TEACHING PRODUCT DEVELOPMENT THROUGH AN INTERNET SCENARIO: DESCRIPTION OF THE CONCEPT

Sanderson César Macêdo Barbalho
Av. Trabalhador São Carlense, 400
scmb@sc.usp.br

Henrique Rozenfeld
Av. Trabalhador São Carlense, 400
roz@sc.usp.br

Felipe Botta Tarallo
Av. Trabalhador São Carlense, 400
felipetarallo@yahoo.com.br

Artur Gonçalves Filho
Av. Trabalhador São Carlense, 400
agfilho@sc.usp.br

Abstract. A description is made of the concept of an Internet-based product development scenario. This scenario evolved from an engineering teaching method employed since 1997, which is based on the use of active didactic techniques to simulate the design of an ideal product in a fictitious company, with characters that represent typical functions in the development process of a new product. The original scenarios were conceived to be executed through physically attended courses. The new proposal aims to add to the positive results achieved by its predecessor initiatives based on e-learning tools and on the use of educational techniques derived from artificial intelligence, which allow the deficiencies reported by trainees and instructors in evaluations of the courses given under the old concept to be overcome. The article presents the original concept of the scenario with its outcomes and limitations, as well as the new concept, the way in which the limitations of the previous scenario are overcome and an application of the new scenario. It is concluded that the new usages given to the elements of the original scenario, associated with available Internet tools and the adoption of the case-based reasoning concept, render the new concept free of the described limitations.

Keywords. *Product development, Internet, Education.*

1. Introduction

The development of a new product (PD) is an intrinsically interdisciplinary activity. Based on the "total design" concept, Pugh (1990) pointed to the need for professionals to be trained with a sufficiently broad vision to see the existing interfaces among the disciplines interacting in the development of a new product. In his opinion, the technical skill taught at engineering schools is no more than "partial design". "Total design" should be taught according to a vision that integrates other sectors of the company. This vision, in engineering, became well-known as Simultaneous Engineering (SE) (Syan, 1994), which can be understood as a philosophy that integrates activities, resources, organizations and strategies under a systemic approach (Rozenfeld et al., 2000).

On the other hand, professionals involved in new product development in a business context rarely have time to take courses to complement their "partial" vision of the activities related to the introduction of a new product in the market (Lima, 2002). This reflects the fact that *time to market* today is one of the main critical factors for the success of new products (Wheelwright and Clark, 1994).

For the product development process of a given company to be effective and integrated without, however, losing out in speed, there is a demand for the introduction of training possibilities that satisfy these two elements: an integrated vision and low availability of time of professionals. This article proposes a PD training concept that utilizes the Internet to implement a corporate education method that has been employed since 1997 and that, according to reports (Mundim, 2002), is highly effective to transmit a global vision of the PDP (product development process), as well as to pass on technical concepts of various functional areas involved in this process. The fact that it was conceived for physically attended application (with the physical presence of trainees) has been an obstacle to the democratization of this concept, as we shall see later herein. Lima (2002) made an initial attempt to implement the concept through distance education techniques, using CD-ROM. The work reported on herein intends to explore the use of e-learning tools to implement the cited method, namely, that of integration scenarios.

The following section describes the teaching method utilized as the starting point for our proposal, focusing on the overall results achieved in its application, as well as on its main limitations. The new concept is then introduced, and a description given of how we intend to attack the limitations imputed to it. Lastly, an application of the concept is presented and final considerations made, with forecasts of future work.

2. Integration scenario

The integration scenario is “a new product development teaching proposal… based on active didactic techniques, in which the participants interact and experience situations in an environment that reproduces the conditions of a real manufacturing company” (Amaral et all, 1999). The basis of the proposal is a structure of concepts and elements that support the planning and execution of the activities utilized to simulate real situations. Figure (1) illustrates the basic concepts of the scenario, divided into planning elements and execution elements. As the name itself indicates, the scenarios use a theater metaphor to plan and execute PDP courses. The planning elements are based on a product development knowledge map, starting from which other elements are constructed, which, together, make up the execution elements that are “designed” in a PDP course. The course is given using a company, a product, characters in an organizational structure and a story that simulates the unfolding of a product development project. The planning elements are called thus because they do not constitute a method or content broached in the course. The users do not have access to the planning elements, but the elements used in carrying out the training are built based on them.

