PEDAGOGY FOR DESIGNING COLLABORATIVE AND AUTONOMOUS LEARNING TO ACCOMMODATE DIVERSE LEARNERS[1]

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Abstract: Collaborative and autonomous learning is required for accommodating a variety of learners in education and training. The most convenient media for learning are printed materials and mobile phones, but these require a sophisticated instructional strategy, a well-defined framework and procedure for developing high quality learning. Different types of knowledge representations and five developmental stages of concept, metaphor, image, model and proposition for implementing instructional technology are introduced in this paper.

KEYWORDS

instructional design, collaborative learning, autonomous learning, ubiquitous ICT, knowledge creation, empirical approach

1. Introduction

The remarkable development of Information and Communication Technology or ICT forces us to restructure industries and change our way of living. This drastic change ends to produce many unemployed people and NEETs, who are obliged to be in such situations mainly caused by discrepancies between their professional competencies and requirements in the labor market. At the same time, the recent development in ICT enables us to explore an entirely new framework for teaching and learning and to shift from teacher-led to learner-centered instruction which is entirely different from conventional teaching in schools and universities. In spite of such perspectives of changing society, the instruction in well established educational institutions is still teacher-dominated and provided to competent students selected through entrance examinations. Some people working in public education are reluctant or even resistant to reform the conventional educational system which was firmly established in the past century. It is indispensable for us to renew professional competencies to keep our lives more stable and reliable for keeping Quality Of Life or QOL at reasonable level and needed to accommodate people who cannot keep pace with this changing and diversifying society. In such circumstances we have to initiate instructional designs based on personal needs and diversified backgrounds at first, and then proceed to national goals that have been agreed upon through democratic consensus.

Ubiquitous ICT such as mobile phones, Personal Digital Assistants (PDA) and microchips embedded in our surrounding environments enable everyone to learn at any-time and anywhere (Ogata 2004a, 2004b). When we plan to implement ubiquitous ICT in a specific instructional situation, we have to take into account a variety of factors relevant to effective learning for diverse learners. We are expected to apply the abundant scientific findings from past instructional research in designing and implementing instruction, but we often find it difficult to apply previous findings for designing instruction effectively due to diverse learners' needs and interest. We know very little about ubiquitous learning free from teacher-controlled

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instruction and we face difficulties in designing lessons suitable for diverse student populations considering their different academic achievements, intelligence, ages, socio-economic backgrounds and countless other factors. Any instruction in a specific classroom is unique and requires technological experience (Flechsig, 1997). This means that any technological profession requires ample experience and support from colleagues and superiors. Complex problems are not solved merely by applying scientific findings, but require technological know-how based on experience. In many cases while developing a course, several preliminary trials and many revisions must be conducted to achieve satisfactory outcomes. This implies that learners' active learning cannot develop from the mere application of scientific findings, but from intuitive trials and systematic revisions for refining the learning itself. This developmental process requires a systematic procedure for enhancing the professional disciplines involved in collaborative and autonomous learning development.

2. Technological Approach to Collaborative and Autonomous Learning

The scientific and technological approach for producing modern machinery has resulted in the mass production of cheap and convenient goods for daily life as well as large-scale complex undertakings such as aircraft, tankers, high-rise buildings and even space stations. Computers, the Internet and ubiquitous ICT are also modern technological products resulting from the development of information and communication science and technology. Thanks to high technology-based machinery and facilities, we benefit from the convenience of inter-city and international travel, the rapid transference of information on a worldwide scale and the rise of transnational communities. This contrasts strongly with labor-intensive inefficient traditional manufacture, which often requires costly and time-consuming efforts to produce very simple outcomes. Yet with the proliferation of convenient, mass-produced daily necessities, we are losing traditional, high-quality craftworks rich in character.

The same ICT is now being applied to education. Teaching is still a labor-intensive profession, but it is now entering a more innovative stage in our profession toward more learner-driven learning to cope with the great demands of life-long learning, especially in higher education at the professional level. This requires the urgent development of autonomous learning technology that can accommodate a huge number of learners at low rates of tuition or fees and high quality materials to guarantee effective learning outcomes. In this context new instructional technology should maintain the quality and best features of the conventional instruction, while incorporating the innovative features of mobile or ubiquitous learning.

