TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE OF UNIVERSITY PROFESSORS WHO ADOPTED AN ONLINE AUTHORING TOOL IN THEIR EDUCATIONAL PRACTICES

A Case Study of blended Learning Experiences in Health Science Education

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Abstract: This paper is an analysis of cases of university professors' incorporation of information and communication technology (ICT) in their instruction in terms of their expression of their pedagogical, technological and content knowledge. Our analysis is based on semi-structured interviews with nine professors who used a web-based authoring tool to build virtual learning environments (VLEs) to support their classroom courses. Results show that the manner in which professors incorporate ICT in their classrooms is expressed in terms of the specifics of the field of Health and Science education, with regards to the nature of both teaching content and teaching strategy. Thus, much focus was given to the use of resources that enabled visualization of abstract phenomena, the use of primary sources of information, the development of new ways to carry out practical activities, and communication tools that broadened the space for solving cases and problems.

1 INTRODUCTION

Generating tools for easy use on the Internet, like course management systems and authoring tools, has enabled professors in various fields to experience building and publishing their own educational material according to their educational interests, needs, and approaches (Giannella and Struchiner, 2006).

Harris et al (2007) describe teaching as an activity that is strongly dependent on context, covering a wide variety of learning environments, situations, and connections between theory and practice. They suggest that the integration of technology in teaching needs new knowledge in this area. Teachers' great challenge in adopting Information and Communication Technology (ICT) is developing pedagogical creative opportunities to use educational technology based on an integrated knowledge structure for teaching their specific contents (Niess, 2005).

Recent literature in the field of educational technology addresses the need to investigate relationships among different pedagogical, technological, and content knowledge of professors when incorporating ICT in education (Mishra and Koheler, 2005 and 2005, Niess, 2005, Lee and Tsai, 2008). The objective of this study is to present the analysis of a group of nine University Health and Science professors' experiences with ICT in teaching. We focused our analyses especially with respect to professors' content, pedagogical, and technological knowledge involved in the process of adopting innovations in their teaching practices.

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2 THEORETICAL AND METHODOLOGICAL BACKGROUND

The incorporation of ICT in teaching is a complex process that involves the interaction of multiple factors composing each educational scenario. Traditionally, the field of educational technology combined efforts to study technological, pedagogical, social, and institutional factors that influenced the process of incorporating ICT (Moersch, 1995; Hooper & Rieber, 1995; Stoner, 1996; Sherry et al, 2000; Lim and Khine, 2006). Recently, this field has grown wider on account of studies that have emphasized the importance of including context characteristics of each teaching content in order to find effective ways of using ICT (Mishra and Khoeler, 2005; Kanuka, 2006).

Based on their experiences in training professors to use ICT, Mishra and Koehler (2005) observed that the ways in which professors pedagogically used technology were intimately related to the nature of teaching problems faced by each academic discipline, to specific elements of the subject matter, and to the culture of professors' field of knowledge. The authors thus showed that the aspects of pedagogical content knowledge proposed by Schulman (1986) were fundamental for understanding the strategies of ICT utilization adopted by the professors. Based on this, Mishra and Khoeler (2006) proposed a conceptual system of Technological Pedagogical Content Knowledge (TPCK), including technology-related knowledge in the construct previously proposed by Schulman (1986). TPCK thus seeks to express pedagogical, content, and technological knowledge with strategies chosen by professors for the incorporation of ICT in their teaching practices.

Content knowledge (CK) refers to knowledge harnessed for teaching, including the identification of central aspects to the content, concepts, theories, procedures, and methodologies in the academic field as well as knowledge of organizational models. It further involves an understanding of the nature of the field and respective research methodologies. Kennedy (1990) proposes the elements that comprise CK: 1. the content area itself, i.e. the facts, concepts, principles, and laws; 2. the organization and structure of the content, where facts and ideas interact; 3. the research methods in the specific field of knowledge; 4. the field's social norms; 5. how the topic relates to social questions; 6. how students value the topic in their every day life, and 7. the nature of the field and the teaching problems it faces.

Pedagogical knowledge (PK) is the knowledge of teaching processes, practices, and methods, and how these relate to educational values and objectives (Mishra and Khoeler, 2006). It is a knowledge based on epistemological concepts regarding education that include student learning, class management, planning, evaluation, and assessment (Harris et al, 2007).

