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A Theoretical Framework and its Practical Application for Virtual Exchange in Problem Based Learning: Using an Integrated Online Learning Platform to Beat Entropy[1].

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Abstract:

This paper seeks to place Problem-Based Learning in virtual exchanges in the context of information theory, looking particularly at how social learning is influenced by the type of technology used at different stages of the learning process. This paper analyses processes underlying social learning in information-rich and information-poor environments and draws conclusions as to the type of learning system most suited to virtual exchange in PBL. Finally, it proposes a scenario in which such a system could be used to engage students in a distance-learning environment that corresponds to their learning habits and to the expectations of the industry.

INTRODUCTION

Most universities are faced with three competing challenges: to expand their student base and international orientation by increasing exchange programmes, to modernize by introducing student-centred learning methods into the curriculum, and to lower costs in a turbulent economic climate. In this context, the concept of virtual mobility (Bijnens *et al*, 2006), meaning that 'students and teachers can experience international exchanges of expertise while staying at home' (2006: 5), is becoming more attractive. A certain number of institutions are trying to adapt the Problem-Based Learning (PBL) methodology to distance learning programmes and virtual exchanges. Attempts at doing so through asynchronous, blended and synchronous learning technology have been partially successful, although no programme to date has been able to completely translate the essence of the PBL experience into the virtual space. This paper proposes to look at what has been done in PBL in distance and virtual learning, to account for the shortcomings of current distance learning technology through the theoretical framework of the information space, and to offer a potential opportunity for virtual mobility in PBL through the use of an Integrated Online Learning Platform.

PROBLEM-BASED LEARNING AS A PEDAGOGY

Problem Based Learning is not a new teaching methodology. Its philosophical foundations can be traced back to the critical-rationalist discourse of Karl Popper (Bailey & Parton, 2008) and the work of John Dewey on Education and Democracy (Dewey, 1916). Dewey instilled into the academic debate the idea that education is a fundamental process through which the citizens of tomorrow are formed (Schecter, 2011), and must therefore allow these future citizens to develop the skills sets with which they will govern their nation wisely: critical thinking, problem solving skills, the capacity for analysis. Eric Weber argues this point when he states that 'Plato believed that knowledge is something possessed. By contrast, Dewey would have said that knowledge is a form of activity. For Dewey, knowledge, truth and meaning rest on the consequences of action. As such, we are first and foremost dealing with actors, not spectators when it comes to knowledge and education' (Weber, 2008).

The earliest adoption of PBL can be traced back to the late 1960's and early 1970's, led by the field of medical education (Barrows & Tamblyn, 1980). The application of PBL to higher education was first developed by the School of Medicine of McMaster in Canada (Saarinen-Rahiika & Binkley, 1998) and rapidly adopted by 'reformed' universities in Denmark (Kolmos *et al*, 2007; Kropp, 2011; Nielsen, 2001; Nielsen & Webb, 1999) and the Netherlands (Moust, Schmidt & Bouhuijs, 2007; Moust, Van Berkel & Schmidt, 2005). From there, it spread throughout the world to over 150 universities and polytechnics, in diverse fields of study and practice. Estimates place the number of courses currently using PBL at 500 (Moust et al., 2007: 11).

All variants of PBL are driven by the same philosophy: 'to foster collaboration among students, stress the development of problem-solving skills within the context of professional practice, promote effective reasoning and self-directed learning, [...] aimed at increasing motivation for life-long learning' (Bidokht & Assareh, 2010: 1147) Scholars have long agreed that problem solving stimulates the mind to expand into a greater zone of potential development (Cole, John-Steinerm Scribner & Souberman, 1978; Vygotsky, Luria, Golod, & Knox, 1993; Leontiev & Luria, 1999), when accompanied by the process known as 'scaffolding' (Wood, Bruner & Ross; 1976; Hmelo-Silver, Duncan & Chinn 2006; Hmelo-Silver & Barrows, 2008), which, in the words of Kim and Hannafin (2011), can best be described as 'a process through which more knowledgeable others [teachers, peers, artificial intelligence] provide cognitive and social support designed to augment student problem-solving' (2011: 404).

PBL presents students with an unknown real-life problem to which they are required to apply their prior knowledge, in groups, in order to formulate the learning outcomes. 'Thus, rather than a pre-specification of what is to be learned, the assessment focuses on the issues that the learners have identified' (Savery & Duffy, 2001: 10). PBL is usually presented in a cyclical format, of varying length depending on the more or less project-orientated nature of the course to which it is applied. The cycle comprises of group work phases, self-study phases and feedback sessions in which the group tutor helps the students to scaffold their knowledge of the problem. At the end of the cycle, students will typically be expected to submit a report on their findings, and be required to present them in front of their peers and qualified examiners.

