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Incremental Prototyping Model for the Development of Educational Platforms: a Process of Design and Quality Standards

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Abstract: Incremental Prototyping Method is an engineering methodology which is presented as appropriate to collect progressive contributions of users and experts of technological solutions that are designed to meet educational challenges. This paper presents the design process that is based on four circuits: theoretical, pedagogical, and technological and management. These circuits involved experts from different disciplines such as; computer engineering, computer science education, graphic design and communication and education. Results show educational platforms which are the result of a recurring review process of the developed technological products and the inclusion of quality standards. That ensures the usability of the product; this means that the product must be coherent and consistent with the educational purpose for which it was initially required.

Keywords: Método Incremental prototype Method, educational platforms, quality standards.
Categories: L.3.6, L.6.0, L.6.1

1 Introduction

Numerous studies indicate that Information and Communication Technologies (ICT) contribute to economic, social development, and to the modernization of the state and its institutions. They also contribute to equity in access to information [Lugo, 10; Hepp, 04, 11]. The use of ICT has been sharply incorporated in school systems during over a decade in school systems. Its impact has generated that traditional learning contexts are complemented by new technologies, especially virtual platforms as *Wandering* [Baraka & ZivVera, 13], *EduXs* [Chang, Yang, Deng & Chan, 03], *CADI* [Cabrera-Lozoya, Cerdan, Cano, Garcia-Sanchez & Lujan, 12] y *The HumBox* [Millarda, Borthwick, Howarda, McSweeneya & Hargooda, 13] which are a set of structures, policies, technical, strategies and learning elements that are integrated into the implementation of the teaching-learning process [Vera & Careaga, 12; Galindres & Garcia, 09].

This publication proposes a framework to fit together the metalanguage and the individual looks with the different disciplines involved in the management processes of educational solutions that are based on the pedagogical use of ICT. The technological development methodology proposed to design and optimize virtual platforms for educational purposes is called Incremental Prototyping Method (IPM). This method consists of applying an engineering design to educational challenges that can be solved by combining face-to-face and online teaching. The first phase is to define the methodological and communicational issues related to education, then the most appropriate technology architecture to improve learning and gradually add the details according the development the different phases proceeds, instances of evaluation and optimization of the prototypes.

In the incremental models of reference, each linear sequence causes an increase in the prototype, which is a product of a portion of the operational system platform development. In the process, the first increase usually becomes an essential product. Key informants who provide relevant information to evaluate and optimize the prototypes may be experts in pedagogy and advance ICT user, and virtual platform users, who initially evaluate the product then the new sequence is iterated repeating phases of analysis, design and development. The process is considered evolutionary because in each cycle of analysis, design and evolution, gradually refine strategic and tactical decisions related to pedagogical and technological factors.

This platform development methodology requires successive stages including at least: implementation, evaluation, optimization and routinization. In these stages, inputs from interdisciplinary teams are coordinated. To do this, the multidisciplinary teams are part of the realization of a set of activities, such as project definition, which covers the problem, analysis and definition; design and specification, implementation incremental prototypes and final product construction. The success of a platform is the development of a thematic content supported by an instructional design, a reliable technology platform that ensures fast access to the system, and a technical support that gives quick and effective solutions [Marquina, 07].

2 Incremental Prototyping Model for the Development of Educational Platforms

The proposed model includes six phases in the design and development of learning platforms which can be applied to learning modalities in mixed contexts and distance learning (*b-learning* or *e-learning*).

The phases are recursive, linking prototypes with pilot programs and stages of expansion and routinization. The processes are recycled depending on the application of quality criteria that enable to optimize permanently pedagogical and technological solutions designed [Shih, Tseng & Yang, 08] and put into action (see Figure 1).

- **Incubation phase:** It is the discussion about the main idea supported by pedagogical requirements. It considers a preliminary analysis that allows us to refine, and include the idea of the four balanced circuits: theoretical, pedagogical, and technological and management.

• **Prototype Phase 1**: It must include the teaching, communicational, educational, and technological and management designs. It also considers sub-phases of evaluation and optimization.
• **Pilot Plan Phase:** This is the main stage where designs are subjected to technological and pedagogical situations in minimum and maximum limits. The idea is to test the operation of the systems and the users in real contexts of performance.
• **Prototype Phase 2:** It consists of an optimized version of the pedagogy, communication, educational, and technological and management designs.
• **Routinizing phase**: It consists in the operating phase over the time, in which the technical teaching system demonstrates its robustness.
• **Expansion Phase:** In this phase, the cycle iterates expanding the extension of pedagogical and technological solution that has been developed and validated.

