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Towards An Intelligent Learning System for the Natural Born Cyborg

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Abstract

We propose to design a Custom Learning System that responds to the unique needs and potentials of individual students, regardless of their location, abilities, attitudes, and circumstances. This project is intentionally provocative and future-looking but it is not unrealistic or unfeasible. We propose that by combining complex learning databases with a learner's personal data, we could provide all students with a personal, customizable, and flexible education. This paper presents the initial research undertaken for this project of which the main challenges were to broadly map the complex web of data available, to identify what logic models are required to make the data meaningful for learning, and to translate this knowledge into simple and easy-to-use interfaces. The ultimate outcome of this research will be a series of candidate user interfaces and a broad system logic model for a new smart system for personalized learning. This project is student-centered, not techno-centric, aiming to deliver innovative solutions for learners and schools. It is deliberately future-looking, allowing us to ask questions that take us beyond the limitations of today to motivate new demands on technology.

Keywords

Mobile Learning; Mobile Devices; Artificial Intelligence; Intelligent Systems; Future Innovation; Interaction Design; Student-Centered Design; Personalized Learning

Introduction

This paper identifies a number of opportunities for intelligent systems to improve, expand, and personalize learning experiences. It highlights the ways in which intelligent systems can facilitate personalized learning through the delivery of customized learning content and authenticate the essential skills students are developing in their digital lives. Intelligent systems, such as the recommendation system used by Amazon.com, collect data on users and their actions in order to provide improved and personalized services to users. In regards to an educational context, intelligent systems are flexible and dynamic tools that can be useful across subject areas and year levels. They also offer new processes to systematically integrate informal and formal learning within existing curriculum frameworks by aggregating data from online and mobile data sources.

We approach this research with an explicit aim to produce innovative solutions to the challenges of teaching and learning in the 21st century. This paper begins by identifying the pedagogical potentials of intelligent systems and analyzing their components using Amazon.com as a case study. The paper then moves on to describe a presently proposed strategy for the design and development of a new intelligent system for learning. This description includes an outline of our design approach, the core values of the project, and the steps to be taken to develop a new smart learning system. This strategy places the student at the center of the design process and prioritizes the development of complex and authentic learner profiles. It also focuses on developing complex logic models and a taxonomic scheme to process vast data and translate it into customized feedback, through simple and easy to use interfaces.

Pedagogical Potentials for Natural Born Cyborgs

Today, many young students are undoubtedly ‘natural born cyborgs’ (Clark, 2003). This ‘how-to’ generation are highly motivated by their social lives to engage in the use of sophisticated digital technologies and highly connected networks to teach themselves and each other all kinds of complex processes (Jacobs & Polson, 2006; Polson & Morgan, 2008). They engage with information at ‘twitch speed’ (Prensky, 2001) delivering their own just-in-time learning materials. To these students, the web and the mobile phone have become essential tools for maintaining multiple profiles on multiple networks, enabling them to contribute to both their local and global peer groups. Consumer and social tools and services have experienced great advances. Vast databases, smart systems, and highly connected networks mean that individuals can find the things they want and people they like with little effort. Books are recommended to them with uncanny accuracy, they teach each other how to play the guitar on video networks, they organize RSS feeds to refine their research, and their mobile devices tell them if they have been to this shop before and with whom. Each time they browse, search, buy, join, comment, play, travel, upload, or download, an intelligent system collects, analyzes, and processes the data in an effort to further improve the service. To remain competitive, it is of benefit to all commercial content and service providers to offer meaningful options and personalized experiences to their end users. This is in great contrast to the experience young people are having in their schools. Currently, we have an education system that struggles to respond to the individual for many reasons and at all levels of government, school, class, home, and community. Cost, time, training, resources, and existing structures are just a few of the things limiting student progress.

If effectively exploited for teaching and learning, intelligent systems can offer unique opportunities to deliver personalized learning experiences and to form reciprocal relationships between formal and informal learning groups and environments. Through aggregating personal mobile and web data, intelligent systems have the capacity to develop complex and authentic learner profiles that allow learning content to be customized according to a student’s individual interests, skills, and learning styles. They can aggregate data from a wide range of digital sources including a student’s digital social networks, affinity groups, RSS feeds, blogs, wikis, social bookmarks, and Internet search history, to name a few. Also through gathering data from mobile devices, they can map students’ surroundings tracing things like their location, motion, weather, connectivity options, and proximity to others. Because mobile devices are always on and ever-present, they can identify patterns of student activity, when they spend time learning, and the times of day they work most efficiently. Using this personal data, intelligent systems can be adopted to customize and personalize learning content.

