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Abstract. Prensky's talk about *Digital Natives and Digital Immigrants* is often used as a milestone for the field of study addressing this "new generation" of users. However, when talking about *Digital Natives* the general attitude is to think of them simply as students and not as perspective teachers. This is, in our opinion, a lost opportunity: their way of studying and doing things at present will influence the way they will work in their future workplaces. When they will assume, for example, the role of teachers, what kind of tools and environments will they really need? We will try to address this problem analyzing a project we held with four master's students, for the creation of a serious game about Amazon deforestation, were they had an interesting role, at the crossroad between students and teachers.

Keywords. Co-adaptation, *Digital Natives*, serious games, user modeling, learning environments

Introduction

The intersection of Technologies and Education in general, and AI&ED in particular, have historically been marked by several profound debates - and by the corresponding research orientations- disputes, arguments, often rich of paradoxes.

In our opinion, these debates are still useful as reference points for the past but rather limited for the future, since the oppositions concern a teaching versus a learning centered approach, or a formal versus informal learning [1]. For the rest of the paper, our position will be as much as possible the one of observers of the "natural" phenomena occurring in learning (and in learners, *Digital Natives*[2]) having the goal to identify what kind of conception will be likely to be used by the same people once they will become teachers (in the deep sense of the term: at school as "real" teachers, as seniors in the workplace, as parents with their children) in the information society of the next years. Our conviction is that the real revolution within society, schooling included, will emerge not from new laws, curricula, instructional design methods, tools or professional training investments, but from the radically different approach in

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solving problems adopted "naturally" by *Digital Natives*, that will impact their teaching methods, at home as well as at school. In this position, we totally adhere to the authoritative views express by Eileen Scanlon and Tim O'Shea [3] and by Marc Eisenstadt [4].

Nowadays, *Digital Natives* are migrating into a workplace run and organized by the "previous generation" natives. Obviously, the first scenario we can think about is a workplace world dominated by *Digital Immigrants* (elders who often feel less at ease with new technologies), a place where *Digital Natives* adapt to *Digital Immigrants* technologies and working methods. However, at a certain moment *Digital Natives* will be the only generation present in this imaginary workplace. If we focus on the educational field, this means that *Digital Natives* will be the only "teachers" for the "next generation" of students. For this reason, it will be interesting, to answer to questions such as: How different are they from previous students and will be from previous teachers? Will they need tools or environments different from previous ones?

While an articulated answer to these questions would need an ethnographic approach, we will try to sketch out some implications based on the evolution of a project that involved four *Digital Natives* with an interesting role, at the crossroad between student and teacher, as a preliminary source of reflections eventually to be further investigated.

In the rest of the paper, first of all we will talk about the subject of the project, a serious game for sensitizing players to the Amazon situation, that was, in our opinion, the first cause of motivation for the students' involvement as "teachers". In fact, the social impact of the project was a strong motivation for them, so that they took very seriously their educational role, as enablers for sensitization to Amazon problems. Next we will try to understand what kind of generation are our future teachers, the so-called *Digital Natives*. We will then get into the core of the project, basing on students' description of the tools they used for the project management, and we will finally sketch some implication.

1. The Amazon Situation

As we have said, the topic of the project was one of the motivations that caused the students' switch from the "project developers" role to the "enablers" one. While the Amazon's deforestation problem is a complex one, is worth to spend some lines describing it for better understanding why this switch happened.

In recent years, the Amazon has experienced high levels of deforestation, including the largest loss of forest on record between 2002 and 2004. Between May 2000 and August 2006, Brazil lost nearly 150,000 square kilometers of forest—an area larger than Greece—and since 1970, over 600,000 square kilometers (232,000 square miles) of Amazon rainforest has been destroyed [5].

Several studies tried to analyze the Amazon deforestation through models of deforestation patterns [6]. Results show that heterogeneous occupation patterns of the Amazon can only be explained when combining several factors related to the organization of the productive systems, such as favorable environmental conditions and access to local and national markets, proximity to urban centers and roads, agrarian structure, and so on. While for years, studying Amazon deforestation meant only study such deforestation patterns over the land, in recent years there was an important shift in the focus. Studies such as [7] state that containing the advance of deforestation in

Brazilian Amazonia requires understanding *people actions*, i.e. roles and movements of the involved actors. For example, landless migrants have significant roles in clearing the land they occupy, colonists and other small farmers are also responsible for substantial amounts of clearing, but ranchers constitute the largest component of the region's clearing. Capitalized farmers, including agribusiness for soy production, have tremendous impact in certain areas, such as Mato Grosso. Landgrabbers, or grileiros, are important in entering public land and beginning the process of deforestation and transfer of land to subsequent groups of actors, and so on.