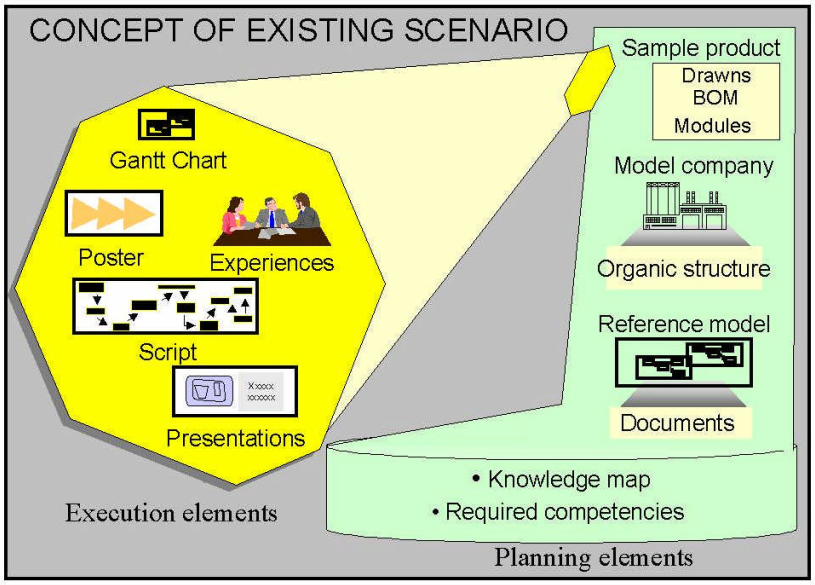

Figure 1. Original concept of the integration scenario.

- **Reference model**: consists of the representation of the macro sequence of development activities or phases of a given product in a company, as well as the information manipulated by those activities (input and output information, templates, etc.) and the methods used by those activities.
- **Sample product**: is a fictitious product resembling a real one that is used to exemplify some of the documents and resources described in the reference model, which serve to make up the script used in a given course. In other words, the specifications, drawings, schemes, modules and other documents used in the courses to represent examples of some results generated during a product’s design are developed based on the definition of the product.
- **Model company**: is a simplified version of a company structure with positions occupied by fictitious characters with responsibilities, who are connected to organizational elements of that company (departments, times, etc.) necessary for the PDP.
- **Knowledge map**: consists of the specification of all the knowledge used in each PD activity.
- **Required competencies**: a subset of knowledge existing on the knowledge map that is considered important for a given application of the scenario.
- **Script**: a simple way of joining all the elements of the scenario into a story about the development of the “sample product” in the “model company” using the “knowledge map” and the “reference model”.
- **Poster**: is an illustrative description of the story through a type of medium that facilitates the assimilation of the holistic vision. In the poster, each act of scene of the script is transformed into a figure that represents the activity related to it and its characters, resources and/or methods. The figures that represent the activities of a given phase are grouped so as to transmit the idea of a sequence of activities without one losing the notion of their iterativeness.
- **Presentations**: are contents taught in depth through the use of *power point* presentations, in which concepts existing on the knowledge map or activities of the reference model considered pertinent for a given course are discussed.
- **Experiences**: consist of group games or activities, whose purpose is to challenge people to solve a problem or stimulate a discussion about some topic considered essential to the course.
- **Support material**: is the didactic material used in the courses and consisting of a description of the activities, showing times and other information, Gant graphs, electronic charts to be used in the activities, etc.

Going back to Fig. (1), one can see that some of the above described elements are used to plan the courses and others to execute them. Starting from an analysis of the "required competencies", the teachers access a knowledge base in order to map the knowledge most necessary for the profile of the public in question. Having mapped this knowledge, it is customized (instantiated) in a "reference model" based on a "sample product" in a "model company" resembling the reality experienced by the group. These elements are then used to plan the "script", the "presentations", the "support material", the "experiences" and the "posters" used in the courses. As mentioned earlier, the planning elements have that name because they are not directly accessible to the users of an integration scenario, but only indirectly through the elements of execution. Thus, in the application of the scenario in a course prepared as described above, the students have access, for instance, to the "sample product" through the activities performed during the "experiences", to examples used by the teachers in the "presentations", to situations described in the "script", and so on.

The original concept of the integration scenario was developed aiming at its application in courses physically attended by students. The following sections give a summary of the results obtained from these courses, as well as the limitations detected by the instructors and reported in evaluations by the students themselves.

2.1. Results and limitations of the scenario

The traditional scenario was applied in ten courses between 1997 and 2003. The courses were composed of "experiences", "script" and "presentations", in quantities that varied according to the public's profile, the available time, the instructors' characteristics and those of the specific objectives of each course. The course participants were basically undergraduate students and a small percentage of graduate students, and mainly professionals involved in product development projects: engineers, managers, designers, etc.

Results

Figure (2) shows the results of these applications of the scenario. Each student answered a course evaluation questionnaire, on which they could attribute a score of 1 to 10 to each element of the scenario. All the 160 students who participated in the courses filled out the questionnaire. The results revealed that the courses were given an average score of 7.7, and Fig. (2) shows that the elements *support material*, *script* and *presentations* were given above average scores, from which it can be concluded that the students found these execution elements more satisfactory than the others. On the other hand, the element *experiences* received a lower score in the scenario, second only to *time and scheduling* and well below the average score of 7.7, suggesting that this item was weaker in the concept's applications.