Technological knowledge (TK) involves the knowledge of information and communication technology to be productively applied in one's work and daily life (Mishra and Khoeler, 2006). Cox (2008) defines TK as the knowledge of ways to use emerging technologies, focusing on the discussion of technology whose use is yet uncommon or infrequent in the learning context.

Pedagogical content knowledge (PCK) is pedagogical knowledge applied to the teaching of a specific content. It refers to an understanding of which approaches, representations, and expressions of pedagogical concepts and strategies best adapt to teaching a particular subject matter, and how to organize topics in such a way as to be better understood. It also includes knowledge of students' prior ideas of the subject matter and knowledge of what makes a topic difficult or easily understandable for students.

Finally, it includes knowledge of teaching strategies that incorporate appropriate representations of content to help overcome student difficulties (Shulman, 1986; Mishra and Khoeler, 2006).

Technological pedagogical content knowledge (TPCK) is an emerging knowledge that goes beyond the sum of the three basic components. Upon reviewing studies referring to TPCK and upon interviewing each study author, Cox (2008) synthesized the definition of TPCK as the knowledge of activities that are specific to a given content or topic, and their representations using technology. Thus, this element refers to the understanding of pedagogical strategies that apply ICT to teach content in different manners according to students' learning needs (Harris et al, 2007).

Recent research has incorporated the concept of TPCK to investigate how and why professors integrate technology into their teaching practices, and where they encounter difficulties in this process (Niess, 2005, Lee and Tsai, 2008, Tondeur et al, 2008). Tondeur et al (2008) analyzed the ways professors' teaching conceptions affected the incorporation of ICT. They related traditional and constructivist teaching approaches to the different types of educational computer use. The results of their study suggest that professors with traditional teaching views generally emphasize guided self-instruction, while those with constructivist views lead to the use of computers as tools for seeking information and for communication. The authors conclude that teaching conceptions strongly influence the ways computers are used in professors' educational contexts. Nevertheless, they also stress that seemingly opposing views are not exclusive and, often, reflections of both conceptions are found within the practices of a single professor.

Niess (2005) used the theoretical bases of TPCK to evaluate the development of in training teachers' use of ICT in the context of Science and Mathematics education. The author investigated teachers' characteristics on the following aspects: 1. conceptions of teaching Science and Mathematics with technology; 2. pedagogic strategies and representations for teaching, using technology; 3. student content learning with technology, and 4. curriculum and curricular materials.

Among the conclusions presented in Niess' research was the predominance of the use of ICT for demonstration and for carrying out laboratory activities, which are traditional practices in Science education.

The TPCK approach is compatible with our perspective about the integration of ICT in education, since we seek to understand ICT use in natural educational contexts, where this knowledge is in play and shapes educational practices.

3 METHODOLOGICAL PROCEDURES

3.1 Study Participants

The study was conducted with nine Science and Health professors at a public university in Rio de Janeiro. They are pioneers in the use of the Constructore authoring tool for the development of virtual learning environments to complement classroom education.

These professors, in general, are PhDs and full professors working exclusively for the university, three of whom work in the Department of Biomedical Engineering, two in the Biophysics Institute, two in the Institute of Psychiatry, one in the Center for Educational Technology for Health, and one in the Institute for Medical Biochemistry.

3.2 Description of the Constructore Authoring Tool

"Constructore" (http://ltc.nutes.ufrj.br/constructore) is an authoring tool developed to provide university professors with resources to easily build, publish, and manage educational activities and/or material on the Internet, without the need of any prior programming knowledge. Constructore was conceived with a flexible structure that allows users to develop activities and materials based on different learning approaches and strategies.

Constructore's interface encompasses three main working areas: 1) The "teacher's space" is a personal management area where the author has different ways of accessing all courses s/he has developed as well as the course development area; 2) The "course creation environment" is where the professor begins authoring the course: (a) defining basic information (name of the course or activity, target students, course outline, etc); (b) identifying the number and name of the course modules, and (c) selecting the resources that will be made available to students (consultation and communication resources, etc); once these initial parameters are defined, users may access the 3) "course environment" (Figure 1), an area that provides facilities for users to built course contents and activities (inserting learning objects, reading and consultation material, and communication resources) on a "what you see is what you get" basis. It is in this environment where the learning process ultimately takes place.