As we have seen, land changes in Amazon are the result of a complex web of interactions between human and biophysical factors, which act over a wide range of temporal and spatial scales. An important opportunity for us (the authors) to address such a complex scenario came when, in November 2008, two conditions were met:

- a conference was held in Manaus[8] where the key actors committed to the management of scientific knowledge by means of ICT met(among them one of the authors of this paper as invited speaker); and
- 4 master's students adopted a proposal for a "student's project": a "serious games" for knowing and learning the Amazonia biodiversity. We proposed them to exploit the simulations resulted from the GEOMA sub-projects [9] - in particular Dr. Tiago Garcia de Senna Carneiro projects[3] - in order to collaboratively design and prototypically implement a serious games about human decisions (such as deforestation) in Amazonia. We also proposed them a set of tools for asynchronous (such as Wikipedia) and synchronous communication (Agora, GSD and De Visu)[10][28].

2. Digital Natives: from Vital Statistics to Common Practices

Before addressing the way the project was managed by the students, it is in our opinion interesting to understand the way our students' generation address learning and technologies.

From a vital statistic point of view, the so-called *Digital Natives* generation includes people born between 1981 and 2000. However, we can see them under a technological perspective. Today's 24-year-old was born in 1985 – "10 years after the first consumer computers went on sale and the same year that the breakthrough "third generation" video game, Nintendo's "Super Mario Brothers," first went to market. When this 24-year-old was a child, the basic format of instant messaging was developed. And at the time he entered kindergarten in 1990, Tim Berners-Lee "wrote a computer program" called the World Wide Web. At the dawn of high school (for him in 1999), Sean Fanning created the Napster file-sharing service. When he graduated from high school four years later, his gifts might have included an iPod (patented in 2002) and a camera phone (first shipped in early 2003). Our 24-year-old college career saw the rise of blogs (already two-years-old in 2000), RSS feeds (coded in 2000), Wikipedia (2001), social network sites (Friendster was launched in 2002), tagging

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Del.icio.us was created in 2003), free online phone calling (Skype software was made available in 2003), podcasts (term coined in 2004), and the video explosion that has occurred as broadband internet connections become the norm in households (YouTube went live in 2005)." [11]

As we can see from this little history, *Digital Natives* cannot be defined only through vital statistics, but through a set of characteristics and common experiences. As Palfrey and Gasser [12] claim, *Digital Natives* "are connected to one another by a common culture. Major aspects of their lives- social interaction, friendships, civic activities – are mediated by digital technologies. And they've never known any other way of life". We can then say that *Digital Natives* are characterized by a set of common practices, including the amount of time they spend using digital technologies, rather than by their age.

From a "learning" point of view: "*Digital Natives* are used to receive information really fast. They like to parallel process and multi-task. They prefer their graphics before their text rather than the opposite. They prefer random access (like hypertext). They function best when networked. They thrive on instant gratification and frequent rewards." [2]. Moreover, they like to "learn by doing" (doing is more important than knowing, and learning is accomplished through trial and error) and they consider human interaction an essential part in the learning process [13]. Furthermore, Studies at the Pew Internet & American Life Project [14] show that virtually all college students play video, computer or Internet games, and 73% of teens do so. As a result, for example, they become accustomed with a style of learning that takes place informally [15].

Finally, if we look at their views on technology:

The definition of **technology is not confined to computers or the Internet**. Technology is viewed as any electronically based application or piece of equipment that meets a need for access to information or communication. For *Digital Natives*, technologies that are still considered transformative by their parents' and grandparents' standards (for example, instant messaging) are a basic part of their everyday lives. For them, technology is simply "what's new".

Customization is central to their definition of technology. Technology is something that adapts to their needs, not something that requires them to change. For them customization is the ability to adapt technology to meet individual needs, rather than vice versa [16].

The *use* of available technologies is precisely what we found very interesting in the way our students approached a project that, paradoxically, is clearly centered on the *production of* new technologies. In the next paragraphs, we will address this aspect in order to find what will be the "future generation" of teachers' approach to technologies.