Furthermore and perhaps just as importantly, intelligent systems provide a way of authenticating the important learning that is already occurring in a student’s digital life. They provide new processes for education institutions to support networked learning through communities of practice. As George Siemens (2005) notes, students can no longer personally experience and acquire the learning they need to act as effective participants in the world. In a world where “networks constitute the new social morphology of our societies” (Castells, 1996, p. 468) and access to knowledge is increasingly dependent upon connections within and across networks (Downes, 2007), the capacity for education institutions to support networked learning is critical. Intelligent systems offer an opportunity to acknowledge the highly social and networked nature of learning today. They provide new processes to systematically integrate this networked learning, which is currently often described as informal learning, with formal curriculum.

While intelligent systems offer exciting potential, transforming such opportunities into actual learning resources in order to improve teaching and learning practices is still a major challenge. In his closing keynote presentation at the Handheld Learning 2008 Conference, Lord David Puttnam called for greater communication between education experts and the technology development industries in order for the promises of future learning to be realized. Puttnam stressed that we have been aware of the exciting opportunities that new technologies offer; however, we are still failing to innovatively apply these technologies to create new solutions for learning. Intelligent systems require highly complex taxonomies and logic schemes for processing data and translating it into customized feedback for users. It is another challenge to conceal this complex system behind a simple and easy-to-use interface that teachers can use effectively, and that is useful across multiple areas and levels of teaching. With these challenges in mind, we present an analysis of the components of intelligent systems using Amazon.com as a case study. This is followed by a proposed strategy for the design and development of a new intelligent system for learning. This strategy will be driven by an interaction design approach and will rely upon collaboration across a number of knowledge domains.

Existing User-Based Intelligent Systems

To begin to develop innovative solutions for education that exploit intelligent systems, we need to identify the key components that constitute intelligent solutions. In order to do this we have analyzed the recommender system used by Amazon.com. Amazon.com is a useful example that illustrates how an intelligent system is able to make sophisticated recommendations to users based upon user profiling and comparison. The intelligent system used by Amazon.com employs a "fine-grained taxonomy of more than 13,500 hierarchically arranged topics" (Ziegler, Lausen, & Schmidt-Thieme, 2004, p. 406) to frame the process by which the system produces the recommendations to users. The process through which recommendations are made is based upon a number of system actions: 1) tracking a customer's browsing and purchasing profile; 2) identifying what similar items are for sale on Amazon.com; 3) identifying who else has purchased the same items; and 4) comparing profiles for similar interests. The system then uses the data from these actions to propose recommendations to the customer. In order to further refine its recommendation system, Amazon.com also gives users the option to rate Amazon's recommendations and mark items purchased as gifts so as to remove them from the systems recommendations logic. The Amazon.com system of recommendation continues to improve and refine with each purchase made as it deepens the complexity of its understanding of individual customers' interests and preferences.

The data that can be collected and delivered to users by intelligent systems need not be limited only to online data. With Internet connectivity, mobile devices provide online data AND offer the potential to collect additional forms of location-based and communication (phone calls, SMS etc.) data. Importantly, mobile devices are always present with the user and always on. Nokia has identified the immense potential of the data that a mobile phone can aggregate about users, and is engaged in a research project entitled 'Rich Context Modelling'. The project "is characterized by the use of a wide range of sensed and historic information, aggregated into a coherent model of a user's state and surroundings; including things like their location, motion, weather, connectivity options, and proximity to others" (Nokia, 2010). A mobile device is able to collect this information because of the services inherent and ubiquitous in mobile devices such as Global Positioning Systems (GPS), phone calls, SMS, emails, documents, and web browsing and searching. Unlike the commercial consumer whom Nokia designs for, a learner engages in a particular set of activities and generates quite different data sets. As such, this project aims to exploit data that can be aggregated from mobile devices through an understanding of what this data is and how it relates to learning.

We can see from the above examples that a user-based intelligent system requires a fine-grained taxonomy to support two key components: complex user profiles and logic models. Together these components define how data is analyzed, interpreted, and presented to a user.

The value of intelligent systems in education lies in their ability to formulate complex learner profiles that systematically integrate a student's personal world with a formal curriculum framework. In creating complex learner profiles, intelligent systems offer immense possibilities for supporting personalized learning through delivering custom content shaped to the needs and interests of individual learners. Pairing learner profiles with logic models that are based upon a curriculum framework provides a formalized and systematic process through which personalized learning can be facilitated, observed, and assessed. The challenge for this research is to identify what data components can contribute to learner profiles and what logic is required for this data to become meaningful in a learning context. In order to meet this challenge we propose a development strategy driven by an interaction design approach.