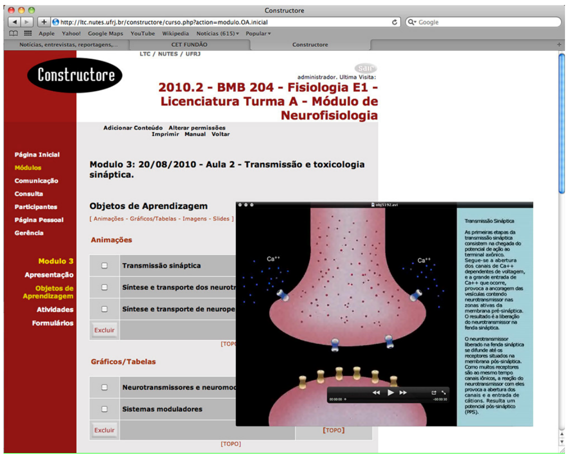

Figure 1: Example of a Constructore based VLE.

Figure 1 shows a typical page of a course environment. Constructore allows for the planning and development of the following elements: the course's front page (a page with the course

Table 1: Categories of analysis and elements analyzed.

Categories	Elements analyzed
Content knowledge	Content knowledge harnessed for teaching, including the identification of professors' main concerns regarding teaching content.
Pedagogical knowledge	Involves professors' teaching views and conceptions of the teaching-learning process.
Technological knowledge	Cases of ICT use and views of its use in the educational context.
Pedagogical content knowledge	Pedagogical strategies that professors considered most adequate to teaching content.
Technological pedagogical content knowledge	Expression of each professor's specific course content with pedagogical opportunities to incorporate ICT and the use of the Constructore tool

presentation), modules (where learning objects, activities, and exercise forms are inserted and organized; a presentation of the objectives, and activities, etc. are offered on each module's initial page), communication (announcements, forums, frequently asked questions, and emails), consultation (glossaries, links, and bibliography), participants (a list of all participants, with access to their personal pages), personal page (user page), and management page (resources for monitoring the course, such as user administration, grades, course navigation, analysis, and usage statistics). Constructore enables available resources to be associated and linked. In other words, the professor is able to indicate the resources that in some way relate to or are associated with others. This can be done with all consultation and communication resources, learning objects, activities, and exercise forms. In addition, another element considered when designing the authoring tool was to provide professors with the choice of defining users (students, tutors, and monitors) permissions to insert and/or to edit content (consultation resources, communication, learning objects, activities and forms).

3.3 Procedure for Collecting and Analyzing Data

In an attempt to understand how different knowledge is expressed and influences the process of incorporating virtual learning environments (VLEs) in teaching, we conducted semi-structured interviews with the nine professors. We collected information on the profile of these professors, their expectations, their views of the teaching-learning process, and the use of ICT; their experience in building and implementing their courses with the support of the Constructore tool, and the strategies they used; their central needs with respect to course content, and the role of technology in their practices.

The interviews were recorded, transcribed, and analyzed using the method of content analysis (Minayo, 2003), using the proposed TPCK categories. In this process we sought to identify which aspects related to content, pedagogy, and technology the professors deemed significant and how these aspects interacted in the context of ICT integration. The elements analyzed within each category are included in Table 1.

4 RESULTS

All participating professors developed their course VLE as a complementary space to provide resources and/or engage students in learning activities (Table 2).

In some cases, the VLE involved mandatory activities, such as the submission of guided studies, uploading notes from weekly readings, reports with problem-solving steps submitted by students, online group work, and discussion forums.

The following describes the results of our analysis of interviews with professors. In this analysis, we attempt to approach the knowledge involved in the use of ICT and subsequently we seek to understand how such is incorporated to comprise TPCK, which served as the bases for the professors' pedagogical online experiences with the use of the Constructore authoring tool.

4.1 Content Knowledge

The professors refer to the content of their courses as extensive, complex, and dynamic. Scientific knowledge is constantly evolving, and many fields involve a high degree of abstraction (P4, P7, P9).

> "The course has such a heavy information load that a class period becomes very short to provide time for student reflexion and discussion." (P3)
>
> "I teach a highly abstract content, which deals with abstract concepts such as molecules and energy, which are really difficult to observe, and therefore to mentally represent." (P9)

Table 2: Description of VLE classes implemented by professors.