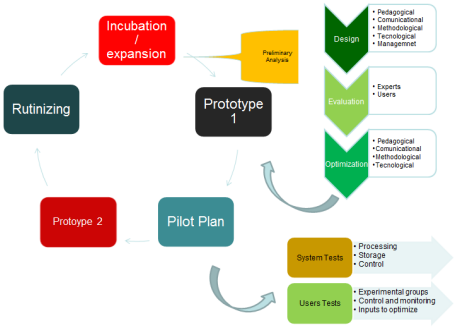

Figure 1: Incremental Prototyping Model for the Development of Educational Platforms [Careaga, 2010]

The design process of the model was based on the balanced and consistent application of the four circuits (see Figure 2). **The Theoretical** is a system of ideas that brings the founding essence of the model, considering key and conceptual issues so that becomes the core idea of the other circuits. **The Pedagogical Circuit** is related to innovation of the curriculum to integrate ICT in teaching practices and includes theories of education and curricular approaches that support their use. In addition, it considers definitions of pedagogical standards as benchmarks for quality accreditation of ICT applications in education. **The Technological circuit** contains aspects of the architecture system, the communicational aspects, hardware and software definitions and standards that ensure the quality, interoperability and scalability of technological solutions applied either blended learning or distance modalities. Finally, **The Management Circuit** is a modeling of the aspects related to economic, curriculum and technology sustainability, on which other circuits operate, so it should include process models, procedures and protocols that enable the functioning of the systems.

3 Quality standards

The applied quality standards were pedagogical and technological. Standards are specific explanatory rules, criteria, descriptive measures, which establish what, can be considered as a quality product. Therefore, to create quality standards is necessary to define qualitative or quantitative indicators that can be objective, specific, quantifiable and measurable. The idea of standardizing involves structuring a battery of pedagogical standards, including indicators that can be contrasted with the experiences of educational practices. These are proposed because there is still an open debate about the definition of pedagogical standards applicable to the curricular integration of ICT. There is a clear trend towards technological focus in Latin American projects related to ICT use in teacher education, even when they declare the subordination of technology to the educational component, in practice [Unesco, 05].

In order to validate educational platforms five categories have been developed for the educational standardization: theoretical Standards, Standards based on pedagogical principles, Methodological standards, Teaching and Evaluative standards.

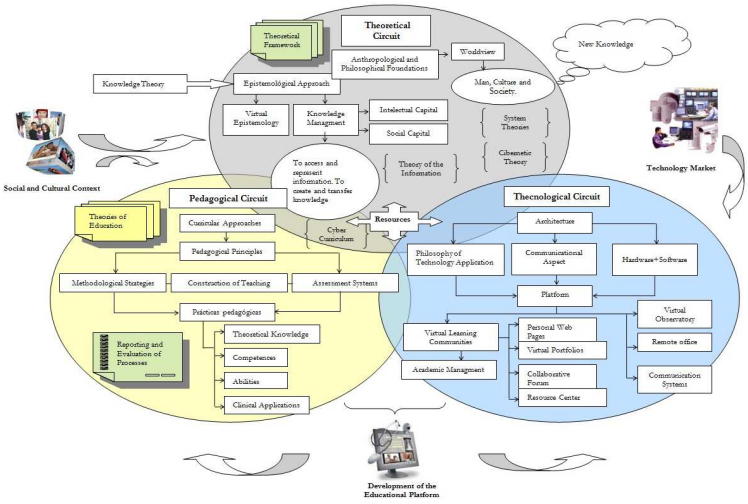

Figure 2: Circuit Model for the Development of Educational Platforms [Avendaño and Careaga, 2006]

Category 1 Theoretical Standards: Systems of ideas that contribute the curricular and pedagogical arguments to programs, courses, units or modules of teacher training with ICT use (see Table 1).