The theory and practice of introducing ICT in education is entirely different from those of ICT itself. While information and communication science have developed efficiently to accelerate the development of ICT, the present state of educational science and technology is not sufficiently developed enough to accommodate new technologies such as ubiquitous ICT in the educational settings rationally and effectively. Ubiquitous ICT can enhance autonomous learning in today's completely teacher-led classrooms as well as independent learning away from educational establishment.

The technological approach is often confused with the scientific approach due to its objective and generalized features when considered by outsiders' observers, but the approaches are entirely different from

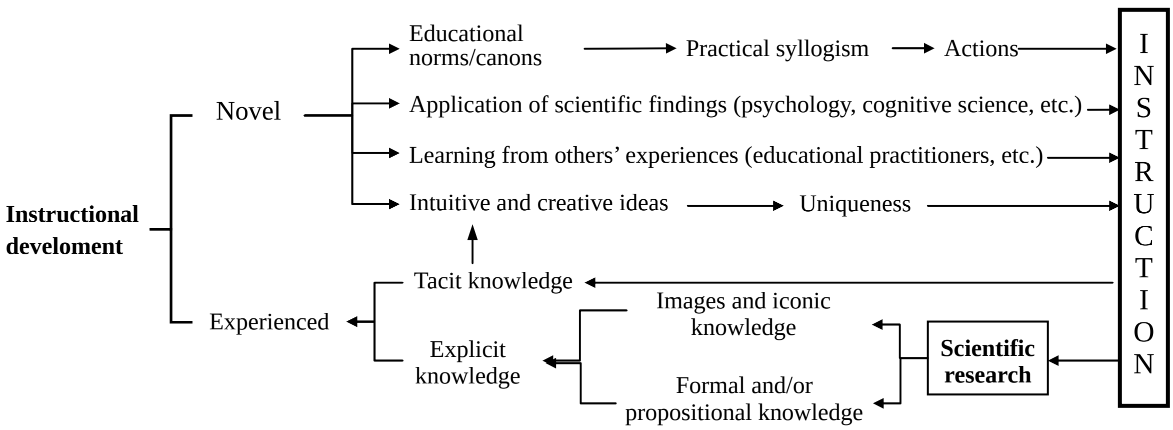


Figure 1 Empirical Approach for Learning Development

the insiders' perspective of implementing procedures to achieve final distinct goals. A scientific approach is adopted in order to clarify one's recognition and to result in new knowledge, while a technological approach emphasizes the importance of subjective prescriptions and prospects, actions to realize them and resulting outcomes. In the latter approach, outcomes should be clarified before or during their adoption and described in visible or tangible form and described in statements of instructional objectives or learning objectives in conventional instructional technology. On the other hand, ubiquitous learning aims to realize a learning process and/or outcomes free from teachers' control and intervention.

Despite such characteristics, ubiquitous learning should be designed to achieve quality learning outcomes and a high level of learning. How can we describe such high quality learning without alluding to instructional objectives? Figure 1 shows four different approaches to design instruction: (1) a traditional and teacher-led instruction approach based on educational norms/canons, or practical syllogistic derivation from educational norms to actions, (2) the application of a scientific findings approach based on psychology, cognitive science and other social sciences, (3) learning from others' experiences by relying on colleagues and elders, and (4) an approach featuring intuitive and creative ideas based on our own experiences and tacit knowledge.