Prof	Courses	Course objective and manner in which VLE is used	Target Audience
P1	Curriculum Planning and Teaching in the Health Field	To analyze health from the point of view of integral care; to grasp teaching aspects in the field of Health through the discussion of texts in forums and the preparation of electronic reports with steps for resolving the problem presented	Graduate students in Health
P2	Computational Methods	To provide the bases for basic programming of digital computers with an emphasis on applications in Biomedical Engineering, providing exercises and resource materials for students	Graduate students in Health
P3	Mathematical Methods	To provide the Mathematical bases for Biomedical Engineering by making software files available so that students can do Mathematical modeling exercises	Graduate students in Health
P4	Physiology - Neurophysiology Module	To understand the organization of the nervous system; to analyze neural activities at the different neural-axis levels under a functional-anatomical lens. To facilitate visualization of the organization and functioning of the nervous system by making available different materials in different formats for representing knowledge	Undergraduate students in Physical Education
P5	General Psychopathology	To introduce the field of Psychopathology and to enable the student to use this knowledge as a clinical tool, making leaning resources available, including texts, slides and statements by psychiatric patients	Undergraduate students in Psychology
P6	Special Psychopathology I	To provide a practical and theoretical introduction to the main clinical diagnoses in psychiatry, making psychiatric patient statements available	Undergraduate students in Psychology
P7	General Physiology 1 – Biophysics (Neurophysiology module)	To provide an overall understanding of organization of the nervous system by offering reliable sources that can be consulted with various means of representing the content. To encourage scientific questioning in the field of Neuroscience and to enable a critical view of practical activities	Undergraduate students in Medical Biology
P8	Measuring Biological Phenomena	To impart notions of transductors used in Biomedical instrumentation by offering resources and exercises online to apply the concepts taught	Graduate students in health
P9	Biochemistry M1 – Compementary activities	To offer the student the opportunity to deepen his/her knowledge of metabolic integration through guided online studies based on scientific articles	Undergraduate students in medicine

One recurring issue posed by the professors when delimiting their teaching topics is the need to deepen the content while applying this knowledge in the specific area in which the students will act (P2, P3, P4), given that some students show preconceived notions in terms of course contents (P5) or they consider it extremely difficult to learn (P3, P8).

> "The student starts the course with preconceptions … he believes we will only focus on the biological foundations (basic science versus clinical science)". (P5)

> "I already knew that course contents would be considered by students the most difficult among all semester courses."(P8)

Another concern is the integration of the traditionally fragmented knowledge that comprises the content of their classes (P4, P5, P6, P7, P9). The integration of knowledge is the focus of the classes taught by professors P4, P7, and P9, who teach physiological or biochemical functioning in the body.

4.2 Pedagogical Knowledge

The majority of the professors reported that their pedagogical knowledge was built on the very practice of teaching and from the examples of other teachers, especially academic research advisors with whom they shared a classroom. Professors P1, P3, and P6 were the only professors who participated in institutional teacher-training initiatives, and professor P8 reported dissatisfaction with the lack of teacher training.

In their interviews, the professors spoke both of their concern with the development of students who are critical thinkers (P1, P2, P9), reflective (P9), capable of making autonomous decisions (P9), who value collaborative learning opportunities based on discussions (P1, P5, P6, P7, P9), and the development of a habit of studying (P2, P3, P8) through individualized learning activities (P2, P3, P8).

> "I hope students become able to develop critical sense and autonomy to make decisions, and not to become robots... they need to be critical with regard to new information because the world is changing every second, and they need to be prepared to deal with those changes." (P9)

> "I avoid giving lectures, I adopt study groups, the classroom layout is always a circle. Let's say that it is a dialogical lecture." (P1)

> "The most common students' difficulties are not perceiving and not believing that it is necessary continuing training to be able to computer programming. Working in groups, students have the unreal feelings that they know the contents and are able to complete tasks." (P2)

Some professors valued flexible study hours (P2, P3, P8, P9), respecting student preferences. Moreover, the professors expressed different views of their role in teaching students. Some of the duties highlighted were: provide learning resources (P9), evaluate and assess what students have learned (P3), teach cases and the reasoning and logic in the field (P5, P6, P9), and question learning topics (P1). All professors also considered their role of motivating students an important one.

