proponents of adaptive systems require from pedagogues that they provide "rules" (Von Neumann, 2000) deemed to inform the initial modelling and all aspects of the adaptive process (selection, creation, sequencing, aggregation, distribution of available material). Unfortunately, in most cases, a systematic and automatic application of pedagogical principles turns to be disappointing, and even dangerous (Banks, 2004). Our experience in Elektra, a game-based learning project (see http://www.elektra-project.org) and iClass, a project focused on the development of an e-learning platform featuring innovative personalization functionalities (see http://www.iclass.info/iclass01.asp), concurs in this idea for the following reasons.

Pedagogy remains an unstructured field of problems

Enjoined to provide "rules" on iClass and ELEKTRA, we had several times to answer either "we do not know" or "it all depends…" It is not that pedagogues are especially hesitant, coward, slow or clumsy. Their answer flows from their awareness that education remains, and for long, an unstructured field of problems (Allert, Dhraief, & Nedjl, 2002, p. 17; Aviram & Richardson, 2004; Dreyfus, 1972; Friesen, 2004, p. 2; Matan & Aviram, 2005, p. 9; West-Burnham & Coates, 2005, p. 39). Those problems are characterized by an unlimited number of facts, features, and situations whose interplay is not clearly known. Since few results can be generalized, due to the highly situated (Lave & Wenger, 1991; Verpoorten, 1996, p. 55) character of learning, the pedagogue is reluctant to state any set-in-stone machine-readable rule like the ones adaptive systems are eager of. There is no such thing as a "learning algorithm" that is optimal for all situations. Factors are numerous and very context-specific. In pedagogy, few things are proven several times; many things are proven once; and much more things are not proven and remain in the realm of the "best-educated guesses" (Anderson, 2004, p. 55; Heargraves, 2005, p. 12; Merrill, 2000, p. 4). Moreover variations in effect size values in meta-analysis of experiments dedicated to test the same hypothesis show how conditions may affect the results. Despite the importance of impact factors meta-studies (Hattie, 1993; Marzano, Pickering, & Pollock, 2001; Phipps & Merisotis, 1999), the efficacy they allocate to pedagogical principles or innovations is probably shaped by components active at very fine-grained, contextual, intimate and intricate levels of the learning process. Last but not least, when studying such a complex phenomenon and construct as learning is, the "illusion of exploratory depth" - people feel they understand complex phenomena with far greater precision, and depth than they really do -, as coined by Rozenblit & Keil (2002), is always looming, especially for persons whose knowledge of pedagogy is rather low or superficial, which can be the case with project partners for whom pedagogy is not the primary expertise. Does that mean that we are condemned to say nothing valid about pedagogy or to become totally relativist? Not necessarily. It means that we need to keep the teacher/learner wisdom and responsibility in the loop for choosing, pondering, organizing, adapting the specific influences of learning situations. It means that adaptive systems are rarely self-sufficient and that the major challenge lays in their articulation with non adaptive components of the learning process (Belisle & Linard, 1996, p. 31; Depover, Giardina, & Marton, 1998). Educationists can pinpoint where adaptivity can properly be applied (and provide rules) but the area is certainly far less spread out than the initial idea adaptive researchers might expect. And in most cases, rules provided will address "principles or facilitators of learning" more than learning itself. This reminder about the limitations of pedagogical expertise might sound self-speaking. Nevertheless, any fruitful joint work between adaptivity and pedagogy should keep in mind, from the start, that, in the view of pedagogues: "The idea that technology can second-guess the needs of learners is superficially attractive but riddled with problems" (Jennings, 2006), all the more so when it is deemed to be applied without human control. Too a technology-centred perspective and the usual bypassing of teachers it entails raise fears that "The machine is being delegated a problem which is and remains primarily a teaching problem" (Maragliano, 2004, p. 1).

Rules' transparency as a condition of acceptance of adaptive systems by teachers and pedagogues

One can doubt that ITS and adaptive systems serving personalization purpose will soon spread in schools (see also (Ainsworth & Fleming, 2006, p. 132; Murray, 1999, p. 127). Among reasons given for this pessimistic forecast, Baker (2000, p. 134) mentions an underrated one:

Now, if a teacher, for example, is to accept devolution of part of responsibility for teaching to a machine, that individualises its instruction, then not only will the teacher have to manage the individualisation within a group (such as a class), but the teacher will also have to understand how that individualisation occurs in order to accept the devolution of responsibility. Software producers' manuals and demonstrations are unlikely to be sufficient in this respect; no doubt the system will have to be "transparent", in some sense of the term, for teachers. This is one of the classic problems that faced expert systems".