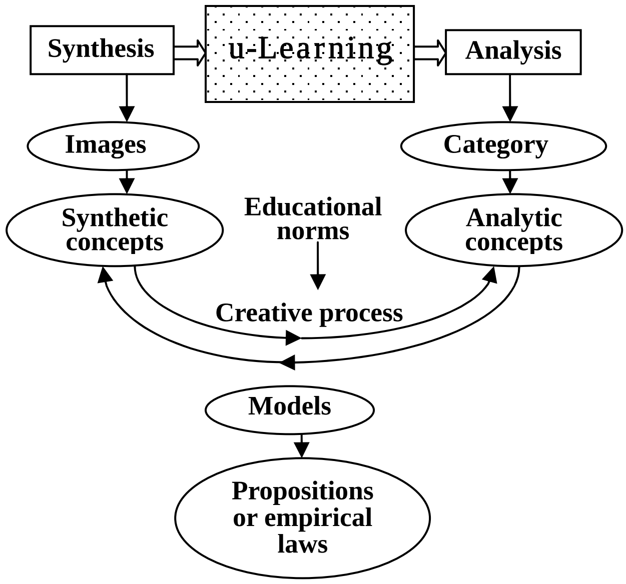


Figure 2 Empirical Research on u-Learning

The major concern in this paper is to develop a research method for formulating explicit knowledge in the forms of figurative and/or iconic representations as well as statements and/or propositions so that this accumulated experience will be easily communicable, systematically revisable and sharable with other experts. Even though four approaches are distinguished here, a comprehensive approach based on creative ideas and genuine procedures is always essential to design appropriate learning suitable to local requirements and personal needs. We must initiate new ideas or breakthroughs and develop them for instruction entirely suitable for unique learning environment and content. Figure 2 shows two possible procedures, one of which derives from synthesis and the other from analysis, to extract concrete knowledge of models and propositions from analyzing actual learning situations, mainly depending on an empirical approach rather than a science-application approach. In this procedure, we must observe the learning behavior, record and analyze it and evaluate the design process to interpret the effectiveness of learning. Novice teachers prefer to start by making images and then refining them into figurative and/or iconic models. In this process, discussion and critiques are essential to improve their initial ideas and clarify feasible plans. On the other hand, experienced teachers are strongly advised to start by analyzing their own teaching. They may be accustomed to teaching via unilateral lecturing and may find it difficult to transform their teaching style from being teacher-dominant to learner-centered instruction. The knowledge that emerges from analysis should relate closely to the synthetic aspects of instructional design, otherwise it will be useless. After several trials, however, these teachers will begin to express recognition about the lessons and describe their empirical laws in the form of statements and judgmental propositions, sometimes after having conducted lessons by themselves. The author makes a greater effort to develop instructional design technology sharable in expertise than to identify information technology applications in education, believing strongly in the potential for fruitful and creative outcomes from collaborative teamwork.

In this framework, a definite presumption is not a required prerequisite regarding instructional design in the initial stage. Instead, a back-and-forth process between synthesis and analysis focuses on learning during its implementation. It starts from intuitive ideas, proceeds relying on empirical knowledge and repeats systematic revisions, from which ideas emerge, from our previous experiences and tacit knowledge.

3. A Case of Problem Solving Approach for u-Learning in Large-size Classes

Before we come to the theoretical framework for implementing u-learning in higher education, we should introduce our trials at Bukkyo University, located in Kyoto, Japan. Present instructional technology starts designing instruction from the standpoint of instructional goals which reflect national policies and an emphasis on nation-wide economic prosperity and success in science and technology. Teachers as well as student teachers tend to adhere to such goals without referring to students' individual needs and requirements. This approach raises complicated issues in our ever-changing and diversifying society. The conventional educational philosophy suggests that small-size classes are preferable and face-to-face interactions are indispensable to maintain quality education and human relationships between teachers and students. Despite such idealistic expectations, however, in practice universities are faced to offer large-size classes in undergraduate courses due to the huge demands for higher education and the high cost of expertise. The framework discussed here does not emerge from theoretical considerations, but from empirical trials repeated for practical implementation of one-semester classes twice a year for the last six years. Adaptation of simple hardware is essential and appropriate for critically effective and inexpensive instruction. In the u-Learning project, we started instruction mainly with printed materials and mobile phones and have tried to work out a premise for autonomous learning suitable to distance learning. Textbook-based instruction helps us focus our efforts critically on instructional design technology for students' active, creative and collaborative involvement in learning. This approach also requires a well-thought-out strategy in order to develop appropriate instructional materials. At the same time, if we start from discussion and communication with peers and fellow instructors in institutions or at remote workplaces, we find that ubiquitous communication devices such as mobile phones, PDA and portable computers are also useful tools to enhance knowledge creation and refinement inside and outside the classroom, even at students' distant homes.