A full description of the common features of the PBL cycle across universities from Denmark, the Netherlands, Canada and Australia can usefully be found in De Graaff and Kolmos' work (2003). The main characteristics which they isolated are as follows (2003: 3)

- The learning process is divided up in the three central components: group-work, self-directed study and tutor-support sessions.
- The assessment patterns have to be changed to reflect the change in pedagogy.
- The course is best organized as a project to develop organizational and co-operative skills.
- The type of projects are highly structured and guided by the tutors, such that while remaining the property of the students, they correspond to the learning outcomes expected within the curriculum.

PROBLEM-BASED LEARNING IN DISTANCE AND BLENDED EDUCATION

Distance learning has long been a practical solution for busy professionals who wish to update their qualifications or further their education. From the outset, it was designed for individual learning in one's own private time, providing the necessary assessment structure to test the knowledge that one gained with materials studiously absorbed by oneself. The incorporation of Blackboard Inc. by Chasen and Pitinsky in 1997 and the subsequent launch of Blackboard Learn,

its trademark Learning Management System (LMS) ushered higher education into the era of Web 2.0. Institutions were suddenly presented with the opportunity to create dynamic content for distance learning courses. Participants could now write to one another via email, online fora and instant chat functionality. Dozens of start-up educational entrepreneurs (most of which have now been bought out by Blackboard) released what are popularly known as Virtual Learning Environments (VLEs), both in proprietary and Open Source versions. Although VLEs were widely used in a 'blended learning' mode where students could access course materials from the lectures they attended on campus, the biggest impact of VLEs was on distance education. Paulsen (2003:134) claims that 'much of the success of e-learning can be attributed to the availability of LMS, also known as VLE or learning platforms'. Institutions specialising in distance learning, such as the Open University in the UK began developing their entire curricula using VLEs (Sciater, 2008).

Dougiamas, creator of the widely used Open Source VLE 'Moodle', designed his environment with specific constructivist learning objectives in mind (Dougiamas & Taylor, 2002). In an experiment which he ran at Curtin University of Technology with his dissertation supervisor, Dougiamas tested eight students on an early version of the Moodle software. The learning objectives were threefold: to learn about constructivism, to reflect critically on their own learning and to learn collaboratively by engaging others thoughtfully and emphatically. Their findings confirm that 'the course seemed to have been quite successful in achieving the three learning goals originally set' (2002: 5). However promising these results for the delivery of online education, these students were not working in a PBL environment.

The University of Southern Queensland offers a more recent study (Brodie & Porter, 2008) of a PBL environment run on a commercial LMS (unspecified) in an undergraduate engineering programme. At the time of the author's writing, this was a 'novel, even world-first process' (2008: 440). The environment comprised of email, discussion boards, instant messaging capability, electronic submission of work capability, electronic surveys and wiki pages. The results of the experiment are encouraging. Compared with traditional lecture-centred distance learning courses, '54% of students thought that the PBL courses had increased their ability to learn, with only 14% unsure of the effect' (2008: 440). The authors conclude that PBL will continue to have an important role to play in distance education in the future.

Donnelly (2010) reports on a blended-learning PBL experiment in Ireland in which face-to-face contact time was supplemented by asynchronous discussion fora, video conferencing, synchronous chat sessions, online reflective journaling and podcasting. Responses to these media were mixed. Donnelly notes that 'the asynchronous discussion forums were seen as positive for supporting reflection but causing frustration in how peers used the threaded discussion structure and yielded information overload' (2010: 354). There were also mixed responses about the chat function; some felt that they 'could not have survived' without it, other felt that 'it did not further

our direction a whole lot with regards to the problem'. Only the use of online reflective journals resulted in 'almost universal support and praise'.

