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Essential Knowledge Aggregation, Delivery and Assessment

Abstract

It is clear that the use of ICT for education has not yet achieved its potential. In this paper we present our vision on the further development and widening of learning through the enhanced use of ICT. In this context, learning is considered as having a framework with several essential and connected processes. Web semantic methods now enable the monitoring of knowledge and curriculum updates. Substantial research is required as well as an understanding of how the human brain manages various channels of information delivery. We consider knowledge delivery in combination with textual, visual and audio information. Its efficiency can be improved when we discover and apply methods used for successful performances and plays. A paradigm shift from in-class assessment toward self-assessment assisted by individually tailored ICT increases the efficiency of learning. As a first step, an individual assessment tool (App) for iOS is briefly described.
What does education need from ICT? It is clear that we need to address how we extract knowledge from Web, how we aggregate new with existing knowledge, how we deliver more current and essential knowledge and how we can ease and improve assessment. All of these steps include ICT, web and human involvement. This is called Essential Knowledge Extraction, Aggregation, Delivery and Assessment. It is a practical pathway for considerable research in knowledge aggregation (using information processing support), extraction, and delivery. To succeed in delivering this aggregated knowledge we must understand how the learner's brain absorbs knowledge. In addition self-assessment supported and implemented by individually tailored (adaptive) assessment technology and tools can also improve knowledge delivery.

This aggregation provides answers to the following questions:
- How to make courses more responsive to real-world changes in the field or area of knowledge?
- What kind of technologies and tools are really effective for supporting curriculum development?
- Can we get support and achieve real impact for eLearners through better use of different information channels?
- How to make knowledge delivery and assessing less stressful for both the eLearner and the curriculum provider?

First things first, what is really required? A simple Google search on "IT role in education" produces 1.5 billion hits; "curriculum design" gives 8.9 million; and "curriculum design models" yields a healthy 9.7 million. The numbers vary day-to-day, but the scale is impressive. In the last two years, MIT and Stanford offered software engineering and other courses online to which they enrolled thousands of students [1]. Government statistics highlight web-accessible, massive open online courses (MOOCs) as a new learning option [2].

Unfortunately, digging a little bit deeper we find:

- The quality of lectures , e.g. on YouTube varies greatly.
- The pedagogy and materials used for online delivery are typically the same as that used for face-to-face delivery in the classroom which does not take advantage of the potential online can offer and makes line delivery a poor second to face-to-face;
- MIT's R. W. Picard indicates PowerPoint style presentations tend to lose the engagement of students within about 10 minutes [3];
- Bloomberg's 2014 report on the open online initiative EdX warns of poor student retention of e-learners on courses [4]; and
- The impact of ICT, and especially the Web, on human is not actually positive [5].

Thus, it seems there is much enthusiasm for online learning however, the success rates can be as low as single figures. Higher education curricula could benefit from the technological advantages of ICT [6, 7, 8]. Furthermore keywords and their change and movement in any knowledge domain can be extracted and monitored using semantic Web methods in [9,10]. This opens up the possibility for support tools to automatically???? keep the curriculum up-to-date. This involves monitoring a knowledge base of ??? and recommending changes and upgrades for courses and materials when necessary.

Issues with Using Existing Technology
Since the beginning of the 21st century, the efficiency of learning has actually deteriorated, particularly due to quality and impact of ICT [5]. To counter this information flow needs to be adapted and personalised to ensure effective knowledge delivery.

ICT platforms are changing rapidly; the modern user's preferred devices are smart phones and tablets; screen size is reducing, thus putting greater pressure on humans and challenging interactive user interface design. Computing and database facilities are rapidly becoming remote and cloud-based, while offering more power and security, there can be issues such as delays and localised access restrictions.

ICT needs to be tamed and used systematically or it will fail to deliver to its potential. Achieving the potential benefits of productively combining knowledge formation, curriculum design, and re-design, requires improvement in several areas including ICT involvement, for example:

- Monitoring the current state of knowledge on topics in relevant subject areas;
- Selection of core learning material;
- Improving the curriculum design process;
- Creating and using information system support for the maintenance of "core knowledge," using semantic web searches for knowledge evolution and monitoring the structural knowledge dependencies and state transformations;
- Studying the impact of the application of ICT on human creativity, using models of the impact of Web/ICT-based systems on knowledge delivery and consumption, as well as individual workload and assessment
- Analysing how information is delivered to optimise knowledge transfer *for each individual*, such as by the effective use of the human's channels available.