Interaction Design Approach

As Interaction Designers, we begin by acknowledging the multiple domains of expertise required to effectively design and implement innovative learning solutions. These knowledge domains include: pedagogy leaders, information technology experts, service providers, designers, and developers. Throughout the research and design process an interaction designer aims to negotiate and translate the various knowledge domains into effective learner systems, tools, and interfaces. To achieve this we adopt a Design-Based Research methodology that is practice-led, relying on collaborative and iterative interventions in 'naturalist settings' to evolve the most effective solutions (Barab & Squire, 2004; Gray, 1998). In addition to the production of new tools, we aim to produce demonstrations, evaluations, new theories, and recommendations that generate new knowledge about how people can and do learn.

Core Project Values

This research team has successfully designed, deployed and evaluated a number of dynamic learning projects (Farm It Right, 2008; MiLK, 2008; SCAPE, 2005; SCOOT, 2009) that exploit mobile devices and game systems to develop custom authoring tools and learning simulations (Polson & Morgan, 2008). Although these projects involved different content and contexts, the collaborations consistently came across the same design and deployment challenges. Schools, in particular teachers, have limited access to technology (hardware, software, and networks) and time for ongoing training. They also find it difficult to compare and evaluate the value of the learning products that are constantly offered by researchers and developers. There is also a widespread cautious attitude towards social technologies that can result in the common practice of restricting access to certain websites and banning mobile devices in schools. For these reasons the research team decided on the following core values that informed the iterative process of design and evaluation:

1. Teacher confidence: Tools must be simple to understand, master, and integrate for all teachers.
2. Curriculum enhancement: Interactive experiences should improve, not just replace, the delivery of curriculum materials.
3. Expanding learning partnerships: Exploiting contemporary social tools (web and mobiles) should extend student collaborations with teachers, other students, and parents in an effort to motivate interest in, and application of, learning in formal and informal environments.

These values continue to be core design considerations. However, intelligent systems offer many more opportunities for broader application and impact on student learning lives. As such we have extended our core project values to include:

4. Curriculum adaptability across subject areas and year levels.
5. Promoting personalized learning (student centered).
6. Authenticating informal digital learning.
7. Motivate solutions beyond current limitations.

Beyond simply re-presenting specific curriculum materials, we have decided instead to concentrate on developing a broader system that is adaptable across subject areas and year levels. Many existing learning solutions currently focus on very specific subject matter (such as the study of an historic era), and learning locations (such as a museum visit). Regardless of the focus of a learning task, our system will tweak the delivery of learning material relevant to each student. This way, the project will adopt a student-centered approach to teaching and learning in order to foster personalized experiences of learning. The aim of personalized learning is to support relevant, engaging, and meaningful learning experiences by customizing learning content to the learning styles, needs, and interests of individual students (Department for Children, Schools, and Families, 2007; Rudd, Gifford, Morrison, & Facer, 2006; Sutherland in Pollard & James, 2004). We aim to design a tool that delivers custom learning content based upon complex learner profiles. It will offer an interface with which students can choose from custom-designed learning objects, identify their personal learning goals, review their progress, network with other students, and compare themselves to others locally, nationally, and perhaps even globally. The design process will begin with resolving the Learner Profile components and requirements to determine user scenarios, design specifications, and system logic.

This project acknowledges that informal learning already occurs in many students' digital lives. Through their online activities students are already learning the skills to collaborate across networks, independently inquire, analyze, synthesize, produce, and disseminate. A number of future learning experts have effectively identified these new core competencies (Jenkins, Clinton, Purushotma, Robison, & Weigel, 2009; Morgan, Williamson, Lee, & Facer, 2007), and the United Kingdom has introduced new Personal Learning and Thinking Skills (PLTS) into the National Curriculum. However, schools are still lacking solutions that authenticate and systematically facilitate the delivery of these new core competencies across the curriculum.

This project is forward-looking and utopian in an explicit effort to provide innovative solutions for learning. As such, this project puts aside some of the current technological limits and policy implications regarding privacy and access. Studies from Futurelab (Sutch, Rudd, & Facer, 2008) and Becta (Knight, Bryan, & Filsner, 2009) indicate that we must look to future possibilities and be prepared to take risks in order to promote transformation and innovation in schools. As designers it is our role to not only design within the limits of today, but also to motivate new demands on technology by imagining ultimate futures. In motivating these new demands, we create incentives to overcome present technological and economic limits.