Very recently, a group of Dutch, Danish and American Universities launched a cross-border project-based business and marketing programme, mainly using the free VoIP software Skype combined with Googledocs and email as a means of file sharing. The project deliberately left the students a choice of means of communication (Schroevers, personal correspondence, 2011). The 30 ECTS programme focuses on building intercultural competences, employability and internationalization through the virtual mobility and guest / web lectures. The project is building a website, labelled 'museum', in which they include the best samples of students' work as a motivational tool for the students. The students work in teams of five, exchange ideas with the teams from the other universities (via skype and email), inform the other teams of the specificity of the products found in their country, perform local research and share findings with the other teams. The whole project is expected to last one semester. The project is a first of its kind experiment with cross-border PBL through synchronous communication tools. The team behind project 'Market Basket Analysis' delivered a low-cost programme, within the boundaries of the Erasmus programme, and in a way which provided students with new skills, virtual team experience and international exposure. The project also had a positive impact on the institutions and the faculty involved in terms of low-cost internationalization, new competencies and motivational factor, among other positive outcomes (Schroevers & Bisgaard, 2011).

However, the professors behind the project outlined some of the difficulties that they faced in a presentation at the EAIE conference of 2011 (Schroevers & Bisgaard, 2011). Principally, the organizers found it difficult to manage the time and academic calendar differences between the three countries. The strain on staff time was a major hurdle. Interestingly, the presentation noted that the virtual nature of project engendered a loss of informal contact opportunities. We shall dwell on this further later in the paper. Although this project marks a leap forward in the virtualization of PBL, the organizers believe that virtual PBL has yet to reach its full potential (personal correspondence, 2011).

This is a sample of the type of PBL programmes being adapted for distance and blended learning courses. There is an increasing number of such projects being developed by universities across the world (see for instance Hmelo-Silver, Chernobilsky & Jordan, 2008; Price, 2000)

A THEORETICAL FRAMEWORK FOR UNDERSTANDING DISTANCE LEARNING

The virtual PBL experiments analysed in this paper indicate that, although there are challenges to implementing PBL curricula in distance learning, this idea is not an 'educational bridge too far' (Price, 2000). However, current best practice in PBL in virtual education struggles to fully translate the scaffolding experience, particularly peer-scaffolding. We know that PBL involves

certain cognitive processes that cannot be found in teacher-centred learning and are difficult to replicate in an asynchronous learning environment. Scholars have labelled the learning process in a PBL environment 'deep and complex' (Chan, 2010: 40) as opposed to rote learning, in which the student memorizes but does not understand (see for instance Lai & Tang, 2000). Hmelo-Silver et al. (2006: 105) define the ideal learning situation as providing 'students with opportunities to engage in the scientific practices of questioning, investigation, and argumentation as well as learning content in a relevant and motivating context'.

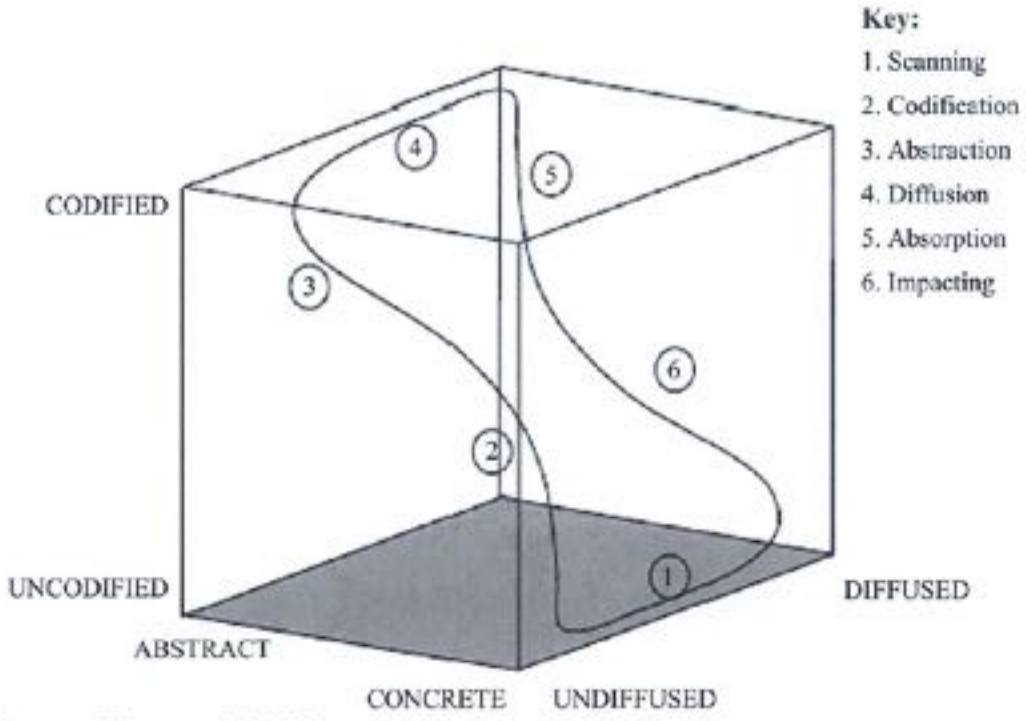
Barrett (2010: 171) goes further to talk about the PBL process as 'finding and being in flow'[2]. In a study in which he analysed the progress of two groups of students during a PBL tutorial, he concludes that 'the concept of finding and being in flow was my way of making sense of the students' talk about the PBL process […]. The PBL process did not involve a neat transition from *a* to *b* but rather a messy transition of finding flow'. This type of messy process can be entirely lost once digitized. Beetham and Sharpe (2007) warn that 'less thought has been given to the knowledge that is forgotten or lost in the process of digitization: practical skills, know-how that is deeply embedded in the context of use, and other tacit knowledge associated with habits of practice (Dreyfus & Dreyfus, 1986). Ironically it may be exactly this kind of knowledge that is drawn on by effective teachers, and by effective learners too' (1986: 4).

