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# *Learning through Teaching*

***Knowledge Acquisition by Digital Natives in the Post-Industrial Age***

***Future Present Series No 4.***

## *Introduction*

This paper presents a provocative view of the "Future Present" of e-learning. The intention of this paper is to provoke a discussion on more effective learning methods and strategies, better suited to the needs and wants of the so-called Digital Natives[i]. It focuses on large-scale collaboration, production, dissemination and consumption of e-learning material.
A not-for-profit electronic learning environment and integrated market place is used to disseminate the material. The principal focus of this paper is the process and software environment that could enable consumers of electronic learning material to collaborate and produce new material. Thus they become producers/consumers, "prosumers", as Alvin Toffler coined the term[ii]. The concept is technologically feasible, as most of the technology is available at the time of writing.
The paper starts off with a series of micro-cases seen from the point of view of Emily, a digital native and fifth grade student at grammar school. Each micro-case is enlarged upon in terms of the advanced learning environment. Subsequently, some background detail is given on specific aspects of the learning environment.

## *The micro-cases*

### LTT – Learning through Teaching

Emily is in her last year at secondary school. Starting next term, September 2010, she intends to study medicine. A few years ago, the school she attends adopted "Learning through Teaching" (LTT). She uses this to show she has learned her tasks, not just by answering questions, but in by producing novel learning tasks. An advanced software environment helps her to produce and publish her new learning tasks, both with friends at school as well as anonymously.

*"Learning through Teaching" is based on the premise that comprehension of learning material is most effectively tested by demonstrating the ability to explain and test the material in novel ways. Supporting this notion, the LTT stimulates students to produce e-learning material. The content is published on a public -- not-for-profit -- market place called 'the Knowledge Superstore'. Content is either produced in a school project or as a result of personal interest. Anonymity of the producers is the default publication option, which ensures that they are shielded from discouraging attention, particularly important as the majority of producers (authors and editors) are still at secondary school. Furthermore, it allows subjects not to be dominated by a few producers, based on their reputation only. The usability and applicability of the e-learning content is based on actual use, integration, extension and adoption, the true measures of the value of the material. Anyone registered can use the learning material. Likewise, anyone registered can submit learning material to the Knowledge Superstore.*

### PKC – Personal Knowledge Cabinet

Emily has decided to stay home for the morning to review the feedback she has received from her test group. She is working on a module for a biochemistry subject about absorption rates of oxygen in the blood stream. Last night she saw that all responses of her test group have arrived. She activates her Personal Knowledge

Cabinet, logs in, clicks on her active projects and opens the dossier on oxygen absorption.

*"Learning through Teaching" is particularly suitable for subjects requiring comprehension and internalisation of knowledge and less suitable for rote-learning tasks. To be able to support knowledge-intensive learning tasks, the environment depends heavily on semantic analysis and filtering of text. While simple questions & answers are possible (using multiple choice questions) the ability to analyse written text sets the learning environment apart. The PKC, Personal Knowledge Cabinet, enables all users of the Knowledge Superstore, whether consumers or prosumers, to keep track of information they find, within the Knowledge Superstore, personal mail, or any web-accessible knowledge store like Wikipedia.*

**TSM – The Subject Master**

Opening the dossier automatically activates the e-learning authoring and editorial environment called "The Subject Master" (TSM). Using TSM Emily checks the WikiBlogs related to each learning unit and test. She verifies whether her peer-reviewers have tested the changes she proposed and agree on them. After reviewing the posts from her testers, she checks them off on the to do wiki page. Now, only five issues remain open; 23 have been resolved.

*TSM, The Subject Master, operates on so-called WikiBlogs, a hierarchical set of interrelated pages. Each WikiBlog basically is a set of subject-specific wikis and web logs. Some of these (wikis) can be changed by the authors and editors involved in the composition of the subject, while other pages are effectively web logs (blogs), hence the name 'WikiBlog'. TSM has tools to aggregate information from the blogs into the wiki; generally, only the module's editors use these tools. WikiBlogs have automatic version and status control.*

**TOFT – The Old-Fashioned Teacher**

The multiple-choice questions are the easy part, so she runs TOFT ('The Old-Fashioned Teacher') on default settings first. After a few seconds she receives the scores of her test group. They all score between 72% and 95%. TOFT doesn't generate any comments, so on surface level everything looks OK. She changes the settings and runs TOFT in trace-mode. This allows her to evaluate the system's 'comprehension' of the textual questions and answers of the test.