The Need for a Taxonomy

The system that we are proposing draws upon complex combinations of data derived from multiple sources. Therefore, a strategic approach and ontological framework is required to identify, understand, and use this data. This ontology will consist of definitions of entities and a nested taxonomic scheme that classifies data according to the relationships between entities (van Rees, 2003). This taxonomic schema is an effective device that necessitates a process of identifying categories of data, unpacking the entities of each of these categories, and exposing and classifying the relationships between entities. It is from this ontology and nested taxonomic schema that the logic model will be derived.

Figure 1 represents the first step in this process. This first step was to map a student's state and surroundings by identifying the categories of data that may constitute a learner profile. This category map represents an amalgamation of research findings from a review of a range of relevant discourses including personalized learning, mobile learning, networked and social learning, web 2.0 learning, smart systems, intelligent authoring systems, and personal learning environments. This category map illustrates an authentic learner profile that takes into consideration the many aspects of a student's life. It encompasses not only a student's formal learning context, but also acknowledges the highly distributed, social and networked nature of learning of the 'natural born cyborg'.

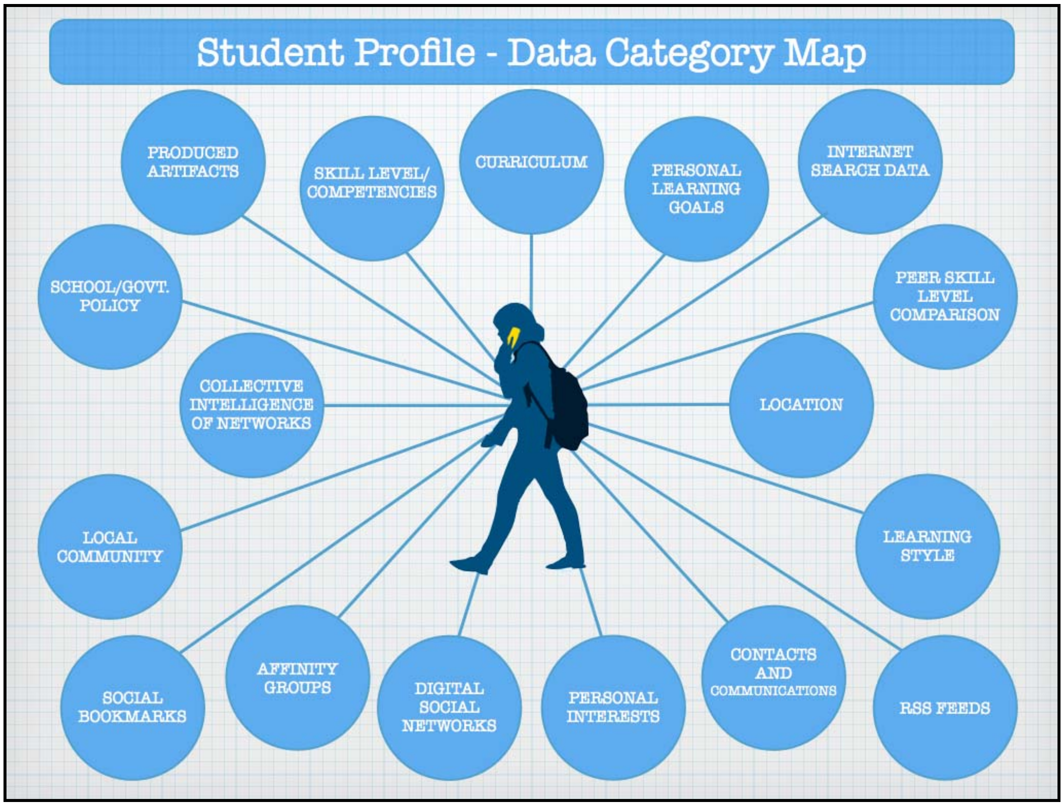

Figure 1: Student Profile – Data Category Map

Investigating With Scenarios of Use

To refine both our understanding of the possible taxonomy and the requirements of a logic model, we need a process for exploring the detailed entities of each category of data and their relationships to one another. In keeping with the 'student centered approach', we experimented with potential 'scenarios of use' based on a number of student personas representing different student contexts and learning levels. Table 1 provides a brief example of one such experiment.

Table 1: Sample Scenario of Use

Example of a Persona	Use Case Scenario
Gerri is a Year 9 student. She plays in a local under 15s football team, loves fantasy fiction (books and films), plays the clarinet, and is a fan of Britpop music. Gerri is currently achieving higher than average marks in English, Physical Education, and Music Theory. Her marks in Social Studies are average while her marks in Science are below average.	Gerri's Science teacher sets a new physics assignment. Her Custom Learner Profile identifies the keywords in the assessment criteria and suggests that Gerri focuses her assignment on the physics of a football being kicked. It also knows that Gerri prefers to produce video media over science reports, so it suggests that she accompanies her report with an annotated video clip of a ball being kicked. Gerri receives an average mark for her physics assignment. Knowing that she is predominately a self-directed learner, her Learner Profile gives Gerri the option to increase her Science difficulty level. Gerri decides she would like to keep it at the current difficulty level until she feels more confident.