3. The Amazonia Serious Game Project: the Story so Far

As we have said, the complexity of the Amazon situation is based on land changes and at the same time on people behavior. In order to address such a complexity we (as teachers) decided for the creation of a serious game. In the purposes of the project, such a mean will allow us to achieve two major goals: sensitize people (perspective users of the game) to Amazon problems, and model users' behaviors and believes through their own taken actions (the first may be considered a pedagogical goal, the second one a kind of experiment for group modeling). In the first part of this section, we will detail

our motivation for the choice of the serious game as "pedagogical" mean, in a general way. A description of the generated serious game would be an interesting element of analysis for understanding better why the students take very seriously their educational role, i.e. their role as enablers for sensitization (in fact, students also developed the history and worked on the game design). However, for our purposes – understanding *Digital Natives'* approach to technologies in order to identify what they will need when they will become teachers – it is more interesting to analyze the way they approached the other technologies they used. In the second part of this section, we will show what "really happened" when students started to work for the project.

3.1. Serious Games and Learning (or, old generation, very academic reasons for the approach)

The serious games movement started with the U.S. Army's release of the video game *America's Army* in 2002 [17][18]. The same year the Woodrow Wilson Center for International Scholar in Washington, D.C. founded *the Serious Games Initiative*, and the term "serious games" became widespread [19].

The term itself is nowadays established, but there is no current single definition of the concept. Serious games usually refer to games used for training, advertising, simulation, or education, which are designed to run on personal computers or video game consoles.

Among the various (more or less) formal definitions for serious games, we like Zyda's [20, p.26] words:

"Serious game: a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives."

When comparing serious games with just computer games, Zyda argues that serious games have more than just story, art, and software. It is the addition of *pedagogy* activities that makes games serious. Now, we want to take his *pedagogy* term in the Greek original sense: paidagōgeō; from παίδ *paíd*: child and άγω *ágō*: lead; literally, "to lead the child". So, in our vision, serious games are not simply a way to "instruct " about something (a skill or a competence) but a way to convey knowledge within a motivationally rich context (enabling the self construction of knowledge but not excluding the acquisition of scientifically correct information), and, why not, sensitize people about potential consequences of behavioral choices performed while playing.

If we can think serious games in this way, the question of interest concerns the claimed positive effects of such games, or of their applications from related and sometimes overlapping areas such as e-learning, edutainment, game-based learning, and digital game-based learning.

Corti [21], considers that Game-based learning (GBL) and serious games have the potential of improving training activities and initiatives by virtue of, e.g., their engagement, motivation, role playing, and repeatability: failed strategies etc. can be modified and tried again. Digital game-based learning (DGBL) is closely related to GBL, with the additional restriction that it concerns digital games. Analyses have been conducted over the years, consistently showing that games promote learning [22][23].

DGBL is, following Prensky [24] ideas, based on two key premises; firstly, the thinking patterns of learners today have changed, that is, today's students are 'native speakers' in the language of digital media. Secondly, this generation has experienced a

radically new form of computer and video game play, and "this new form of entertainment has shaped their preferences and abilities and offers an enormous potential for their learning, both as children and as adults" (ibid., p. 6).

So, we posed ourselves the same question as Squire et al.[25]: how educational technologists will respond to the "digital native speakers", i.e., "a generation of students who, raised on interactive games, expect the same kinds of interactive experiences from their educational media?" (p.34).

As we have mentioned, our answer was linked to our idea of pedagogy: we will convey knowledge through a serious game, and the game will not be an educational game in the classical sense of edutainment: it will talk the Digital Natives' language.

3.2. Bring the project to light (or, what really happened when Digital Natives become enablers/ pedagogues)

Towards the end of the project, we asked our students to describe what kind of tools they used for managing their work (as we have said in par.1 some were proposed by the teachers, but, as a matter of fact, most of them were chosen by the students). They produced a report describing the tools but also why they found them useful (or not). In the rest of this section, we present a synthesis of their report that will be analyzed in the last section in order to identify a few properties of our experiment supporting or refusing convictions about the needs for tools in the years to come.

Flash Meeting

The first software they were asked to interact with was Flash meeting (FM)[26], an Open University's[27] project that implements a set of collaborative tools to manage real time video meetings with participants from all over the world.

From a technological point of view, students found very interesting the simple way used to access the meeting (a web browser with Adobe Flash and an internet connection). They also liked the easy way to manage "speaking turns" through queues, a functionality that is not available in most Instant Messaging software.