Table 1: Theoretical Standards and Pedagogical indicators

Standards	Indicators
E1.1: To Circumscribe to anthropological-philosophical conceptions.	1.1.1: Consider a profile of teacher education with ICT use based on one or more anthropological-philosophical conceptions (worldview). 1.1.2: Consider one or more views about the role of teachers and their professionalism in society. 1.1.3: Consider one or more views about the role of teachers and their professionalism in culture.
E1.2: To ascribe to theoretical concepts.	1.2.1: Consider one or more theories of education that guide the courseware design and implementation of strategies for improving teaching with ICT use.
E1.3: To define epistemological approach.	1.3.1: Consider one or more theories of knowledge. 1.3.2: Consider notions about knowledge Management.
E1.4: To select curricular notions as guidelines of training.	1.4.1: Select notions of one or more of the curricular approaches: Cognitive, Constructivist, Model based on Skills, Problem Solving Methodology, Contextualized Curriculum, Curriculum flexible and distributed progressive or Cyber Curriculum

Category 2 Standards based on pedagogical principles: Assumptions that guide teaching practices either developed in virtual environment or blended learning contexts. They must be considered to ensure the quality of distance learning (see Table 2).

Table 2: Standards based on pedagogical principles and indicators

Standards	Indicators
E2.1: To define objectives.	2.1.1: Define min and specific objective of the course, unit or module. 2.1.3: Formulate clear and concise learning objectives. 2.1.4: The learning objectives are consistent in relation with the contents. 2.1.5: Users must be aware of the course objective, unit or module to learn what they can get from it.
E2.2: Consider motivational instances that promote learning.	2.2.1: Pedagogical designs include incentives for learning systems. 2.2.2: Include motivational module with positive stimuli. 2.2.3: Establish ways to motivate student's attention based on the importance of content and emotional links. 2.2.4: Considered the request for information and / or complaints for channeling concerns or complaints from users. 2.2.5: During the development of the course are asked users' opinion about the level of satisfaction of their expectations and motivation levels. 2.2.6: During the development of the course, tutor sends content and / or specific exercises to unmotivated users.
E2.3: Ensure consistency of content.	2.3.1: Contents related to learning objectives. 2.3.2: Contents include the implications and complexity of the learning objectives. 2.3.3: Content developed with consistent language in order to achieve the understanding of them.
E2.4: Promote autonomus learning.	2.4.1: Design course, unit or module which is adapted the learning path 2.4.2: Pedagogical design facilitates users to be the principal actors of their learning and learn at their own pace. 2.4.3: The teaching design promotes self-learning. 2.4.4: Users can address the contents flexibly.
E2.5: Encourage educational collaboration.	2.5.1: Promote the idea of creating pedagogical collaboration networks. 2.5.2: Promote the relationship between the development of intellectual Capital and Social Capital. (Knowledge management).

E2.6: Involve learning meanings.	2.6.1: Users construct their own meanings when they are learning. 2.6.2: Users learn to learn alongside their peers, teachers and / or tutors. 2.6.3: Users learn to unlearn in order to build new meanings in their learning processes.
E2.7: Contextualize learning placing them into reality.	2.7.1: The contents are related to the real improvement needs. 2.7.2: Teaching methodologies promote to place the contents in real contexts of personal performance. 2.7.3: The applied methodologies encourage the practical steps to be placed into the educational reality in which teachers work. 2.7.4: Learning occurs when it can be applied or when it is needed.
E2.8: Explore, rehearse and asume the error.	2.8.1: The virtual learning environments encourage and facilitate the exploration of sources of information and allow to experience and / or simulate situations to learn rehearsing 2.8.2: The virtual learning contexts considered potential learning errors and provide useful feedback to achieve effective learning.
E2.9: Diversify the scenarios	2.9.1: There are virtual spaces to publish learning products. 2.9.2: There are collaborative spaces, forums and virtual portfolios.
E2.10: Linking theory and practice.	2.10.1: Contents must allow fluid relationships between concepts-experiences. 2.10.2: Users are exposed to exercise frequently.
E2.11: Contextualize culturally and socially.	2.11.1: The treatment of content considers the cultural context. 2.11.2: The language has universal connotations. 2.11.3: What is taught is current and updated.

Category 3 Standards of methodological principles: Methods that should be applied to solve problems of teaching and learning in virtual environments, including the pre-selection of methods and techniques in order to ensure quality of learning (see Table 3).