> "Teach student how to think. It is not necessary that the professor keeps talking and transferring information that can be accessed in a book. The point is that the professor has years of experience and he is able to support student learning in a dynamic way, related with the way things happen in real life." (P6)

> "I would say that my role is to complicate students' minds... " (P1)

4.3 Technological Knowledge

Professors expressed different views and experiences regarding technology. Professors P2, P4, and P8 reported using technology in all areas of their lives, including teaching activities.

Prior to using Constructore, Professor P4 was already adopting a CD-ROM with material in html format, seeking to offer his students information in various formats to facilitate visualization and understanding of how the nervous system functions.

Professors P3, P5, P6, and P7 reported that they use multimedia projector as their primary tool to support their teaching activities; professors P5 and P6 also seek to incorporate the use of audiovisuals in their classes.

Since professor P9 does not feel comfortable using technology for educational purposes, he reported that he used just blackboard, books, and articles in his classes, before adopting Constructore.

In turn, professor P1 expressed his concern with the increased emphasis on technological devices and the decreased focus on professors' pedagogical attributes. We observed that many participating professors consider the Internet to be a familiar language for students (P2, P6, P7, P9), which can serve to motivate student engagement in activities. They emphasized universal access to information (P4, P7) but were concerned with unreliable information and with students merely copying information available online during learning activities (P2, P4, P7, P9).

4.4 Pedagogical Content Knowledge

In general, professors' choices of teaching strategies are focused on contextualizing Science and Health content in students' future professional practice, decreasing the abstraction of basic content and, thus, motivating students to become engaged in activities, as can be noted in the following statement:

> "We tried to select motivating articles. Therefore we used clinical based published articles because students show high expectations on this kind information, as they want to link learning with their future professional practices. They are not interested in knowledge by itself but they are eager to understand knowledge application. " (P9)

The diversification of information sources is a frequent concern in professors' discourse, due to the following factors: lack of uniformity in text books and didactic material (P7); difficulty in visualizing phenomena and representing problems in text format (P2, P4, P8); need to include updated information (P9, P7), and need to bring students closer to patient experiences (P5, P6).

> "In my course, content problems are best represented with sketches, graphics, or circuits … merely using text turns out to be inappropriate." (P8)

> "Some students are afraid of having close contacts with psychiatric patients, so this is also a difficulty." (P5)

According to professors (P1, P7, and P9), scientific articles are used as a source of information to bring students closer to scientific language and to enable constant class content updating. The activities proposed by professors P1 and P9 for their students were based on journal article analysis and interpretations.

Professor P9 develops activities based on the rediscovery method, which consists of focusing important findings in the history of knowledge development in the field. Concerned about the subjective nature of the diagnosis of psychiatric patients, professors P5 and P6 adopted a strategy of discussing clinical cases or vignettes. This strategy seeks to situate students in the field of psychiatry and to demonstrate how professionals in this field view psychological changes, enabling learners to make diagnoses in the future.

> "Case based exercises are supposed to enable students to recognize health problems described in the textbooks."(P6)

The focus of professor P1's course is problem-based learning (PBL) through group discussions, in order to develop students' critical and inquiry skills. According to professor P1, this strategy requires much students' dedication, which represents a challenge for the dynamics of the course.

> "I choose a problematic situation covering all course topics. Then we work together with students to identify these problems. This turns out to be the conceptual part of the course, covering concepts about health, health care, curriculum... the problem ends up taking a much larger space in the course schedule …"(P1)

Those professors whose classes are based on solving problems in Mathematics and Physics use teaching strategies focused on establishing basic content, wherein the students must solve various exercises to better develop their reasoning in the area; the process involves repetition and training. Moreover, these professors look to practical activities, whether in the programming laboratory (P2) or by virtual simulators given the difficulty of conducting real practices at the undergraduate level (P8).

4.5 Technological Pedagogical Content Knowledge

All professors stressed the use of the Constructore tool to facilitate student access to learning resources, with an emphasis on facilitating access to materials in different formats and to the large amount of information needed for their classes.

The need to diversify the formats for representing content led professors to use images and animation to help visualize biological phenomena (P4, P7, P9), to use films and audio recordings to help bring students closer to psychiatric patients' experiences with illness (P5, P6), and to use computer-graphics to represent physics and mathematics concepts (P2, P3, P8). The statement below provides and example of the use of video in one professor's particular experience:

> "Video is a way of bringing the voice of the patient into the classroom without the need to bring the actual patient in." (P5)

Professors P1, P6, and P9 involved students with active information search in texts and in scientific articles available to resolve the problem studied or to answer to clinical case situations presented.