What these authors are describing is best understood in terms of movements in codification, abstraction and diffusion, what Boisot has referred to as the three dimensions of the information space, or I-Space (Boisot, 1995, 1998). The I-Space is a model of information processing which tries to capture how people and organizations deal with and learn from information.

- Uncodified knowledge cannot be captured in writing or stored without losing the essence of the experience it relates to. Codified knowledge, however, is structured such that it can be recorded and passed on without damaging the meaning of the information being transmitted (Boisot, 1995:145).
- Concrete information is defined in relation to the immediate circumstance in which the information is presented. Abstraction, however, 'saves on data by correlating features of the forms so defined on the basis of shared attributes, thus avoiding the need for independent description or treatment' (Boisot, 1995: 175)
- Simply put, undiffused knowledge is the property of one individual, and has not been shared. Diffused knowledge is shared with a more or less wide community of people. The more abstract and codified information is, the easier it is to diffuse.

[2] Barrett described 'being in flow' as 'an elaboration of the Csikzentmihalyi's (1996, 1997) concept. Csikzentmihayli defines flow as: being completely involved in an activity for its own sake. The ego falls away. Time flies. Every action, movement and thought follows inevitably from the previous one, like playing jazz. Your whole being in involved, as you're using your skills to the utmost (1996, p.1)'. (2010, p. 171)

FIGURE 1
Learning in the Information Space



Source: Boisot *et al.* (2004)

Learning is a dynamic movement in the I-Space, depicted here by a cyclical curve, the Social Learning Cycle (SLC). Learning is can be broken down into 6 distinct phases according to the I-Space model: scanning, problem-solving, abstraction, diffusion, absorption, impacting (see Boisot, 1995, Ch.4 for full description). There is no specified beginning point for the learning process, its trigger can be in any of the phases of the cycle. It is a continuous process of codifying idiosyncratic patterns of data such that they can be generalized and diffused, at which point the newly created knowledge is internalized through repeated use and becomes embedded in concrete practices and physical artefacts (Boisot, 1995: 165). The process of scaffolding, however, is located specifically in the 'scanning' phase of the SLC. Boisot (1995: 193) wrote that 'the triggering stimuli [for detecting novelty] are as likely to be scanned through the information face-to-face interactions that occur among members of a specialized community possessing relevant codes as they are to emanate from inanimate physical objects'. This is what

we have referred to as 'peer-scaffolding', 'teacher-scaffolding' and 'technology-mediated scaffolding'. If scanning is a 'way of bringing about a spatiotemporal concentration of the information required to transform a disordered state into an ordered state' (1995: 194), then it translates the scaffolding process into the I-Space. Boisot (1995: 199) describes the problem-solving phase according to the Piagetian (Piaget, 1968, 1970) principles of assimilation and accommodation, placing the social learning theory within the constructivist tradition of developmental and educational psychology which has long been associated with PBL. Concentrating on the scanning and problem-solving phases of the I-Space theory is therefore especially appropriate for this analysis.