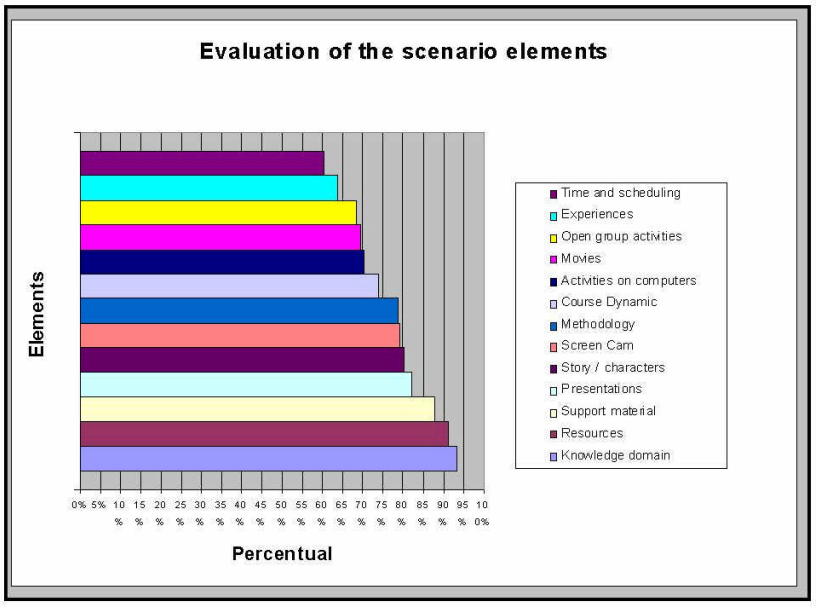

Figure 2. Evaluation of the courses, using the concept of integration scenarios.

The planning elements, in turn, could not be evaluated directly since they were not openly part of the execution of the courses. However, some conclusions can be drawn based on the students' responses to the open questions dealing with the courses' positive aspects. The students listed 31 items considered positive, of which seven items alone encompassed 84% of the satisfaction demonstrated by the courses' public. These items, on a downward scale, were: (1) global vision of the product development process; (2) technical content transmitted; (3) level of concepts; (4) knowledge of the instructors; (5) support material; (6) methodology; (7) script and story. These results suggest that the elements *model of reference*, the *poster* and the *knowledge map* were important for student satisfaction, since the global view (20.3%) and the added content (16.8%) were determined by them. No conclusion could be drawn about the elements *model company* and *sample product* using the collected data, since they are incorporated into the "script".

Limitations

The questionnaires of the first applications were also used to identify the negative items mentioned by the students. The new concept also attempts to deal with these items, which are:

- Large number of activities scheduled within a limited time frame, resulting in exhausting courses;
- Lack of practical examples or use of examples far removed from real situations;
- Deficient application or planning of group activities;
- The way the stories are used leads to passivity on the part of the participants;
- The use of a standard story results in little space for customization of the course to the public's technical profile;
- The quality of the narration of the scripts and the passing on of the large number of concepts relating to the global vision of the PDP are too dependent on the instructor1s experience and knowledge, while it is tiring to have the presence of a single instructor throughout the training course.

In addition to these limitations, the reflections of the concept's creators after the training experiences using the scenarios, systematized in Amaral et all (1999) and in Lima (2002), indicated the following additional limitations:

- The high cost owing to the large number and high qualification of instructors per number of students;
- The proposal is based on the assumption that the courses are physically attended by students, which is a restriction to increasing their scale of use;
- Although they increase learning, the games used also increase the cost of the courses;
- The scripts were built with only one solution to each problem, limiting the possibilities of exploring alternatives, which is a fundamental aspect in the teaching-learning process;
- The costs incurred precluded small and medium sized companies from training their professionals;
- The reproduction of the scenario for undergraduate courses was limited by the construction of the script linked to a given area of engineering;
- The development professionals generally had time limitations in participating in physically attended courses.

As can be seen, the integration scenario satisfactorily fulfills the aforementioned role of passing on the global vision of the activities, knowledge and professional profiles necessary for the design and introduction of a new product into the market. However, it does so at a high financial cost and requires an amount of time not consonant with the average availability of development professionals. As mentioned earlier, the main motivation of the present proposal is to maintain the positive points of the physically attended scenario and add to it the advantages of distance education solutions, as described below. In addition, the use of Internet technology, multimedia and databanks should allow the methodological limitations to be overcome, such as the dependence on instructor knowledge and experience, passivity in experiencing the script, or deficiencies in the application of the experiences.