The issue of transparency as a condition of pedagogical acceptance is also stressed by authors working in the realms of non adaptive instructional design, personalized course delivery or teacher professional development (Friesen, 2004; Goodyear, 2004; Ip, 2005; Martinez, 2002; Poumay, 2005; Rezeau, 2001, p. 295; Wiley 1999). They advocate for reasons of pedagogical quality the up-front adoption of some of the existing instructional events models (Leclercq & Poumay (2005) ; Martinez (2002, p. 12) ; Wiley (1999, p. 10) ; Baumgartner (2007, p. 17)). Working with a model also allows making the instructional design and its rationale "explicit" or "transparent" to the user, helping to defuse the "neutrality" usually professed by providers of e-Learning systems and standards. Without this transparency, namely the precise knowledge of what exactly occurs between the in's and out's of the adaptive process, it is impossible to establish a proper pedagogical reflection on the conditions of use and potential benefits of the adaptive system. Within iClass, for instance, in an effort for pedagogical clarity and control, we proposed to consider (Verpoorten, Poumay, & Leclercq, 2005, p. 11) the Personal Learning Path (PLP) execution as a function (f) of 5 personalization parameters, with associated sub-categories: PLP = f (intention (3: Prepare exam/revise/explore), location (2: Home/class), duration (3: Short/about an hour/leisurely), profile (4: Kolb's LSI), skills (3: Bloom's taxonomy revised by Krathwohl & Anderson). Combining independently all those categories comes up with 216 combinations. But, in reality, several combinations were either dropped or summed up by the system in order to keep the complexity manageable. The pedagogical reasons for the droppings/groupings/attribution of specific paths to specific profiles had, in our view, to be made transparent for users in order to help them to fairly assess the value of the tool. On several occasions, this quest for clarity and concreteness was put aside by highly technical discussions that remained impenetrable (M. Weller, C. Pegler, & R. Mason, 2003, p. 1), if not incomprehensible, for the educationist who sticks to a basic concern: what it means for an educator to work with those systems, tools, facilities and how this affects the type of educational support they produce.

Pedagogical return on expensive adaptive developments

Ainsworth (2006, p. 132) notes:

> Designers of intelligent tutoring systems hope that one day their systems will perform as well as expert human tutors, which, in itself, is very high goal. Bloom (1984) found that one-to-one tutoring by expert tutors, when compared to traditional whole class teaching, improves students learning by 2 sigma effect size. This was the only pedagogical technique which had such a marked effect. Currently, state-of-the-art in ITSs is around a 1 sigma effect with evaluations of ITSs revealing effect sizes of between .4 and 1.2 compared to classroom teaching (e.g., Graesser, Person, Harter & The Tutoring Research Group, 2001; Koedinger, Anderson, Hadley, & Mark, 1997). However, the time and expertise needed to produce such clever systems has meant that such ITSs have not yet achieved widespread application in schools, colleges or workplaces – creating an ITS is estimated to take between 300 and 1000 hours to produce an hour of instructional material (e.g., Murray, 1999).

As for the return on investment, namely an educational benefit resulting from personalization of learning obtained through adaptive systems, it is questioned. Studying the parameters selected by two adaptive systems (3DE, APeLS), Monthienvichienchai (2005, p. 3) concludes that in many personalized learning projects, critics and advocates for particular adaptation parameters have emerged with equal number of arguments for and against personalising to each parameters, with some even questioning the effectiveness of personalising learning in the first place (Marzano, 1998), while others have recommended

personalisation with caution (for example, (Ferguson, Schmoller, & Smith, 2004)). Commenting Hattie's meta-analysis, the Coffield report on Learning Styles (2004, p. 146) also casts doubts:

> The benefits of individualized teaching are often greatly exaggerated, although many teachers will admit that it is extremely difficult to ensure that learners are benefiting from specially tailored approaches when there is a large class to manage. In a synthesis of 630 studies, Hattie (1992) found an average effect size of only 0.14 for individualized teaching in schools. This trivial result strongly suggests that in general, it is not a good use of teacher time to try to set up, monitor and support individual learning programmes where there are large groups to deal with. It should be noted that the potential of ICT to support individualised instruction has not been fully evaluated.