Additionally, assessment techniques need to be modified. D.Patterson's keynote speech at WorldComp12 described how, out of more than 15,000 students recruited only 3000 successfully completed the software engineering MOOC at Berkeley [11]. This implies if there were two assessments for the module, say a coursework and an exam, a vast amount of assessment effort would have been wasted. In short, attempts to use ICT *'as is'* into knowledge delivery '*as is', proved to be unsuccessful*.

So can education do a better job and can eLearners achieve better results? We propose an integrated approach to curriculum design including the essential elements of:

- A theoretical study of the knowledge base, its transformation, and change
- A framework for curriculum development
- Estimation of efforts required to deliver knowledge through the various channels
- Modelling of knowledge delivery including the properties of the human brain
- Creation of, and automatic, supportive assessment schemes

To improve learning effectiveness it's always good to evaluate the amount of required repetitions it takes—keeping in mind our mother's plea "I told you hundred times and you still did not get it!" In practice the knowledge schema and its delivery process must take into account the nature and characteristics of the human brain and the channels through which the information flows. This provides the basis for matching the speed and style of information delivery to the capabilities of eLearners. A birds-eye view of our integrated approach on Essential Knowledge Aggregation, Delivery and Assessment (EKADA) is shown in Figure 1.

Figure 1: Curriculum design and implementation research

Integrated Approach

Our thesis is that knowledge delivery should be considered as a *single* information processing system that *includes* the learners. The individual human's means and ability to learn cannot be ignored; the brain's anatomy, physiology, and function—specifically how it learns—should be part of the scheme. A dynamically updated knowledge base, kept up-to-date, must be accompanied by an adjustable delivery process, which, in turn, has to be adaptively tuned to an individual's capabilities.

The Human Brain and Curriculum Delivery

In the past people had time to think, reflect, and react. They had time to use their associative memory and brain. Nowadays most people are swamped by information. They are like children in a vast Internet sweetshop.

In order to help people cope with this information avalanche it would be useful to introduce schemes that help semi-automatically identify, track, and adapt the changes and additions to knowledge as it develops and is detected. Web-semantics research can be used for educational purposes in two main ways: Firstly to detect, categorise, and extract knowledge and then be used by ICT to manage its delivery. Both of these processes are becoming crucial given the sheer volume of information available now and emerging in the future.

Information technology could help us become even better or smarter, but due to the overload in our brains and the high dependency on our eyes, humans are already close to the limit of our ability to learn, filter information, and extract knowledge [5, 13]. At the same time, if the workload on the brain can be carefully balanced and adapted to consider knowledge assimilation and organization in the brain from the viewpoints of control theory, signal theory, and information processing, then our ability to absorb more and learn faster could be improved [8].

The harmonization of knowledge delivery is based on the use of all possible information channels: textual, audio and visual. When activated, all three information channels tax the brain; each has a different level of information density and all need to be used in concert to achieve the best outcomes for learning. Figure 2 illustrates connections between research paths of brain, perception, and efficiency of knowledge delivery.

Figure 2: Modelling the brain for educational gain

As an example, the visual cortex deals with visual image sensing, while recognition and interpretation of “what we see” uses other segments of the brain. So, to an extent a person’s ability to think while concentrating on the screen is actually reduced or even blocked. The perception of textual and audio information flow also contributes to knowledge formation in an eLearner’s brain. To get quantifiable results of how eLearning impacts the learner’s brain, the structure and processes of information delivery need to be researched in more depth.

There has been considerable research on the structure on the brain: Heinze et al's classic paper [12], and recent results on this subject are impressive and should create a more efficient scheme of information delivery and knowledge acquisition. The challenge is great; the size of the BigBrain model and aggregated data exceeds 29Tbyte and is growing [13]. While a model of this kind exists, experiments to incorporate new information and new links can upgrade the brain model, and be applied in the areas where it is needed most—medicine, education, artificial intelligence, etc.—which might help us understand how the brain learns. The enormity and growth potential of such models present a “great challenge” for computer science in terms of structuring for both: continuous aggregation of knowledge and the associative searching needed to mine the information required. To make this model really useful to knowledge delivery, two “live” experiments are needed to:

- Establish dependencies between areas, links, length of links, domain functions, “distances” of signal propagation inside brain; and
- Focus on applications with specific experiments from application domains.