From an organizational point of view, they found compelling that the meeting has a limited duration (nearly one hour and a half in each case), because this forced them to effectively prepare it, thing that they never did for their "informal meetings". Finally, they considered the possibility to record the meeting the most important feature of this tool "because when you make a meeting speaking English with participants from different nationalities, it is very important to listen a few times more the conference, to make sure you well understood everything".

Their final comment on FM was that "It is full of interesting features to help the collaboration and to forget that the meeting is virtual".

Face to face meetings

The students also participated in (more or less formal) face to face meetings. The "formal" meetings were held in the LIRMM laboratory -with the teacher presence while the "informal" ones were held at one student's home. They considered the first kind of meeting as an opportunity to summarize and discuss the ideas they had since the last meeting (for example they reviewed the needs and the roadmap of the project). In their words, "It allows to give everyone a global vision of the project and especially to motivate the troops".

Meetings at home were their informal way to manage the project. It's interesting to note that nobody told them to do this kind of meeting (nor to add others tools). Simply, where they felt a gap in communication or in project management, they instinctively filled it. They liked this kind of meetings because "there are more ideas that spring out, and you are allowed to think in a more easy way". Moreover, the process of stay together and eat together after the meeting contributed to improve, as they said, the cohesion of the work group, because it allowed them to know each other better.

Skype
In students' analysis, Skype's main drawback, compared to tools like Flash Meeting, is linked to the installation and registration process. If you want to communicate with someone, he/she has to download and install the software, and finally register a Skype account just to be able to receive your call or message (as we have seen FM uses a light web client and only the booker needs to register). They also found that the impossibility to record the meeting was a problem for their "professional" use of the tool.

However, they found also important that everyone in Skype was able speak at the same time: "you can interact more easily and quickly with your interlocutor, and this is a way to be more efficient". Their main interest in Skype was that they were able to use it in an instant way: if they were connected and they wanted to know what the others think about an idea, they just had to launch the Skype call (it's very interesting to note that this implies that they were practically always connected to the application).

Agora GSD
Agora[28] is a platform which aims to deploy collaborative services among virtual communities on the internet. The Agora platform includes two collaborative services: The Grid Shared Desktop (GSD), a service for sharing any application, and De Visu, a video-conference service. For the project, the students experienced only the Shared Desktop.

Students had different opinions over this tool. From one hand they found it interesting because it allowed them to communicate and to collaborate thorough the shared desktop. In an occasion, when there was the need to show in a shared way the result of their work and they weren't able to use Agora, one of them claimed that he would have really appreciated to be able to use it, exactly for the shared desktop idea.
However, some of them found that "in face of this tool, not everybody is equal. The simple fact that we needed an introduction was not a good thing. What will happen to non-informatics people?" (they are referring to a demo that was held to show them the shared desktop functioning). We are sure that, if the project really needed a way to show in a guided, shared way the results, they will have found a tool adequate to manage it.

Wiki (based on MediaWiki, provided with Agora)
In students' opinion, for the project the wiki [30] was not used as a communication tool, but as a tool for future collaboration. In their words, "Maybe this project will go on after we will be forced to stop it, with other students next years. If so, the wiki is a huge amount of knowledge, a trace of what we thought, discussed and decided about it."
They really liked the idea to let a persistent trace of their work, and the direct evidence of this statement is that they spent a significant amount of time not only "filling" the

wiki's pages, but also "personalizing" it, through images and little "hackings" in order to adapt the wiki to their needs (this match with Roberts' founding about *Digital Natives* approach to customization, see par.2).

Summarizing, for them the wiki provided a well-structured and centralized outcome, an organized persistent trace of their knowledge and their decision processes.

Emails

When they analyzed this communication tool, they found the already well-known advantages and disadvantages of asynchronous communication. You don't need to set an appointment to send a mail, and you can send information in a message whenever you want. Messages are almost sent to everyone in the group, so there is a persistence of these messages. However, the way we used mails (through simple clients and not based on a repository) generated some versioning problem with the attached files.
This is why they searched, found, and used alternative tools for managing the problem.

SVN (GoogleCode)

Google Code Subversion (SVN) [29] is a mean to manage concurrent versions of files on large projects. Students decided to use it because it allowed them to work at the same time without fearing data loss (you can easily restore any old version of a file uploaded before). An interesting remark over this tool was "we are getting used to it, because it is a very common tool in development, and widely used".