Hence, if the personalization impact factor is questioned in a context of regular teaching, caution is even more requested when it comes to "automatic customization" which adds its own assumptions and modelling filters (Dotan, 2006, p. 23). Matan & Aviram (2005, p. 8) note in addition that research in adaptive systems has still not yielded a scientifically corroborated set of methodologies to support personal learning and is flawed at an upper level by the lack of validated personalization theories. Better educational benefits measurements for adaptive systems are not necessarily right around the corner. As pointed by Verpoorten & Logan (2006), there are relatively few examples of adaptive educational systems in practical use. Furthermore, those personalized learning platforms based on adaptive philosophy are seldom tested, remaining small scale and mainly as experimental set-ups. It goes without saying that this relative poverty leads to a very modicum of empirical investigations (Weibelzahl, 2005) which would demonstrate that most effective learning is achieved or facilitated thanks to such systems (Ronen, 2006, p. 19).

The behaviourist tropism of adaptive systems

"Every piece of Education Software, Authoring Tool or Learning Management Services (LMS) implements a certain kind of learning theory. Every function of the software has underlying (tacit) pedagogical assumptions" (P. Baumgartner & Payr, 1999). Adaptive systems are no exception. Both in iClass and in ELEKTRA, the adaptive systems lay on domains knowledge representations, obtained thanks to Knowledge Space Theory (Doignon & Falmagne, 1999), KST, which strive to support the learner by scaffolding a domain of information towards level of knowledge and subsequent learning needs. This cognitive toolbox, namely a skills-based cognitive engineering, presents a solid and theoretical basis on which pedagogues must generate adaptive processes that are centred on mastery of competences. It involves a hierarchy of concepts (Razek, Frasson, & Kaltenbach, 2003) and, thus, the system will present ordered activities to the learner, making sure that he will always be clearly positioned in the knowledge space that has been defined in the User Model. This complex, mathematical and probabilistic way of positioning the learner into a knowledge space and, then, presenting adequate learning activities can be characterized as follows:

- KST is based on a teaching paradigm;
- KST has difficulty with ill-structured concept domains wherein knowledge and skills are fuzzier;
- KST is concerned about the adaptive capacities of the system while (constructivist) pedagogues will be more about developing pupil's ones (Gipps, 1994, p. 25; Smith, Ford, & Kozlowski, 1997, p. 90);
- When establishing rules and algorithms that supply the "Rules" component of the system, KST refers to behaviourist theories where learning is seen as a mechanic, adding associations to existing ones;
- KST requests yes/no answers regarding skills mastery where there are several proficiency levels;
- Once a test has been successfully passed over, there is no need anymore to come back to the activities having supported the acquisition. This is pedagogically disputable. Improvement is still possible when a test is successfully passed (need for overlearning, or risk of forgetting or of structural regression).

At first sight, KST is wonderful because it tells what to teach and in what order. It is partly true but the problem of this elegant application programmed instruction is that it ignores totally the variety of methods of learning. It can talk about the "what" and, potentially, the "in what order" but it says nothing about the

"how", or more exactly, the "how it favours" is problem resolution. According to the 8 Learning Events Model (Leclercq & Poumay, 2005), it means that only one major method of learning out of eight is trained. It is still difficult to see where it can be applied in case of more constructivist approaches in less structured domains than mathematics. KST and similar adaptive processes are relevant as long as the conception of learning it supports is made explicit and put into perspective with other views/approaches on the same phenomenon. After two projects based on this framework, the conditions for an adaptive system to support a non behaviouristic-like learning process remains for us an open question.