Table 3: Standards based on methodological principles and its indicators

Standards	Indicators
E3.1: To have a pilot unit.	3.1.1: The system exposes users to a neutral unit to explore the Virtual learning Environment and simulate their expected performance.
E3.2: To organize work in collaborative teaching contexts	3.2.1: Users have at least one virtual space that supports collaborative work. 3.2.2: The collaborative networking allows interaction among all participating. 3.2.3: Virtual space, available for collaborative work, facilitates communication among users. 3.2.4: Interactivity allows uni-, bi-and multidirectional communication. 3.2.5: The collaborative network promotes links with other users who share similar interests.
E3.3: Horizontalizar la relación pedagógica. E3.3: The pedagogical relationship must be	3.3.1: Users and their tutors have teaching-learning relationships in which they can study, explore, investigate, experiment and practice together. 3.3.2: There are personal virtual portfolios to know the progress and achievements of the users.
E3.4: To define knowledge managers networks.	3.4.1: Users can establish internal and external relations in order to manage information. 3.4.2: Users can access, represent, create and transfer information to contribute with the platform information.
E3.5: To have Tutoring Systems.	3.5.1: The systems offer educational, technological, administrative, personal and group tutoring. 3.5.2: Response times of personalized tutoring not exceed one day. 3.5.3: Tutors must give an answer during a period two days as maximum. 3.5.4: Tutors are able to check the progress of users, compared with peers and accompany learning processes.

E3.6: To organize the Contents.	3.6.1: The contents are structured in increasing difficulty. 3.6.2: All users receive the same package of content and exercises. 3.6.3: Tutors send content and additional exercises according to users' needs.
3.7: To apply communicational designs.	3.7.1: The language used is appropriate and consistent to users. 3.7.2: Users are personalized in communicational mode. 3.7.3: The working groups are identified and differentiated.
E3.8: Users learn by doing.	3.8.1: Users learn performing practical experiences that allow applying the concepts, skills, abilities, skills and / or competencies. 3.8.2: Users are exposed to closed (open= activities that demonstrate their knowledge, skills and / or individual (social) skills.
E3.9: To manage the exposure time.	3.9.1: The e-learning systems require one daily hour of direct exposure in digital platforms as maximum.
E3.10: Report the complexity of the content.	3.10.1: Users are properly informed about the basic, intermediate, advanced or expert level of the course, unit or module that they will take.

Category 4 Teaching Standards: Ways to organize and use learning resources to mediate the knowledge sources with distance learning users, based on the quality of design and users' abilities communication (see Table 4).

Table 4: Teaching Standards and its indicators

Standards	Indicators
E4.1: To ensure the treatment of content.	4.1.1: Contents have an extension that maintains users' interest. 4.1.2: Its implications are not either excessive nor reductionist. 4.1.3: The treatment of content provides comfort to users in the training environment. 4.1.4: The phrases used have a simple and short grammatical structure. 4.1.5: Headings and subheadings are included in longer paragraphs. 4.1.6: Key concepts, to facilitate the reading of the contents, are highlighted. 4.1.7: It facilitates user understanding of words and / or more complex concepts with extra teaching resources. 4.1.8: The presentation of learning resources is according to the level of the users who directs the course, unit or module. 4.1.9: The written text of the resources is subject to the level of the users. 4.1.10: Grammatical errors and spelling errors were avoided. 4.1.11: The system provides surprise teaching resources to avoid monotony in learning. (Sound effects, visual, text -ups, etc.) 4.1.12: The system avoids elements as distracters of the learning.
E4.2: To Structure clear contents.	4.2.1: Over 90% of the contents are understood by users. 4.2.2: Contents are very well-organized in order to understand them easily.
E4.3: To represent the contents.	4.3.1: It has concise content. 4.3.2: There is self-restraint in the treatment of content. 4.3.3: It combines text with illustrative graphics and multimedia resources. 4.3.6: The icons and graphical representations are self-explanatory. 4.3.6: Simulators are used to represent phenomena and processes.
E4.4: Sources of information.	4.4.1: Link content with conventional means when learning experiences are enriched with such uses.
E4.5: Represent content esthetically.	4.5.1: Contents are organized according to aesthetic canons. 4.5.2: Learning objects are designed combining Resources. 4.5.3: Teaching resources can be represented easily.

Category 5 Evaluative standards: Monitoring and measuring methods of teaching and learning practices in virtual learning contexts (see Table 5).