> "I give them a basic text, and the rest they look for on the Internet. They look up these texts, make note cards and upload them (onto the VLE forum). The group leader is responsible for tying these note cards together and preparing the report." (P1)

Understanding the need to involve students in practical scientific activities led professor P8 to use virtual simulators, as he explains in the following statement:

> "We are going to make a virtual thermometer, so how is it that we design a thermometer? How are the signs read? The objective is to transform your PC into an instrument." (P8)

Some professors who used group activities to solve cases and problems sought the help of Constructore to offer an additional space for discussion and interaction (P1, P9).

> "The purpose of using Constructore was primarily to contribute to expanding the space for discussing 'problem based learning' outside the classroom." (P1)

The integration of educational technology was also viewed as enabling greater contact between students and professors, allowing students to feel more supported in the learning process, and to become part of a learning community (P5, P6).

> "I faced a challenge: I have seventy students; how was I going to interact closely with them? One student had the opportunity to bring me a text he had found discussing a pathological issue; the text was uploaded into the course VLE at Constructore, and we discussed it. So, it also allows for absorbing what the students bring to me." (P5)

5 DISCUSSION AND CONCLUSIONS

The analyses of pedagogical aspects, of the nature of teaching concepts, and of experiences and views concerning the use of ICT enable us to contextualize and understand the ways Science and Health professors incorporate ICT in the process of building and implementing VLEs (Niess, 2005, 2006; Mishra and Koheler, 2005; Tondeur et al, 2008).

The concern with bringing scientific content closer to students' reality, as noted in the interviews with all the professors, constantly appears in curricular and methodological proposals for teaching Science, as it also does the involvement of students in research practices (Krajeik, 2002; Laurillard, 2004; DeHaan, 2005; Schank & Cleary, 1995). Based on concrete experiences, students develop their reflexive and abstraction abilities (Kolb, 1984). This is considered to be a crucial procedural step in developing scientific reasoning (DeHaan, 2005).

Professors of subjects with similar content and teaching concepts tend to support ICT in a similar manner. Professors with content based on Physics and Math problems, for example, used teaching strategies to train students through exercises to reinforce basic content and student involvement in practical laboratory classes. The statements by these professors pointed to views of leaning that valued individualized learning and instruction. These professors explored the potential of ICT to make materials and exercises available and to simulate practical activities, which is consistent with other Science and Mathematics professors described by Niess (2005). Another pattern of ICT use was also observed with Physiology and Biochemestry professors. As their teaching needs necessarily including the visualization of phenomena and building student capacity to deal with the rapid growth and constantly updating information in their fields, they have harnessed the potential of ICT to use images, audiovisuals, and scientific articles as sources of information.

Health professors seek an approach to biological, psychological, social, and cultural dimensions from the perspective of integral healthcare (Kell, 2006). Thus, they use pedagogic strategies in which the student is encouraged to reflect and produce knowledge based on practical situations, such as case studies and PBL, which, according to Berbel (1998), emerge from the field of Health education to overcome fragmented and technical-based teaching. These professors used Constructore as a space to discuss problems and to access materials that enable students to have contact with the different dimensions and representations of class content.

Thus, we conclude that the approach to the conceptual system of TPCK can contribute to understanding the different roles attributed to ICT in professors' practices. There are many pedagogical and resource possibilities based on ICT to be explored by Science professors, but they will only be incorporated to the extent that professors develop their technological and pedagogical knowledge in an articulated manner (Espíndola et al 2007, Mishra e Khoeler, 2006). In this sense, the discussion surrounding ICT in education should be focused on the teaching role, investigating the challenges faced by professors in the process of integrating material, and in their needs for continuing education.

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REFERENCES

Berbel, N. A problematização e a aprendizagem baseada em problemas. *Interface - Comunicação, Saúde, Educação*, v. 2, n.2, 1998.

Cox, S. Conceptual Analysis of Technological Pedagogical Content Knowledge. Brigham Young University, Doctorate Thesis, 2008.