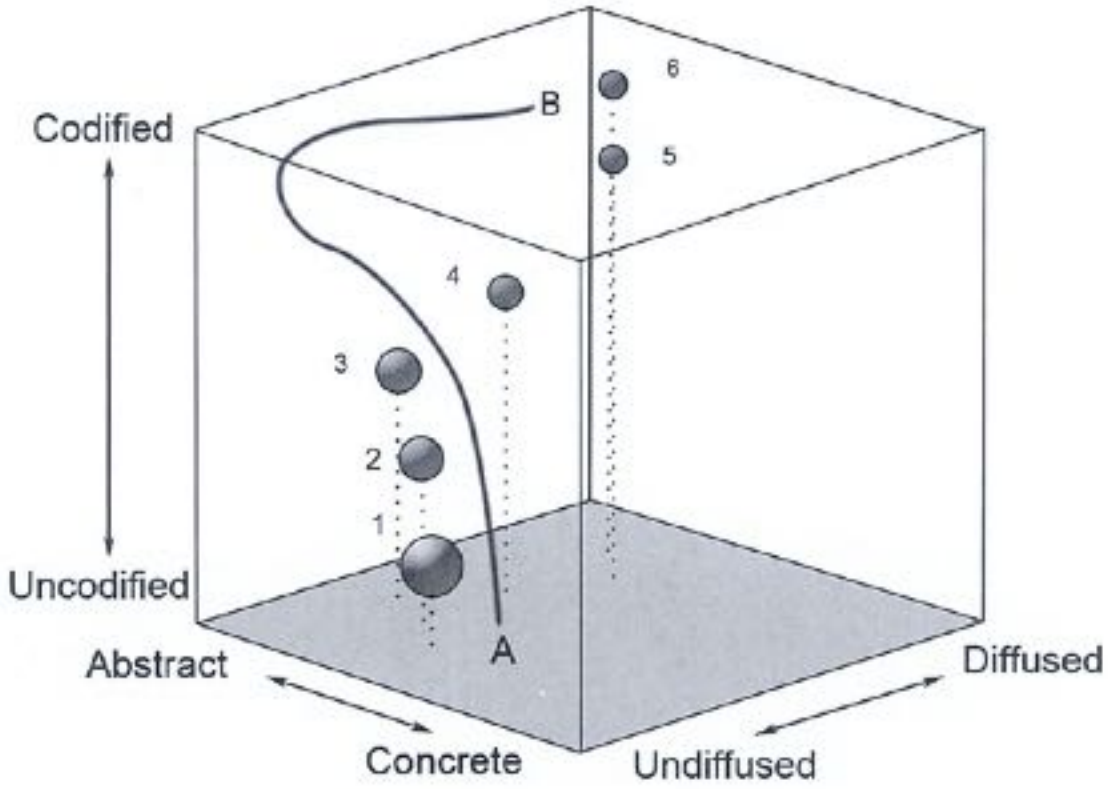
The usefulness of social learning as a criterion for evaluating the efficacy of a learning system was confirmed by Tolbsy, Nyvang and Dirckinck-Holmfeld (2002) who surveyed the Virtual Learning Environments at Aalborg University (Denmark). Even though the authors did not originally link their concept of social learning with the I-Space, we submit that this is the best model through which it can be understood.

In lecture based learning, the teacher orally diffuses highly codified and information to passive students who further write the information down. The teacher has one, perhaps two hours to cover a topic so he will tend to use abstract concepts to structure the lecture. He may supplement the lecture with concrete examples, but they will only serve to support the abstract principle rather than the other way around. In distance learning, this highly codified and abstract knowledge becomes also extremely diffuse, reaching a large audience across the globe through the Web.

FIGURE 2

Modes of learning in the I-Space

1. **Face to face small group interaction;**
2. **Video conferencing;**
3. **Instant messaging;**
4. **Forum discussion;**
5. **E-lecture;**
6. **E-books & e-journals.**