The experimental instruction started in 1999 for an undergraduate course entitled 'Introduction to Instructional Technology' which accommodated 228 students in a large classroom. According to our preliminary survey of their impressions of teaching, students complained about the one-sided lecture style, boring contents and passive learning nature of conventional instruction. After repeated improvements while teaching twice a year for six years, we have achieved far more satisfactory instruction of active participations for our growing number of students (enrollment accounted to 276 for the Spring Semester 2005). At the beginning of the class, we conduct a survey on their self-perceptions of teaching, images of their school experiences and questionnaires on communication types in order to divide them into small teams of five or six members in the second week. Then they start to play ice-breaking games to become familiar with each other. They proceed to teamwork sessions to create proposal about ideal schools and instructional plans to share with other teams during poster sessions. After the interim presentation session, they start working independently, but continue communicating with each other and collaborating to finalize their personal reports to be submitted at the end of the lesson. An aim of this course is to cultivate the collaborative competencies, communication skills and critical thinking needed to tackle complicated problems in contemporary education.

To cultivate critical thinking competence and promote the right to learn among students is a common ground for designing autonomous learning, but it does not necessarily imply any specific method for instructional development. Today is the right time to explore learner-centered instruction for cultivating discussion competence among students and for promoting autonomous learning rather than passive attitudes in the classroom. There already exists extensive literature discussing on instructional development, but it has not persuade us to change our mental models and frameworks, which are deeply embedded in the current instruction. One possible way to change such theoretical rigidity is to start from actual problematic situations and develop a persuasive framework for active learning among students even in large-scale classes. Designing is the creative process of imaging learning events and actualizing them in reality. The instructional development procedure discussed in the following sections emerged from our successive attempts to make this process more flexible and easier to implement.

4. Knowledge for Developing Collaborative and Autonomous Learning

In the coming knowledge society, learners' intentions and autonomous learning capabilities will be key in enhancing the right of learning and to accommodating students' diverse needs. The development of learning technology suitable for autonomous learning at the secondary as well as higher education level is urgently needed to cope with students with diversified academic backgrounds and learning needs. In a Web-based and computer-mediated learning project, most developmental trials start from the implementation of ICT, especially multimedia and broadband technologies in the conventional classroom situation. In this case, the designers' attention and interests tend to focus solely on technology, not on learning itself. If we approach universal education purely from a high technology standpoint, it is almost impossible to overcome the ICT divides faced by economically deprived people. High technology versus low technology approaches are not a dichotomy, but two extremes which should be linked seamlessly for disseminating universal education. In this context, we should take into account the potential of ubiquitous, inexpensive information technology as an important means and take a first step from the standpoint of knowledge creation and problem-solving to overcome technology divide issues. New trials often require entirely new, innovative solutions unfamiliar to our own and others' experiences. Even if we adopt ubiquitous facilities, instructional development should follow a systematic and scientific procedure to make the development more effective and acceptable to other experts in instructional development.

Collaborative teamwork is essential to ensure fruitful and creative outcomes from u-Learning. The Japanese educational system continues to feature harsh competition among candidates aiming to go from elementary to secondary to higher education stages. Their learning heavily deviates towards exam preparation and forced competition with their peers. Collaborative teamwork is not fostered and difficult to realize yet, even at the university level. To overcome such a distorted and dissuasive attitude, five principles are emphasized in classes as an example of educational norms: Autonomous learning, Collaborative work, Contributions to teamwork, Responsibility to the team and Respect for other people. Universal education rather than selective streaming and a smooth articulation between different stages of educational life are urgent issues to be tackled in our rigid schooling system. Ubiquitous ICT and collaborative work are expected to be very effective for solving these problems.