*The Old-Fashioned Teacher, TOFT, is used to check both multiple-choice and free text tests. It tracks and traces the use of learning material. When the learning material has a 'final' status, TOFT is primarily used to help score the results of tests and check for plagiarism. However, when the learning material is being developed, TOFT is used to debug the tests.*

**TATA – The Archiving and Tracking Assistant**

While studying the textual performance, Emily notices that all but one have answered one particular multiple-choice question incorrectly, at least according to TOFT. "Mmm. Strange." Then she finds a note from one of her respondents in the WikiBlog, showing she made an error with that particular answer. After correcting the typing error, she re-runs TOFT. The scores go up to 75% to 98%. That's better… Based on the response received, she decides they are close to publishing the module to a wider audience, by promoting its status from 'peer-review' to 'provisional'. She enters the remark in the main WikiBlog and asks all reviewers to carefully check (and let her know) whether they have missed anything. Emily generates the referring entry for Wikipedia, edits and beautifies the results and pastes them into the TSM wiki page to show her peer-reviewers what that would look like. "Comments, anyone?" She instructs TATA, The Archiving and Tracking Assistant, to automatically promote the status to 'Provisional' if none of the reviewers respond to her question within 24 hours.

*Using TATA, The Archiving and Tracking Assistant, the learning environment automatically tracks status and version of learning material. Depending on the status, more or less consumers within the environment can see and use the material. Any version of the material with a status 'final' is available to all registered users. Any other status is reserved for the development and review of the material. The Knowledge Superstore is interconnected to Wikipedia, the non-profit web-based encyclopaedia[iii]. Thereby, much of the e-learning content is directly accessible from the related Wikipedia page. Care is taken to keep the taxonomies of Wikipedia and the Knowledge Superstore synchronised. TATA monitors the taxonomy of Wikipedia and automatically signals discrepancies between Wikipedia's taxonomy and the Knowledge Superstore's and distributes the differences to any producer working on related material.*

**Hierarchy of Learning Content**

About two years ago, when Emily started producing material, she submitted simple questions and answers only. Initially, she focused on basic learning material that wasn't yet available within the Knowledge Superstore. Also, being the daughter of a pilot, she created quite a lot of basic physics material about motion, acceleration, gasses, pressure, etc., using examples of airplanes. These were used as supplementary material. After receiving encouraging messages from co-producers, she started work on learning units. The response to her first learning unit about biochemistry was so encouraging that she volunteered to create new material on course level for physiology.

*Authors can create elementary tests (questions and answers) that teach and test a limited aspect of a knowledge domain. The elementary test is usually the work of a single author and extends one or more existing learning units. The next level is authoring an e-learning unit. While this is usually a group effort, only one or two authors accept ownership and act as editors of the unit. The third level is the learning module, a set of related learning units within a specific domain. Again, usually one or two authors act as module editors. They guard the direction in which the module is developed, inviting other authors to develop specific learning units or integrating existing learning units. Usually, each learning module has five to twenty compulsory learning units and up to a hundred supplementary learning units. The supplementary units provide additional learning material, based on particular perspectives, catering to students that aren't really interested in a subject. This way they can have the material explained to them in terminology and examples more suited to their interests. The integrating level is the course level: a course is a series of modules that together allow the student to completely master a particular subject.*

**Anonymity and merit points**

Emily is happy about the fact that the process is anonymous; she remembers the response of her classmates and teachers when she published her first physics material. Some classmates were envious; others were awed, and only a few reacted normally. Some of her teachers actually started giving her lower grades: "If you're that good, we must apply a different scoring system to you." It took months before the negative aspects ebbed away. Naturally, the compulsory material she develops in school, usually in co-operation with her classmates, is not anonymous.

*Elementary tests, units, modules and courses can easily be re-used, extended and integrated into other assemblies. Each time learning material is used, the producers are rewarded merit points, especially when the learning material is integrated into other modules or courses. Actually, every time learning material is re-used, the merit points bias weight is increased. The higher the merit points bias weight, the more visible a test or learning unit becomes in the overall ranking. At the same time, the merit points awarded to the original authors increase progressively.*

### Use-based credits and commercial use

Next, Emily checks on the use of her tests at the Knowledge Superstore. To her surprise (and delight!!), she finds that a large pharmaceutical company has just adopted a course containing large amounts of her chemistry material in their life-long learning program. In physics, chemistry and physiology the courses she has contributed to now score in the top-5. This will definitely help her go to university. She may even get dispensation for parts of her curriculum, provided she studies at a university that also uses LTT. By law that shouldn't be; however, universities that don't, usually find all sorts of reasons why the merit points aren't valid in their particular circumstances. Only after the Department for Education and Skills endorsed the method, government funded schools and universities started using LTT. The adoption-rate increased after the central and local government institutions started using the Knowledge Superstore in their life long learning programs. After three years of use, about half of the educational institutions now use LTT. Initially, few commercial organisations joined the partnership, mainly due to concerns about copyrights. Once they were certain that the semantic tools within environment detected plagiarism effectively, they also started contribution to the Knowledge Superstore. Using automatic filtering, references and quotes to existing sources of material ensures that illegal re-use of material is made visible.