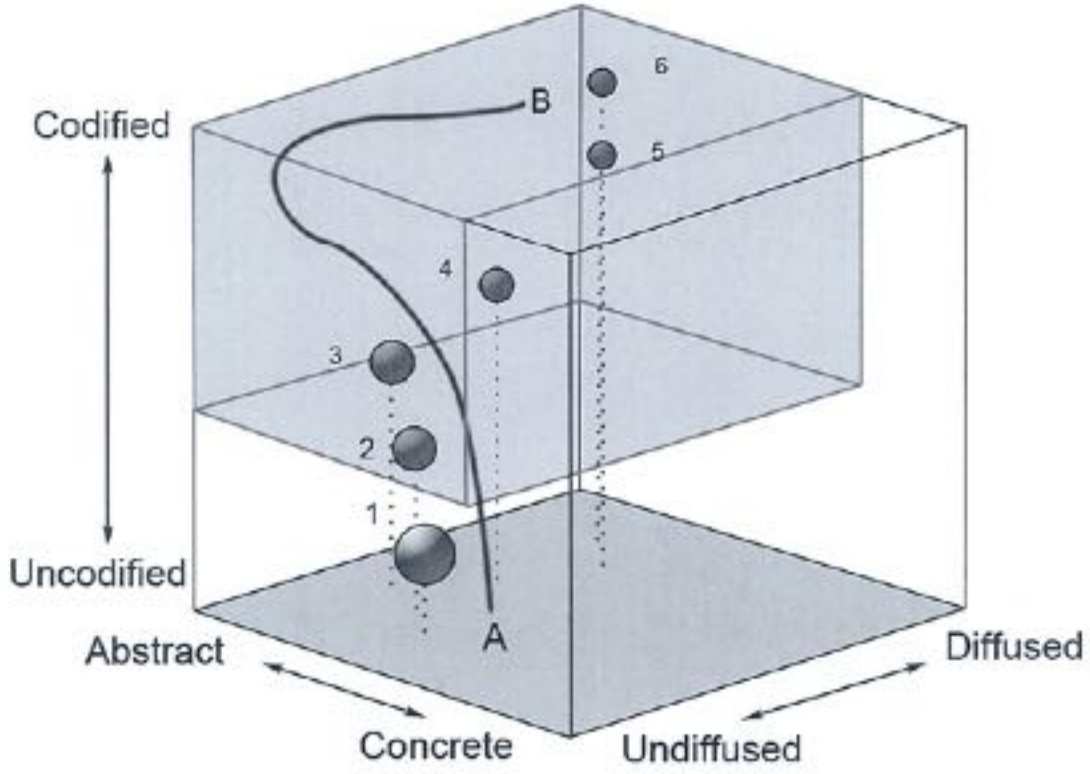


In the highly codified and abstract area where this type of exchange occurs, there is no allowance for the flow of learning which Barrett identified. Focusing the learning experience exclusively on this type of interaction misses the first half of the SLC, where the scaffolding takes place. Uncodified and concrete information plays an important part of our daily learning experience. We learn to make judgements based on facial expressions; we pick up signals and tacit messages from others which tell us more about the situation than what they are actually saying. The process of peer-scaffolding relies heavily on verbal communication (Yew & Schmidt, 2011), both with other students and with the tutor (Chng, Yew & Schmidt, 2011). Chng, Yew and

Schmidt (2011) suggest that 'the ability of tutors to communicate informally with students and hence create a less threatening environment that promotes a free flow exchange of ideas has greater impact on learning at each of the PBL phases as compared to tutors' subject-matter expertise and their ability to explain concepts in a way that is easily understood by students' (2011: 491) Given existing distance learning technology, much of the less codified, less abstract information is lost. In the words of Boisot, 'in its individual biographical articulation, social learning blends together a unique combination of skills, of practical and of personal knowledge not all of which can be shared with others; a society's accumulated stock of knowledge, therefore, always retains a substantial undiffusable private component that accumulates […] in the lower uncodified regions [of the I-Space]' (Boisot, 1995: 181). This is represented in the figure below:

FIGURE 3

Distance learning in the I-Space. The area inside the grey lines represents the part of the I-Space traditionally covered by distance learning. As technology progresses, the box extends downwards and to the right.



TRANSLATING THE PBL EXPERIENCE INTO VIRTUAL REALITY

If current e-learning systems are not capturing the learning that happens in the lower uncodified regions of the I-Space, they are not able to fully translate the PBL experience into distance learning. This poses two challenges for PBL in distance learning and virtual exchanges: on the one hand, there is a required minimal codification and abstraction before information can be passed on, even through video conferencing (see the Fig. 3). While the amount of codification needed for greater diffusion generally goes down with the increased performance of ICTs (Boisot, 1998: 215), one must not underestimate the time that it will take for technology to translate the lower regions of the I-Space to a wider audience, perhaps even the extent to which we can use technology to communicate less codified information, particularly in the domain of interpersonal communications.

We agree with the assertion made by Boisot, Child and Redding (2011: 75) that 'compressing messages into abstract codes and moving them up the knowledge structuring scale becomes unnecessary' with the advent of ICT, but only to a point. The current state of technology means that agents adopt a code of communication when virtually connecting which would seem very odd indeed if it were performed to somebody sitting opposite the speaker. In the process of speaking slower, louder, more distinctly, more composedly so as to be heard by the other side, and all the other small and subconscious adjustments which we make to get our message across to the other side, we are in fact abstracting and codifying more than would two people sharing some gossip over a cup of coffee. However, as we perfect three-dimensional technology and the bandwidth of our communications increases, we move closer to the ability to replicate real-life situations in their finer details.