In the conventional procedure of designing instruction, we start from specifying instructional objectives and sequencing them, and then take into account other factors such as teaching materials, teaching environment and teaching tools. In this procedure, instructional objectives are usually derived from the national course of study, developed into a sequence of sub-objectives and actualized in the form of instructional materials. Instructional technologies come on the scene after the selection of instructional objectives and their sequential

Table 1. Types of Knowledge for Developing u-Learning*

	Tacit knowledge	Explicit knowledge		Characteristics of approaches
		Figurative and iconic knowledge	Formal knowledge	
Scientific approach (recognition oriented)	intuition, cognition, images	figurative models, figures and tables, symbols, pictures	numerical formulae, recognition statements, explanatory propositions	universal, reliable, deductive, analytic, systematic
Technological approach (action oriented)	hunch, intuition, empirical laws, proficiency, senses	images, models, figures, tables, symbols, pictures	empirical statements, judgmental propositions	individual unique, physical, inductive, synthetic
Characteristics of knowledge	difficult to express in language empirical intuitive subjective personal emotional and analogical knowledge at the workplace specific to locality, objects, person and time sharable by collaborative work requiring specific experiences; possible to propagate and develop	expressible in figures, symbols, pictures and behaviors; inter-subjective; unique, digitized knowledge transferable through network; reusable, sharable and editable	linguistic knowledge; systematized knowledge; knowledge about the past lexicographical structure for understanding methods, procedures and objects; objective, societal, organizational, rational, theoretical, digitized and encoded knowledge transferable through networks; reusable, sharable and editable	

*This table was developed by NISHINOSONO following the original table by NONAKA and KONNO(1990) development. On the other hand, when we start from learners' needs and learning objectives, we cannot anticipate the instructional process and final learning outcomes at the very beginning of the course. We need to appropriate technologies that will allow us to analyze their needs, assess their relevance to instructional contents and develop a learning environment in parallel to evaluation related to educational goals. Saegusa (1964) suggested there are two interpretations regarding technology in education. One interpretation is that educational technology is a branch of educational expertise similar to educational philosophy, educational psychology, educational sociology and so on. Another interpretation is that it is a technological discipline, just like brewing technology, processing technology, medical technology, nursing technology and many other technologies. The latter interpretation gives us a broader view of technology in education. When we approach it from the perspective of learners' personal needs, the factors under consideration for instructional design are numerous and complex. Fortunately, ICT is a powerful tool to deal with such complex problems and is now applied in almost all disciplines to solve complex problems systematically and to enhance their expertise. We can describe the complexity of learners with a relational database and plan a scheme for future perspectives adapting simulation technology. In this context, we can borrow ideas from other areas of technological expertise.

From the technological perspective, we can conceive four steps -- metaphors, images, models and propositions -- to create an entirely new instructional process for designing autonomous learning. Creative instructional design proceeds from ambiguous images to concrete procedures, to learning materials and to tangible outcomes. Teamwork requires a framework for creating sharable ideas and common outcomes from diversified participants. Common metaphors provide a framework for generating sharable images, allowing us to proceed to the more concrete process of developing learning activities. In developing the course 'Introduction to Instructional Technology' for a large class comprising more than two hundred students, we chose two metaphors as our framework and followed the MACETO model for instructional design and a set of propositions for learning development. The five-stage framework of transferring instructional knowledge and a logo representing five norms for effective team learning are still at the stage of hypothesis and are to be confirmed by further scientific research.

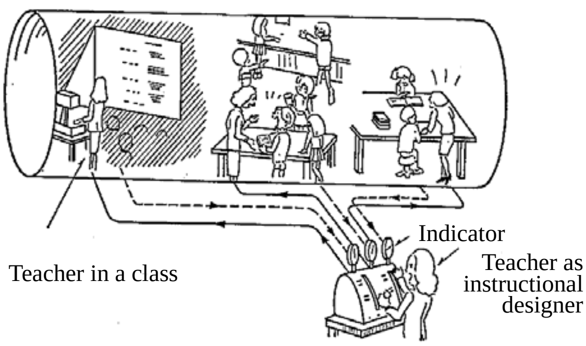
Concept or Aims: Collaborative and autonomous learning for large-size class

Any design requires a final goal for effective procedure from ambiguous expectation to concrete outcomes.