DropBox

DropBox[31] is a software that allows you to create a shared directory which could be easily synchronized between collaborators, just using an Internet connection. The students adopted it spontaneously (as they did for Skype, SVN, and the informal face-to-face meetings), because they liked it's "collaboration oriented" space.

In fact, everyone can access the files they put in the shared directory at anytime. However they found a lack in the potentiality of the tool. In fact, every time they added a file they had to send an e-mail to announce it. "It wasn't a communication tool because each time we shared a new file with DropBox, we have to send a mail to everybody to inform them of its existence, but it really dealt with knowledge sharing because everyone of us may decide to create a new file and to put some knowledge into it..."

4. Lessons Learned

Based on the above-described student report, in the rest of the paper we will try to outline some interesting aspects that emerged when we tried to abstract from it:

The fading of real/virtual opposition: First, when we asked them to list all the tools they used for communication, they naturally added face-to-face meetings. While their comment on Flash Meeting let think otherwise ("It is full of interesting features to help the collaboration and to forget that the meeting is virtual") it is our opinion that this is a concrete sign of the fading of the traditional real/virtual opposition (meeting with pizza and meeting with Skype are considered at the same level). In fact, both – face-to-face meetings and 'virtual' meetings- were 'recorded (i.e., a synthesis of each meeting was made disposable for the others to work with).

This in our opinion means that future "teachers" will easily use "virtual" and "real" means for their purposes, so they will need environments that will allow them to switch seamlessly between the two.

A love for persistence: It's interesting to notice that the students searched tools able to offer persistence (e.g., the files repository and the wiki) to their work. Moreover, they liked the permanence of video meetings - where virtual meeting became real also trough its permanence and repetition, and therefore through its availability throughout the whole history of the project. However, more than the wiki, the video-meetings were viewed several times, and were used within the game development (contrary to what happens in most projects).

This means in our opinion that future "teachers" will need environments able to support persistence of events (and the associated retrieval of stored events).

MashUps as a natural instinct: This is in our opinion the most interesting aspect. As we have noticed, if students found a gap between the tools they were required to use and their needs, they filled it instinctively (as most young people do in internet trough mash-up [4]). The lack of functionalities didn't stop their work. On the contrary, the gap pushed them to find integrations able to support their work.

In our opinion, this implies that this generation of perspective "teachers" - that is already used to mash-ups - will not need pre-packed tools but, more and more, environments were the current and future tools would be accessed and made available for use.

The new Media Fluency for informal learning: Some of the tools our students listed addressed very particular computer scientist problems (e.g. SVN and DropBox addressed the problem of managing file versioning). However, if we try to abstract, we can note that for them creating a project was all about communication, knowledge creation and knowledge management/sharing. In their report, they never mentioned the tools for "creating" the game. This may seem at first a little bit strange, because nobody instructed them on how to build a game. However, they made instinctively interesting suggestion about how to create it, because, for them, games are experienced tools. We can note the same concerning Skype: most of the tools they used were not "learned" at school, but in an informal way. Moreover, their use of communication tools (e.g. Skype for a quick call about an idea) let really think about peer supported learning.

This in our opinion means that future "teachers", will be literate on many different "new" media, unlike the old generations , and will give much more importance to collaboration, social and informal learning (learning from the others, learning from the context, learning by doing) than to the "tools" they are using (learning at school from books, following curricula).

5. Conclusions

As we have already said, we didn't use an ethnographic approach, so this paper has no pretenses to give any definitive response to the formulated questions. However, we think that in the development of the project some interesting elements emerged that will be worth of further in-depth examination.

Sensitization about Amazon deforestation was, for the students-enablers, the primary goal of this project. The social impact of the project was for them a strong motivation so that they took very seriously their educational role, as enablers for sensitization to Amazon problems. We think that the creation of a (serious) game -a well known medium for them - had the advantage to let them focus on management and development issue, rather than on the medium fluency (as it often happens with other kind of applications that are given to teachers for their use). We know that our students were a very particular kind of students (high level of abilities in informatics, high motivation, and so on) but it is our opinion that future teachers will be the same: considering tools (including perhaps classical concepts in curricula) as commodities and not as the scope of what they are doing, and, in the best of possible worlds, highly motivated. Moreover, we may assume that as teachers they will focus on abstracting and generalizing the instance of the solving problem process itself to new contexts.

rather than in the art of constructing new tools and applications for solving new problems, because they will assume their students will need the same as what they needed themselves when they were students.

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