On the other hand, the process of creating value only reaches its true potential if the learning process begins in an area of sufficient information density. This means that the information in the learning cycle is produced in a context of minimum entropy (Boisot, 1995: 188), or data loss. Entropy is likely to hamper the students' ability to effectively complete the problem-solving phase of the SLC, which in turn impacts the students' ability to scaffold their way up the SLC. So evolving in a minimum entropy environment ensures that the accommodation and assimilation processes and ensuing scaffolding are fine grained enough to power the absorption phase that brings the cycle full circle.

We submit that using integrated online learning environments can foster an information-dense (or minimum entropy) environment, which has the potential to stimulate the scaffolding process and the expansion into the zone of proximal development to an extent not achieved by any LMS to date. Given the finer grain analysis that is possible in an information-dense environment, the learners are able to better define the form and contour of what they are observing, and provide

richer categorization of these formed concepts. In other words, starting from an information-dense environment, students are able to move to higher levels codification and abstraction.

AN INTEGRATED PLATFORM FOR VIRTUAL EXCHANGE IN PROBLEM-BASED LEARNING

To create an information-rich virtual learning environment requires, according to Tolsby, Nyvang and Dirckinck-Holmfeld, (2002: 7) 'a conference system in order to establish the basic infrastructure; the content delivery system in order to provide multimedia resources; the groupeware system to enhance group working, and finally, a web-portal in order to tie all the programs together in a presentable interface'. What the authors refer to with 'tie together' is system integration. Markus (2000: 10) defines the concept as follows: 'systems integrations refers to the creation of tighter linkages between different computer-based information systems and databases'. In the examples which we have studied, either by design, cost considerations or for other reasons, the learning environments were not integrated. Conferencing, content delivery and groupware were managed by three separate programmes, each working under its own rules. While this does indeed offer the benefit of immediate up-front cost reduction, especially when one or more of the components are available in open source or free of charge, this atomizes the learning process which is effectively stretched across three, sometimes four platforms. Without integration, transferring information from one platform to the next is a tedious, sometimes difficult exercise, as issues of compatibility and outdated or incorrect information arise. What happens then in these atomised virtual workspaces is a depletion of the information environment, and as the information density lessens, so entropy increases. The learning process as a whole, whilst functional and certainly operating better than in a lecture-based environment, could become sub-optimal as compared with its potential under a virtualized PBL environment.

To remedy this and provide students with an information-dense virtual learning environment which minimizes entropy, we can imagine a fully integrated system in which the information that is produced within the conferencing system is automatically accessible by the content delivery system, which is in turn automatically accessible via the groupware. This can all be done through the portal system which Tolsby, et al. were referring to. There is nothing new about portal systems. What is new, however, is the off-the-shelf availability of fully integrated server and rich-client systems which provide high-definition video, instant messaging, user profiles, availability, calendaring and discussions off a single database of users. This database is also integrated in the word processing application[3], allowing for simultaneous co-authoring of papers, spread sheets and presentations, which are then stored and saved in the portal using a 'versioning' system, which means that previous versions of the document are kept by the server. The client software offers the possibility to do all of this at the same time. This can be done on

[3] http://lync.microsoft.com/en-gb/launch/Pages/launch.aspx?SessionID=3

one large screen, or split across several screens (one with video, one with the shared document, another one with the virtual white board, for instance). There is a mobile client for this system[4], which allows users to switch calls from PC to mobile device and vice-versa, and to use all of the communication functions of the desktop client programme. Unfortunately, the number of supported platforms is not very high at the moment, but it will undoubtedly grow. There is nothing revolutionary about the actual functions performed by the system, although they are perhaps done in a more user-friendly and effective way than they were several years ago. However, the integration of the system means that the students can have one centralized point of access to the virtual PBL experience, through which they can effectively problem-solve, scaffold and minimize entropy.

We have been using a recently commercialized system from a large software firm to help us build our models for the purposes of this research, although others will no doubt follow suit and it is by no means the only system which can be used for integrating the virtual PBL environment. Taking the example of the product which we used, we can see how the virtual PBL experience will translate in an integrated and non-integrated environment.