Adaptivity and self-regulated personalized learning

But, should the previously described difficulties be overcome, is an automatic customization of learning a desirable endeavour, *per se*? How does this challenge articulate with the apparently contradictory appeal of self-regulated (or self-personalized) learning which considers the learner not as an input of an intelligent rule-based system but as an active agent and possibly the main rule-maker? What is the compared pedagogical added value of huge computational work implied by adaptive systems against forcing students to make explicit learning choices at well pedagogically defined decision points? Since the seminal article of (P.H. Winne, 1995), self-regulated learning has gained momentum and become a pivotal construct in contemporary accounts of effective learning (Heargraves, 2005, p. 18; Peters, 2004; Randi & Corno, 2000). In this context, Self Regulated Learning (SRL) establishes as another facet of personalized learning that facilitates increased levels of learner empowerment. This emphasis on autonomy, self-regulation, metacognition or "learning to learn" ability questions adaptive design: if adaptivity is about the design of a made-to-measure learning, who is the bespoke tailor? In a narrow meaning, adaptivity will answer: "the system". But, so doing, doesn't adaptive system disenfranchise the learner (Papert, 1992) of a crucial aspect of learning: autonomy or becoming a self-regulated learner. According to Boekaerts (1999, p. 449), three regulatory systems are involved in self-regulated learning: (1) the regulation of the self (choice of goals and resources), (2) the regulation of the learning process (use of metacognitive knowledge and skills to direct one's learning) and (3) the regulation of information processing modes (choice of information processing strategies). In their study of adaptive platforms according to a criteria matrix focused on what they offer or not in terms of personalized learning, Verpoorten & Logan (2006) point at the difficulty for adaptive platforms to support actions in the circle (2). Even on the tools/platforms allowing some level of choice – a key component of SRL -, either the metacognitive awareness is not mentioned or mentioned in an evasive way, the main emphasis remaining obviously on delivery of customized paths versus paths "on demand". The automatically adaptive philosophy, eager at delivering "optimized paths" to individuals is, *per se*, bound to erase choice options whilst it represents a hallmark of SRL (Boekaerts, 1999, p. 447; Leadbeater, 2004, p. 10; S.G Paris & Paris, 2001; S.G. Paris & Winograd, 2001; West-Burnham & Coates, 2005, p. 41; P. H. Winne & Perry, 2000, p. 538). Realizing the potentially destructive effect of an antagonism between the seminal assumption of their field ("the machine manages adaptivity") and the fundamental assumption of the self regulated learning movement ("the learner must be in control as much as possible"), supporters of adaptivity are willing to take this piece of criticism into account. Some adaptive platforms (L3, AHA!, ActiveMath, some IMS LD experiments) are already offering some decision points to the student. From a theoretical standpoint, Magoulas (2003, p. 4), for example, includes learner initiative in his definition of adaptive system.

Conclusion and move forward

From the stance on learner's control, it flows that a learning environment has to empower the learners, so that they are in control of and responsible for their learning, or should empower teachers as designers of personalized learning environments (on the urgent need for more implication of end-users in the design of learning systems, see Ainsworth & Fleming (2006), Dillenbourg & Martin-Michiellot (1995), Heargraves (2005, p. 14), Brusilovsky, Knapp, & Gamber (2006), OECD (2006, p. 2)). The above considerations do not deny the value of research in automatic customization procedures but urge for not giving adaptivity more than its due. In a plane, the navigation instruments and control indicators available to the crew have been designed as support to the human decision-making. Even when automatic piloting is entrusted for parts of the trip, the possibility to check, on the fly, the correct execution of the journey plan is kept intact and pilots can, at any moment, come back to manual mode. Materializing that kind of real-time

monitoring within learning processes would be of great benefit to education. It would revolve around the following questions: to what extent is this automatic customization of learning a plausible, desirable, safe and pedagogically productive objective? Where, when, how and for what learning benefits can automatic customization exist independently of human mediation? As pedagogues, we looked in both projects for a balance between what would be a "Summerhill personalization" (the student decides for everything) and a "Robocop personalization" (the student decides for nothing). Patel & Kinshuk (1997), Bowring-Carr (1997) and West-Burnham (2005, p. 104) suggest intermediary positions in this spectrum, pointing at mutual support and articulation between adaptivity and adaptation. Actually, the median part of the spectrum defines a zone wherein adaptivity can support autonomy development. In this respect, Davis (2000) suggests the concept of "liberating constraints", namely providing learning paths combining some pre-structured (by the teacher or the system) elements with a "space of possibilities opened up only in the actual moment of learning". The role of the teacher or the system becomes therefore to create activities that simultaneously limit and enable open choices (of strategies, activities, resources) and metacognitive reflection upon choices. The important question becomes: how can adaptive systems organize the conditions of learner's autonomy and meta-cognitive development? This self-regulated personalization should be triggered, supported, visualized, assessed with the help of adaptive tools in productive ways. The focus moves from "thinking like the learner" to "thinking with the learner". The move of adaptive systems towards more initiative and control left to learners open more pedagogically fruitful and coherent avenues.

Acknowledgement

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