This example demonstrates the important relationships between a learner, her context, and available data, and possible ways in which an intelligent system can provide a personal learning experience. Beyond developing the ontology and taxonomic schema, investigating with use case scenarios also has the potential to reveal unidentified uses of the system as well as test some initial assumptions. Of particular interest is identifying when, where, and how a user may need to access the system. This leads to the next phase of the project, which is to develop student profile interfaces that are supported by a refined logic schema. Figure 2 illustrates how data is first treated by an ontology (determined by a taxonomic framework), is sorted through a Logic Schema (according to a user's request) and ultimately delivered to a user interface (depending on the data format/s).

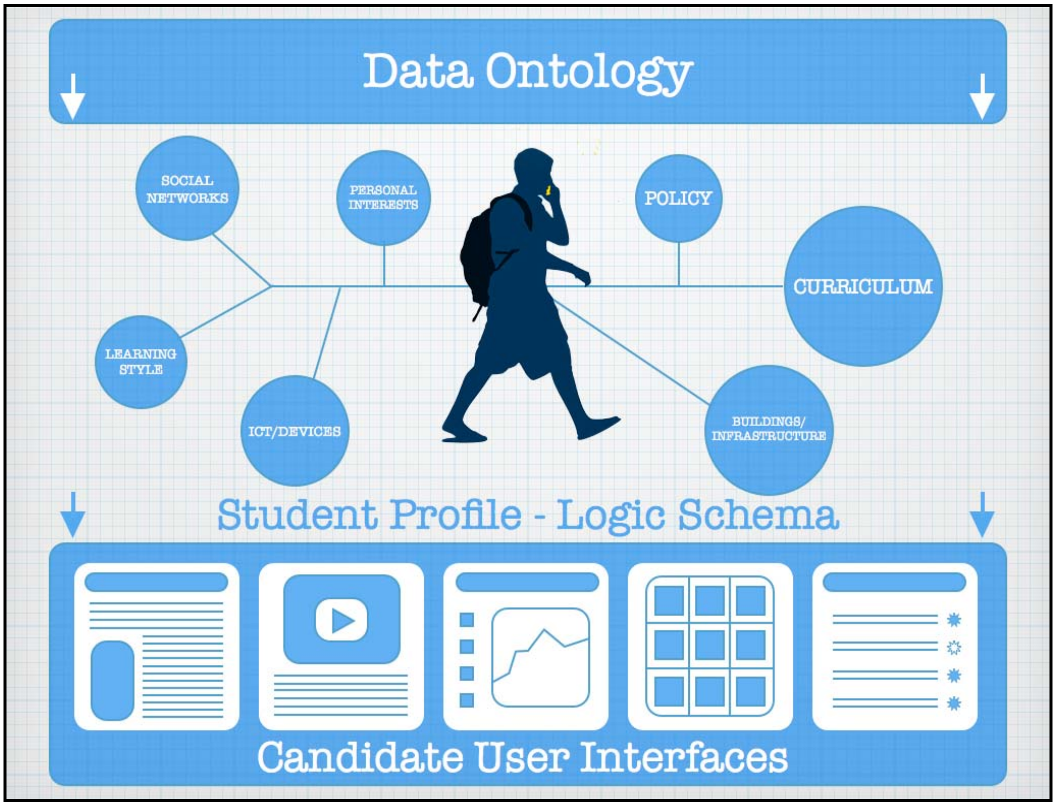

Figure 2: Data Ontology

Conclusions

The paper has highlighted the potential for intelligent systems to support improved learning experiences in a number of significant ways. First, intelligent systems can offer personalized, meaningful, and engaging learning experiences through the delivery of customized learning content that has been filtered through complex and authentic learner profiles. Second, they present an opportunity to acknowledge, authenticate, and facilitate the essential learning that is currently occurring in student's digital lives. Third, intelligent systems provide an innovative solution to curriculum adaptability, offering a tool that can be useful across subject areas and year levels. Finally, intelligent systems present new processes for the systematic integration of formal and informal learning into a single experience that aligns with existing curriculum. As well as identifying these exciting opportunities, this project has presented an innovative approach to the design and development of a new intelligent system for learning.

The scope of this project is deliberately ambitious. As designers it is our role to not only design within the limits of today, but also to motivate new demands on technology by imagining ultimate futures.

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