Combing research on how knowledge assimilation and curriculum delivery occurs in the brain could help make education more efficient, as Figure 3 below illustrates.

Figure 3. Brain research for knowledge delivery

Delivery: Ways And Means

Effective channeling of incoming information and investigating how knowledge is subsequently created inside the brain becomes a part of the field of??? knowledge delivery. Current activities, we believe, should be focused on:

- Tracing information flow from the visual cortex and its assimilation within our brain;
- Models of various information delivery channels;
- Development of an integrated model of information delivery using various inputs;

- Experimental work on the brain's transformation of information into knowledge.

Any lecturer will benefit enormously if the delivery of information is balanced for the best use of the audio, text, and visual channels. Remembering the poor attention span of students in case of PowerPoint-based teaching [3], we argue Stanislavski's work on the theory of performance demonstrated that an interesting performance (knowledge delivery) can keep us present and attentive for several hours [14,15].

Undoubtedly it is possible to maintain attention and create intensive processing of information absorption and knowledge formation when the circumstances are right: the material is relevant; it is presented in a way that is continually interesting and easy to assimilate; and the eLearner has the motivation to give it their attention, learn, and feel confident that they are really learning and gaining the knowledge they need.

If considered together, both Stanislavski's and Gaston Bashlyar's [16,17] systems engage the perception and attention of learners and could result in improved learning abilities that could also be applied to design, education and art.

Information Delivery Channels:

The amount of text, its appearance, and format (including fonts, colour, size, number of columns) have an impact on us, they depend on each other and our ability to immediately absorb/learn; size of sentences, length and familiarity of words all make an impact; intensity of visual support, and the subtlety of emotional delivery may have a strong negative or positive impact on our brain.

Text recognition is one of the fastest processes in the brain, it involves both primarily sensor groups—cones or rods for colour and greyscale sensing. Words, grammar and learned meanings within the brain activate associative memory and other areas, sometimes called "thinking schemes" [8], in contrast to visual recognition ones.

Even though it is the easiest and most ancient scheme, there is no doubt that text decoding is a significant energy overhead that could be better used for thinking. To understand how efficiently information can be processed into knowledge and how to combine delivery and thinking, a program of experiments is needed to determine:

- The set of symbols and their representation, formats required to aid brain processing
- How many brain zones (areas) are activated? How hard to "digest" a piece of text?
- How to minimise the amount of energy the central nervous system and blood supply systems need "to absorb and interpret" text in the brain?

Socrates said "take as much democracy as you can carry," that applies here too. How can knowledge formation be analysed using the independent variables of required power, volume and time? And how much can we "carry?" Can the process of knowledge delivery be visibly improved?

The basis for the analysis of various channels is similar: The relevant segments and pathways of the brain involved in learning need to be studied. Followed by an evaluation of the chosen information delivery channels and quantification of energy required to process, understand, and assimilate information from the input data. The information flow can be measured and analysed in terms of:

- Bandwidth, or the number of bytes per second
- Frequency range usage
- Mean time of reliable delivery of an element of information
- Size of sentences and length of words
- Foreground and background noise

At a higher level noting *theories of performance* by Stanislavsky and Bashlyar's, one should think through combinations of audio, text and visual information flows on knowledge delivery. It's time to stop dreaming that YouTube-like lectures can be platform of effective delivery for education, unless they are based on a sound set of eLearning principles that take account of the physiological and psychological capacity of the learners [14, 16, 17]

To make knowledge delivery efficient, the delivery process needs further "fine tuning" based on the eLearner's innate ability to learn. For those who need extra support teaching within an ICT environment, shorter lectures, frequent tests and self-assessment schemes will be needed. For the more academically inclined the model of curriculum delivery and assessment needs to be different with higher levels of abstraction and self-study involved, supported by infrequent assessments and tutorial support when needed.

"At the lecturer frontline" a quantifiable model of workload including both the eLearner and the lecturer should take into account the range of abilities and prior knowledge of the intended learners. Clearly, such an ambitious goal is hard to achieve as time, effort, and funding are always limited. Therefore, a quantitative analysis and models of curriculum delivery might help to connect wishful thinking and reality.