Dehaan, R. L. The Impending Revolution in Undergraduate Science Education, *Journal of Science Education and Technology*, 14, 253, 2005.

Espíndola, M. B., Giannella, T. R., Struchiner, M. 2007. Análise de Ambientes Virtuais de Aprendizagem Construídos por Professores Universitários da Área de Ciências e da Saúde. *Anais do VI ENPEC*. Available at: http://www.fae.ufmg.br/abrapec/viempec/

Espíndola, M. B., Giannella, T. R., Struchiner, M. 2008. Inovações no Ensino Superior: Análise das Percepções de Professores que integraram Ambientes Virtuais de Aprendizagem em suas Práticas. *Anais do 13º Congresso da ABED*. Available at: http://www.abed.org.br/congresso2008/trabalhos.asp

Giannella, T.; Ramos, V.; Struchiner, M. Research and Development of "Constructore", a Web Course Authoring Tool: analysis of educational materials developed by science and health graduate students, *22nd ICDE World Conference on Distance Education: Promoting quality in on line, flexible and Distance Education*, 1, p.1-10, 2006.

Harris, J. B.; Mishra, P.; Koehler, M. J. Teachers' Technological Pedagogical Content Knowledge:

Curriculum-based Technology Integration Reframed, Paper presented at AERA, 2007.

Kanuka, H. Instructional Design and eLearning: A discussion of Pedagogical Content Knowledge as a Missing Construct. *The e-Journal of Instructional Science and Technology*, 9, 2006. [online]. Available: http://www.usq.edu.au/electpub/e-jist/docs/vol9_no2/papers/full_papers/kanuka.htm.

Kell, M. C. G. *Integralidade da atenção à saúde. Ministério da Saúde. Secretaria de Assistência à Saúde. Secretaria de Atenção à Saúde.* Departamento de Atenção Básica. Coordenação de Gestão da Atenção Básica. Brasília, 2006. Available at: http:// www.opas.org.br/observatorio/Arquivos/Destaque69.doc

Kennedy, M. Trends and Issues in: Teachers' Subject Matter Knowledge. Trends and Issues. Paper No. 1. *ERIC Clearinghouse on Teacher Education*, Washington, DC, 1990.

Koehler, M. J. & Mishra, P. What Happens When Teachers Design Educational Technology? The Development of Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research*, 32, 131-152, 2005.

Kolb, D. *Experiential learning: experience as the source of learning and development.* Englewood Cliffs, New Jersey: Prentice-Hall, 1984.

Krajcik, J. S. The Value and Challenges of Using Learning Technologies to Support Students in Learning Sciences. *Research in Science Education*, 32, 411-414, 2002.

Laurillard, D. Rethink the Teaching of Science. Holliman, R. & Scalon, E. (Ed). *Mediating Science Learning Through Information and Communications Technology*. London: Routledge Farmer, 27-50, 2004.

Lee, M & Tsai, C. Exploring Teachers' Perceived Self Efficacy and Technological Pedagogical Content Knowledge with Respect to Educational Use of the World Wide Web, *Instructional Science,* DOI 10.1007/s11251-008-9075-4

Lim, C. P & Khine, M. S. Managing Teacher's Barriers to ICT Integration in Singapore Schools. *JII. of Technology and Teacher Education*, 14 (1), 97-125, 2006.

Minayo, M. C. *Pesquisa Social: Teoria, Método e Criatividade*. 22. ed. Rio de Janeiro: Vozes, 2003.

Mishra, P. & Koehler, M. J. Technological Pedagogical Content Knowledge: a framework for teacher knowledge. *Teachers College Report. 108*, 1017-1054, 2006.

Niess, M. L. Preparing Teachers to Teach Science and Mathematics with Technology: Developing a Technology Pedagogical Content Knowledge. *Teaching and Teacher Education*, 21, 509-523, 2005.

Schank, R. C. & Cleary, C. *Engines for Education.* Hillsdale, NJ: Lawrence Erlbaum Associates, 1995.

Shulman, L. S. Those who understand: knowledge growth in teaching. *Educational Researcher*, Washington, 15, 4-14, 1986.

Tondeur, J.; Hermans, R.; van Braak, J.; Valke, M. Exploring the Link Between Teachers' Educational Belief Profiles and Different Types of Computer Use in the Classroom. *Computers in Human Behavior*, 24, 2541-2553, 2008.