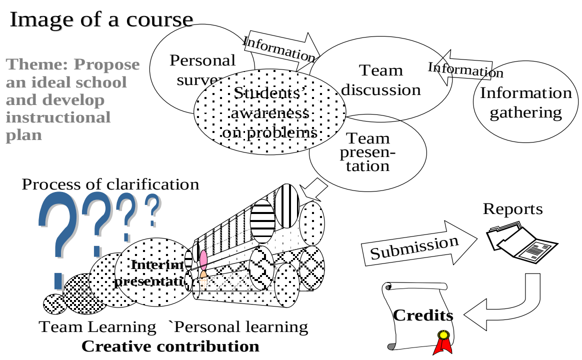
Metaphors: Brewing technology and paragliding technology

Brewing technology depends on biological changes in fermentation and paragliding technology is based on natural laws of aerodynamics and meteorology. These metaphors suggest relatively passive intervention or facilitation in the changing learning process. Despite such passivity, very careful attention to the learning process and scientific knowledge are required to produce effective outcomes.

Images: Images emerge from the metaphors common to instructional designers. We develop many images



(a) Teacher controlling her actions (Nishinosono 1981)



(b) Designing autonomous learning (Nishinosono 2002)

Figure 3 Two Images Showing Gradual Transformation of Instructional Modes

as figurative elements for designing flexible instruction: we show only two of them here. Images make it easier to arrive at a consensus among instructional designers, material producers and teachers. One author (Nishinosono 1978) adopted this approach in the late 1970s at first time and has further developed it since then to clarify internal structures using figurative representation. (see Figure 6)

Models: Models represent more tangible relevant aspects of instruction. The most important model for this instructional design is the MACETO model, which represents meaning (M), actions/activities (A), contents (C), environment (E), tools (T) and outcomes (O). This model consists of two parts: internal conditions and external conditions. Instructional design starts from arranging internal conditions to enable students to learn autonomously. The meaning of learning is of high priority and provides us with an orientation to learning activities as a whole. (see Figure 7)

Hypothesis: If we succeed in arranging learners' internal conditions meaningfully, they can overcome externally difficult conditions and work hard autonomously.

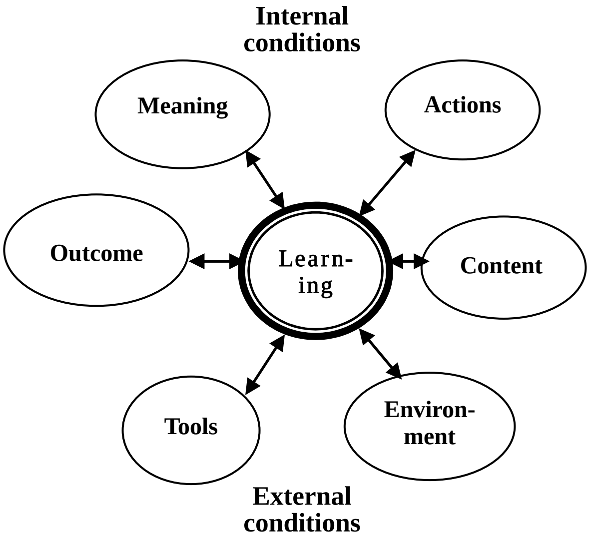


Figure 4 MACETO Model for Instructional

Propositions: Instructional design heavily depends on empirical and tacit knowledge and know-how that is difficult to transmit to other instructors through media. To overcome this difficulty, we must train instructors to express their experience in the form of models and propositions. Only five propositions out of the 65 that emerged from one lesson are listed in Table 2 as examples.