ICT Supportive Schemes for Assessment Process

Higher education institutions across the globe are using a variety of Virtual Learning Environments, Blackboard (now including WebCT) being a common platform. With more innovative VLEs appearing every day, presentations at conferences are booming. It all looks good on paper; databases are full, lectures and tutorials organized, and after answering endless multiple choice questions students are told they have gained the best possible knowledge.

Again, in reality the picture is not quite so impressive as other factors have to be considered:

- The cost of a reliable Virtual Learning Environment platform for a university can exceed $100,000 each year, not including the staff and infrastructure costs;
- Multiple choice questions are not a reliable measure of knowledge [20]
- Setting exams via an ISS (Information System Service) and the assessment departments at universities can be stressful for teachers and students alike;
- Malfunctions of ICT can destroy an exam procedure and timetable, and contribute more problems than solutions;
- Merging and mixing of assessment and ICT complexities so far has not provided any visible progress in terms of educational efficiency.

Use of ICT should ease the assessment phase, for example introducing a new multiple choice approach that ensures students address the relevance and dependencies between several key definitions of the topic in hand [6, 7, 8].

In reality, the rigorous formation of a set of essential questions - derived from the current curriculum has been both elusive and difficult to attain. Keywords help to directly map possible knowledge structures, assist the process of delivery of knowledge, and make assessment almost automatic. Applying this approach reduces a lecturer's workload in creating an assessment and, at the same time, guarantees quality. Web-semantics research might help in the formation of an essential glossary and set of topic related assessment questions.

Easing the Pain of Assessment

Using the Web for assessment has two major advantages: The learning process can be enriched with a training mode for self-assessment, thus becoming an integral part of learning, increasing self-assurance and comforting a learner as this can be done anywhere in the world and at any time. Secondly, during a defined and scheduled assessment time the student has much more confidence regarding the subject and process of assessment. The "training mode" might also offer options for various depths and coverage of the assessment. In principle an unlimited number of questions on any given subject could be generated.

A new web-based assessment tool is needed that is capable of continuously tracking the eLearner's knowledge, whilst progressing along the defined path with automatic monitoring and tuning of individual student knowledge and capability.
Through the work of our students the first version of an Individual Assessment Tool (IAT) has been developed and released. Using IAT, you can create and run multiple choice answer (MCA) assessment design across a wide spectrum of high education disciplines [8].

Note that the proposed MCA is based on different multiple choice question approach where "one of *n*" answers is supposed. The psychological drawbacks of standard multiple choice tests are well described in [18]. Instead, MCA is based on the whole core knowledge set looking at the relevance of questions to various elements on a course, relations and terminology with almost *n/2* right answers from *n* proposed ones. As mentioned above, IAT helps self-assessment during semester; eLearner's devices such as phones, tablets and PCs to help lecturers monitor their progress and allow them to seek relevant advice and pass the module as soon as they are ready. The first version of IAT was released for the Apple iPad. Figure 4 shows a screenshot. Our MCA approach was used to format questions and design an Individual assessment tool, with support of the level of iteration of self-assessment and various penalty policies during individual self-assessment. This tool is called Teachflowapp and it can be downloaded for free from the Apple store.

Figure 4. The first version of IAT application

Conclusion

Our biggest and fundamental problem is how to gain new knowledge, aggregating it with existing knowledge and efficiently deliver and apply it.

There has been a massive shift towards the use of eLearning platforms as well as creating and using virtual learning environments. Regretfully, so far use of ICT to transfer knowledge from the education provider to each specific individual consumer has not been as efficient as it should be.

We propose an approach that considers curriculum design formation and relevance—a process of its evolutionary change, delivery, and assessment—as one framework through several connected and dependent processes.

Semantic Web search techniques and platforms have become essential for trawling the vast expanse of data in the real world and then honing the results down into what is relevant and useful in curriculum terms for a given subject in a given field. This is a far cry from the rather rigid curriculum development committees, based on judgments from the limited experience of a few people, and academic assessment boards that dominate the current educational traditional systems, which inevitably slow down the reaction time of universities in keeping pace with change.

This research is driven by the belief that the way individual people learn is paramount for education to be effective. Understanding how knowledge is transferred into the brain makes it possible to design new delivery platforms that use all available information channels together in an effective way. Initially human audio, video and text channels are being researched.

It is hoped that the aggregation of brain studies with ICT supported curriculum design and development will increase the efficiency of education processes, primarily teaching, learning and assessment.

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