Let us take the hypothetical situation of a business programme that is jointly run between a British and a Singaporean university, using virtual mobility as the means of transaction between the students of both institutions, and PBL as the learning methodology. The students of both groups will register onto the system, completing a 'profile' with their details, photo, and their personal competencies (for instance, marketing, finance, sales etc.) This profile will be saved in the database on the server. In the first instance, the students will be presented with a written problem which will be displayed on the shared screen in the UK and in Singapore via the communication client. The students, being able to see each other on the screen in high definition, will talk through the problem, and use the interactive virtual whiteboard to brainstorm their idea. Either side can edit, drag and drop images and objects onto the board. When they are finished, they can save the session and instant messenger (IM) recordings.

[4] http://lync.microsoft.com/en-gb/launch/Pages/launch.aspx?SessionID=4

FIGURE 4

Snapshot of a review meeting on Lync

In their self-study period, the students will be able to upload notes, documents, recordings, podcasts, videos and any other relevant material to either a portal or shared note-taking site. They will be able to access any resources that the teacher or other students have uploaded, and on each document, they will be able to see the profile of all those who have contributed to the documents, and see whether they are online and available for communication, either by voice or by Instant Messenger. If they edit a document that somebody else has posted, the system will automatically save and label both versions so that data is not accidentally lost. As the tutorials go on and the project moves to a conclusion, the students will need to draft a project report. Both sides will be able to simultaneously access and edit a word processing document, a presentation, a spread sheet or any other format of the commercial suite that comes with this package, accessible straight from the portal site, as well as talk, instant message each other and use the white board. The result can be saved and accessed again later. Students can continue to communicate via the same system on the go with the mobile client, which is important to them ahead of impending deadlines. At the end of the project, the tutor can assess the report, but also the entirety of the group work process by reviewing the session recordings, saved documents and the content of the portal site. At any stage of the process, the students can reach the tutor or the

other students through the communication client, provided that their calendar marks them as being available[5].

Since the platform was originally built for enterprise purposes, some customization to fit the needs of virtual PBL exchange will probably be needed. In particular, functionalities reminiscent of social networking, such as commenting, private messaging, profile linking etc. may be needed to provide the students with a study environment that mirrors their virtual social environment.

This type of integrated environment can also be created fully in house or using open source software. However, this will require a substantial programming effort in terms of integration and user-friendliness. The danger is that if the integration is not done right, the entropy process will continue. The drawbacks of the commercial system are its cost, the customization effort needed to fit an enterprise software to education and issues with its currently limited client software for mobile devices, whether phones or tablet computers.

FURTHER RESEARCH

The system proposed here is a tentative attempt at resolving the problem of virtualizing PBL in the framework of the information space. To the best of our knowledge, this system has not been used for the purpose of virtualized PBL programmes in higher education to date. Empirical research needs to be conducted to test the validity of our hypothesis that integrating all of the components of the virtual learning experience in a unified communications system provides for a more information-rich environment, a more engaging learning experience for the students and results in enhanced codification and abstraction capabilities as the end result of the learning. There are several ways in which this could be tested once the system has been built and run a joint programme between two universities wishing to partake in a virtual PBL exchange. Qualitative research would probably provide the most relevant data. Students would have to be interviewed and the discourse analyzed to reveal patterns of thought and behaviour. Since the system records all online interactions, it would be easy to access the data on the interaction and run it through quantitative and qualitative analysis. There is much opportunity for research in this area. This will be the subject of ensuing research.

CONCLUDING REMARKS

Virtualizing PBL is a major challenge because this type of learning will become increasingly important in a networked world where physical mobility is not always practical and almost

[5] The whole system rests on the Microsoft server architecture. Building on Windows Server 2008 R2 with SQL 2008 R2 as the database application, the core components of the system are a SharePoint 2010 portal with Lync 2010 unified communication interface built on top. The Office 2010 applications, particularly Word, Excel, PowerPoint and OneNote wedge themselves into the two previously mentioned platforms. The entire system comes pre-integrated, but can be customized using .NET programming.

always expensive. The business world already operates under conditions of virtual mobility and it is only natural that education would follow suit. A major challenge facing virtual PBL lies in the current inability of education technology to capture the less structured, flowing process of peer-scaffolding. This challenge is not insurmountable and progress in technology will certainly bring about interesting times for virtual mobility. In this context, it is particularly important to understand the mechanisms underlying the social learning process. By thinking at the cross-roads between technology, education psychology and information theory, education leaders will be well equipped to engage their students in learning that is relevant for the twenty-first century.

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