Table 5: Evaluative standards and indicators

Standards	Indicators
E5.1: Evaluative mode.	5.1.1: Defines the application of different evaluative methods such as; quantitative, quantitative mixed, endogenous and / or exogenous.
E5.2: Evaluative strategies for e-learning and / or b-learning.	5.2.1: Define online assessment techniques. 5.2.2: Select and apply software to assess. 5.2.3: Consider modules with diagnostic assessment tools. 5.2.5: Users are grouped according to their levels of previous knowledge. 5.2.6: Consider modules with assessment tools applicable to the teaching-learning and achievement.
E5.3: To define online assessment methodologies.	5.3.1: Includes instructional self explanatory 5.3.2: Consider modules that help to answer the instruments. 5.3.3: Includes automated security systems to ensure the user authentication and prevent spoofing.
E5.4: Assessment.	5.4.1: Includes different kind of assessments such as; theoretical, practical, self-assessments and co-assessment.
E5.5: Automatic systems to process information.	5.5.1: Consider systems that facilitate the management and a package distributed and applied of test. 5.5.2: Consider automatic systems that manage online information and they are able to generate evaluation reports.
E5.6: Feedback Systems.	5.6.1: Users receives information about their achievements, mistakes and results. 5.6.2: Users can comment on the review of their work.

To define the technological standards, it was studied The Comitee AICC Aviation Industry CBT, IEEE Learning Technologies Standards Committee (LTSC), OKI the Open Knowledge Initiative, ARIADNE, ADL SCORM. According to experts, in the next few years, e-learning standards will be focused on the following topics: content repository, internationalization and localization, certification programs, and architecture.

Technology standards for e-learning set up common rules for the used resources on digital platforms that support distance education strategies, have high levels of agreement in both the design content and the types of infrastructure that are used. This convergence is very important to consumers because the products that adhere to these standards will not become obsolete in a short term, protecting investments in such products [Maurer, 04]. The purpose of applying technology standards are interoperability, which aims to achieve optimal levels in the efficient exchange of information between different systems, the accessibility of users, personal preferences, tests, Authoring tools, the language level, the reusability, the conceptual self-restraint that mean self-explanatory and scalability which consists in the power of learning objects to be integrated into more complex structures.

4 Result of Platforms developed by the Model

Through the implementation of the six phases of the IMP in the design and development of educational platforms, for example the application of quality standards, it has been possible to develop various initiatives such as; Inter-University network for collaborative research, the platform for graduate school of the education faculty of the Universidad Católica de la Santísima Concepción and the platform named managers knowledge networks designed for initial teacher training students.

Students can practice their lessons using a mixed pedagogical practice, complementing classroom teaching - mentoring - with virtual teaching - tutoring, linking with students from vulnerable schools and colleges, among others.

4.1 Example 1: Inter-University Network for Collaborative Research

This is an educational platform, whose goal was to provide collaborative virtual workspaces to 46 teachers and 2,077 college students. They belong to a network of 12 Chilean universities. The research was about different ways to manage knowledge in academic networks and the relationships between expectations of use and innovation in university teaching practices [Careaga, 04]. The incremental process of validation of the platform was carried out by experts' opinion and user performance according to qualitative and quantitative research approaches. Reliability was evaluated through internal consistency, with a sample of 380 students through the Kuder-Richardson-20 test which showed high reliability (r = .89).

4.2 Example 2: ICT-ETP Platform

The aim of this platform was to innovate into the Chilean Professional and Technical Education, specifically in the development of a strategy of curricular ICT uses from teaching practices. The idea was to create a network of innovation in teaching and the review of practices to build knowledge about the graduate profiles and performance expectations demanded of the productive world. The sample was of 20 schools in the Bío-Bío region, whose specialties include manufacturing, restaurant and hotel trade, construction, financial and business services, transport and communications.
It can be concluded that, although ICT-ETP Platform is a virtual environment tested, applying the IPM, it is likely to improve in its design to make it more effective to emerging needs. Moreover, it can be greatly improve the curriculum analysis of specialties involved by incorporating input from teachers and students.

4.3 Example 3: Network Knowledge Management Platform and Talent Management in Intercultural Contexts

This educational platform provides educational collaborative networks between pre-services teachers, teachers and students from vulnerable Mapuche schools. The purpose was to establish intercultural dialogue through assignments based on a Knowledge Management Model and the development of individual talents.

5 Conclusions

It can be concluded that the incremental prototyping method is an appropriate development methodology to gather progressive input from users and external evaluators of technology solutions since it enables gradually to improve products, combining engineering development with educational purposes and users' requirements. In the previous examples, a process of validation and integration of contributions was developed in order to ensure the technological and pedagogical effectiveness and robustness of the initiatives. In particular, the inclusion of cultural and contextual aspects focused on the usability of native Chilean students (named

Mapuches) was condicioned. Thus, the development of digital platforms, with educational purposes, constitutes the result of a recurring review process of educational and technological products in order to generate prototypes that meet the quality and usability of the final product.

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