Table 2. Examples of Instructional Propositions (five propositions out of the 65)

- Transformation from image to key concept, graphic presentation and modeling is indispensable but hard for student teachers to achieve. Modeling is much more difficult than the previous step. - Realization of autonomous learning requires cultivating students' heightened attitude towards learning. To cultivate such an attitude, it is effective to require that students complete a framework sheet (MACETO format) each time before they can organize learning by themselves. - Alternative strategies of degrees of freedom in learning: 1. When we increase the degree of freedom in learning and give more initiative to students, learning results in a wide range, from excellent to poor, in quality and quantity. 2. When we decrease the degree of freedom in learning and give less initiative to students, learning results in a reliable but mediocre outcome of both less excellent and less poor quality. - To manage a large group of students who learn autonomously, it is effective to form groups and clusters of groups, encourage active participation and let them recognize their responsibility towards autonomous learning. - To make learning meaningful, it is effective to start the lesson from one's earlier experiences relevant to instructional contents.

In the conventional procedure of instructional design, we start from identifying educational goals, then specify instructional objectives, develop a teaching process, implement instruction and evaluate outcomes. On the other hand, in the case of starting from identifying learners' needs and motivations, we immediately confront complex problems, so we must proceed to clarifying the meaning of learning, assessing learning outcomes, encouraging learning activities, specifying instructional contents and arranging the learning environment. In this circumstance, teachers are expected to develop their professional expertise, deepen their experience and communicate with colleagues and professionals on the Web, even at a distance, in order to enrich their professional competencies. We need to explore a new means of communication to promote effective sharing of their experiences.

Hypothesis: Our experiences with instruction are accumulated tacitly as well as explicitly, of which explicit knowledge can be described in a set of iconic and/or figurative representations and formal propositions to be easily communicated among instructional professionals for enhancing the Right to Learn.

Effective sharing of experiences in practical instruction requires a common framework to conduct research and report the result and other expertise. We start to generate intuitive and creative ideas by referring to the tacit knowledge emerging from our past experience. The concern in this paper is to develop a framework instructional design for a research method for formulating explicit knowledge in the forms of figurative and iconic representations, as well as formal statements and propositions.

5. CONCLUSIONS

Considering the diversified backgrounds of learners, team learning is adopted to accommodate such diversity and to allow all those involved in teamwork to display their different talents and capabilities for collaboration. This kind of instruction requires highly developed technology to design complex learning situations. In the process of developing educational courses, there are four possible approaches for applying a rational procedure for instructional development: practical syllogistic derivation from educational norms to actions, application of scientific findings, learning from other's experiences and refinement of intuitive and creative ideas. Actual instruction is too complex to manage from a single concept. It is impossible to cover the whole process according to only one specific scientific approach. Learning from other designers and practitioners is always very fruitful. At the same time, we often face many entirely unfamiliar situations, but nevertheless have to conduct our instruction. We cannot wait for knowledge to emerge from scientific associations or for information from others' experiences. In many cases in daily teaching, we start from our intuitive ideas and confirm their validity empirically.

The authors started from intuitive and creative ideas referring to tacit knowledge hard to express verbally but certainly embedded in their own experience and the adopted concept of 'education as technology' and they developed a framework of 'metaphor, image, model and proposition'. In the beginning we may express these ideas in the form of metaphor and iconic representations more easily than in strictly logical statements. It was confirmed in the instructional course that young students were quite familiar with expressing their ideas in non-linguistic ways and started expressing their original ideas, discussing the issues and refining them towards final concrete outcomes, or products of instructional materials, models representing the instructional situation, and logical statements and propositions convenient to revise later or to communicate with their peers in written form. In this process, continuing communication and critiques among students through the Web were indispensable to encourage their active involvement. The authors collected their experiences from the abovementioned courses in the form of statements, judgmental propositions or empirical laws.

Education has become too difficult to tackle by teachers working alone. They need to help each other, obtain public support and communicate personally with students, colleagues and local community. ICTs, including ubiquitous equipment, are very powerful tools to facilitate mutual communication and, in this sense, to contribute to a truly universal education. Nevertheless, it requires us to become more imaginative and creative and to develop scientific procedures in pursuit of a rationale for instructional development in our professional discipline. Thanks to recent technological developments in qualitative and quantitative analysis, we can easily investigate the validity and relevance of empirical knowledge during real classroom instruction. For this purpose, we need to develop a scientific procedure to clarify our experiences and refine them to be able to communicate with each other through international networking.

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