*Market place adoption generates merit points for each test used infrequently and a slightly larger amount when tests are formally incorporated into teaching programs. Adoption by commercial companies generates even more merit points. At some minimum level, the merit points can be converted into monetary value that can only be used for learning purposes. Based on content contribution, measured by the amount of merit points in a particular subject, producers can get dispensation for parts of their curriculum. Therefore, contributing to the learning environment provides positive stimuli, both in terms of prestige as well as financially.*

### Finding under-represented material

A few weeks ago, Emily used TSM's advanced semantic filtering to find knowledge areas not yet fully supported by the material available. One of the areas turned out to be the physiology of muscle contraction and relaxation. With her future studies and the current learning unit in mind, she decided it would be worthwhile to investigate that subject.

*The learning environment has extensive facilities to analyse and filter text on semantic level. Text fragments can automatically be classified using a large and detailed taxonomy. By analysing text, the learning environment automatically extends its internal thesaurus. Only when very specific jargon is used, the terms need to be defined explicitly. This happens only rarely. Based on the source of the text as well as the classification, the learning material is filtered and mapped visually. By zooming in on that graphical presentation, the intensity of the colour represents the amount of material available. Lightly coloured areas (or lack of colour) indicate lacking learning material. In this way, knowledge domains present in the taxonomy but under-represented in the learning material are visualised. To double-check, it is possible to use a particular sub-tree of the taxonomy as a filter. Using such a filter, all semantically relevant cross-references can be shown visually as well. Projecting the usage statistics on the visual representation can filter out learning material available, but under-utilised.*

### A new learning Module

While at the Knowledge Superstore, Emily checks the response to the query on muscle physiology she posted. Would anyone have suggestions? Would anyone want to join her? As she posted the query, the Superstore Message Board automatically inserted her credentials, essentially the references to the content she developed previously. Anyone looking at the query would be able to see which content she produced, anonymously of course. She is surprised to find the response. Within two

days, more than 500 people have reacted. There are seven respondents who would actually want to co-produce the course and eleven who offer to act as peer-review group. Even the domain-supervisor reacted. Based on this response, Emily creates a new project WikiBlog for the course on Muscle Physiology and invites the 19 respondents for an online brainstorm session.

*Extensive collaboration support is a crucial aspect of the learning environment. Consumers can correspond with producers; producers have all sorts of communication channels and can share material while producing the learning content. All users (consumers and producers) must register before they can enter the Knowledge Superstore. Depending on the situation, producers can assume more than one anonymous identity. Usually, producers use one specific identity for distinct knowledge domains, or different identities for each role they have. By default all interaction is anonymous; only rarely there is a need to lift anonymity. The domain supervisors guard against misuse of anonymity; they also act as co-ordinators and referees when necessary.*

**Use statistics**

Before returning to the oxygen absorption task, Emily checks the use of the learning material. She is always amazed by the amount of use the learning environment generated. Since last quarter, the statistics show an increase of more than 50% in registered users and an increase of 18% in new producers. Actually, about 10% of the newly registered consumers are also producers and most of them are her age group, so presumably fellow students.

*To measure the dynamics of the learning environment a large amount of statistics is maintained. This is the basis of the integrated credit system that allows content producers to build up educational credits as well as financial. This provides the basic measures for ranking of producers and quality of the content.*

**TOFT – Semantic Analysis**

Before she exits her PKC, she double-checks the semantic analysis of the answers. She returns to TOFT and switches trace to full semantic level. Running TOFT again, the detailed semantic analysis is displayed. She extracts all references to Haemoglobin, Carboxyhaemoglobin, and Adenosine Tri-Phosphate (ATP) and checks associations, relationships and synonyms. Cross-referencing the answers to the background material in her PKC she finds that none of her testers have mentioned anything about the difference between the absorption spectrum of oxygenated and non-oxygenated haemoglobin or the use of the "pulse oxymeter" to measure the amount of oxygenated blood. Clearly, her questions are not specific enough. Pasting the results of the semantic analysis to the project WikiBlog, she adds a question for her peer-reviewers to the main project wiki, thereby cancelling her previous instruction to TATA.

*Advanced TOFT is a component that evaluates answers in a test. The simple mode is used for multiple-choice questions. The advanced mode is able to plot the questions and answers in a semantic network. Each question and answer pair has a set of background material, which is available as a semantic network as well. In essence, TOFT compares the answer's semantic network with that of the background information, using the question's semantic network as a bias to focus and cluster the results. Automatic second and third order expansion is done using information from the other semantic networks in the same learning module. Based on the correspondence between the semantic networks, a measure of conformance is computed. Since reasoning based on the semantic network is still very difficult, teachers still need to review the results personally. However, in self-study mode, the trace provided by TOFT allows students to a large extent to assess the correctness of their answers.*

## *Notes on the learning environment*

### Digital Natives and Digital Immigrants

Marc Prensky first used the terms Digital Natives and Digital Immigrants writing about Digital Game-Based Learning[iv]. A Digital Native is someone who has always been surrounded by digital media and access to digital infrastructures like personal computers, the Web, TV, Interactive Games, etc. Essentially, he argues that learning based on reading or learning based on a teacher explaining, will not work for Digital Natives. For a Digital Native, everything is digital and interactive, learning included. Methods based on the old paradigm will not work for Digital Natives; learning based on extensive use of interactive digital media are the only way not to lose this generation.

### Learning by explaining, collaboration

In 1993 Kurt VanLehn, et al.[v] describe how (self-)explanation facilitates the knowledge acquisition and learning process (see [vi] with [vii] as an abstract), using a simulation program called Cascade. In 1999 Plötzner et al., elaborate on similar experiments using Cascade (see [viii]). Recently, Dr. H.A.T. [Henny] van der Meijden recently defended her Ph.D. on Learning by Explaining at the Radboud University Nijmegen (refer to [ix] for an earlier, related publication, in Dutch).

### Anonymity

The University of Edinburgh refers to anonymity in the context of 'Learning Organisations' as '… One way of over-coming this fear is to introduce anonymity so that questions can be asked or suggestions made but the source is not necessarily known. …', refer to [x]. Thomas Kuhn, in The Structure of Scientific Revolutions[xi], writes that paradigm shift is hindered by the underlying beliefs in a scientific community, suppressing novelties that could undermine its foundations (refer to [xii] for a synopsis). Anonymous contributions to the body of knowledge would allow a way around that problem by provoking discussion on the content of the contributions instead of the reputation of the contributor. It is likely that without anonymity students would not be motivated to produce new material, for fear of loss of reputation, for not wanting to stand out, etc. No scientific research about this aspect in education has been found, though.

### The semantic web

In May 2001,Tim Berners-Lee, the inventor of html and thus the 'father' of the World Wide Web as we know it today, presented a new vision on the next step of the Web, the Semantic Web in Scientific American (refer to [xiii] for an electronic version of the paper). Only by adding meaningful and interchangeable information on the content of web sites (and pages within the web sites), so-called meta-data, can the Web continue to grow and still the information overload. However, adding the meta-data still presents a problem. Much of the effort of making the Web more 'intelligible' can be alleviated using cost-effective, automated tools that generate the meta-data as adding meta-data manually is no option.

### WikiBlogs

See [xiv] for an article on the use of wikis in the Encyclopedia of Educational Technology in education. The University of British Columbia has a blog-entry describing the use of wikis and Blogs for teaching purposes, posted on February 10, 2004, see [xv].

### Supplementary teaching material

Some students never learn a subject because the way the material is presented and the examples used, just don't appeal to hem. This doesn't mean they aren't interested in the subject but that assimilation of the material doesn't fit properly into their mental schemata. By providing supplementary material, e.g. directly related to current affairs, the gap between the material and the mental schema can be bridged more easily. Examples based on the speed of a football kicked by a soccer

player, the force required to reach that speed, the acceleration of the ball, the air resistance of the ball, the deceleration caused by the air (etc.) could be more appealing learning material to a 14 year old boy who likes football and therefore will be more effective.

## *About the author*

John Grüter is a Dutch-based consultant who helps a variety of organisations in selection, adoption, use and implementation of technology, particularly where the technology enables innovating products and services. Knowledge Management and process optimisation of knowledge-intensive processes are a major focus. John's company, Digital Knowledge, has relationships with several companies that provide products and services in that area, notably Infolution ([xvi]) and AnswerWeb ([xvii]).

[i] http://www.marcprensky.com/default.asp
[ii] The Third Wave, Alvin Toffler, 1980
[iii] http://www.wikipedia.org
[iv] Digital Game-Based Learning, Marc Prensky, 2001, and http://www.marcprensky.com/writing/Prensky - Digital Natives, Digital Immigrants - Part1.pdf
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[xi] Thomas Kuhn, in The Structure of Scientific Revolutions, 1962
[xii] http://www.des.emory.edu/mfp/kuhnsyn.html
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