We will now describe some basic concepts of distance education and e-learning, following with a description of the concept of the new scenario.

3. E-learning

Technological evolution has led to considerable transformations in the area of education. Among these, informatics and the Internet have given rise to a revolution in the way and speed with which people gain access to information, transforming the computer into an important tool for learning and updating of students, teachers and professionals.

According the Rosenberg (2001), the concept of e-learning is based on three fundamental criteria:

1. Online connection, which allows for instantaneous updating, distribution and sharing of instructions and information;
2. Availability of contents to the student via computer, using Internet technology standards;
3. Focus on a broad vision of learning, with solutions that go beyond the traditional training paradigms.

According to Volpato (1999), the advantages for the student with this new approach are:

- Democratization of knowledge due to the easy access to knowledge generating sources;
- Determination of one's own study routine, rendering self-learning flexible;
- Determination of the pace at which knowledge is built, allowing the student to interfere actively in his learning and to determine the exploration of his individual potential;
- Opportunity for personalized assistance;
- Spatial-temporal independence, avoiding displacement from home or work to the place of study; and
- The possibility of learning within the concept of permanent education.

As can be seen, therefore, the use of the e-learning concept is, in itself, a solution for some of the main problems identified in the scenario's old physically attended applications, such as time and displacement limitations for course students (particularly company professionals), poor scheduling of course activities, which render it tiring, and the high costs involved, among others. E-learning, however, should not be understood as a panacea applicable to every teaching-learning situation and method. The specialized literature reports on environmental aspects necessary for the effective implementation of the e-learning concept, as can be seen in Testa (2002). This author, based on nine interviews with specialists and two case studies, identified six critical factors for the success of distance education (DE) programs via the Internet:

- Qualification and experience of the distance education team;
- Involvement of the organization's members;

- Knowledge of and concern with the student's characteristics and behavior;
- Definition of an interaction and collaboration-based pedagogical project, respecting the student's cultural factors;
- Evaluation of the technological and software infrastructure, avoiding the focus from remaining on the technology;
- Establishment of partnerships and strategic alliances.

These elements were used to build a conceptual structure, as well as a strategy of partnerships and the construction methodology of the present proposal. In this sense, several commercial e-learning sites were evaluated based on requisites extracted from the literature, technological partnerships were established that enabled the researchers to focus on the construction of the concept of the new scenario, and the earlier scenarios were carefully evaluated in order to identify aspects from the earlier scenario to be reinforced, reduced, redimensioned or even revised. These studies, however, do not constitute the main objective of this work. The next section contains a detailed description of the new scenario's concept and of how it will use the e-learning potentialities to attack the limitations identified in the evaluations of the physically attended scenarios.

4. Internet-based scenario

The original requisites to implement a new scenario were based on the limitations of the first proposal. Nevertheless, it was necessary to add specific needs that resulted in a new concept and its technological orientation. Hence, two types of research of requisites were done. The first research involved the development of a beta prototype with the scenario's new concept. The second one consisted of an analysis of available e-learning sites, based on which a table of technological requisites for the new proposal was built. This article focuses on the description of the scenario's new concept, which was built taking into account the technological possibilities detected in the analysis of the sites. Future reports will present the description of the requisites, tools and best practices extracted from the analyses of e-learning sites.

4.1. New concept of the scenario

The concept developed for the new scenario was constructed through a prototype that uses Microsoft's *PowerPoint* as a simple tool to generate multimedia titles (Paula Filho, 2000) and supports hyperlinks that can simulate browsing on the Internet. The main elements of the original scenario were analyzed and their use was planned on a new basis. The conclusions were as follows:

- **Reference Model**: in the previous scenario, the reference model was used as the basis to build the script. It was then revised each time a new course (new public) or scenario was developed. That is the reason for the model's classification as a planning element, as mentioned earlier. The new scenario concept has added the reference model as an execution element to enable students to acquire a structured view of the development process. At any point of the new course, the student can access a representation of the reference model that shows him where this point is located in the product development process, as well as its constituent elements.

Thus, the student can see details of the activity executed at that point. On the same screen, he has a vision of the context of the activity and a detailed view of the activities involved in it. In addition, using hyperlinks, it is possible to access views of each level in the *hierarchy of activities* based on the "*function allocation diagram*" (Sheerr, 1999), which is a diagram that shows, in a structured way, the constituent elements of a business process. Another functionality allowed under the reference model item is the easy viewing of the flow of information involved in an activity. With different colors and easy captions, the student can identify sources of and destinations for the information processed in a given activity. Consequently, the scenario's new concept broadens the scope of the reference model, using it as an element for planning (as in the original scenario) and for execution. Figure (3) illustrates the integration of some of the elements of the new concept and provides a view of the representation of one of the scenes of the *script* through the reference model. The activity is identified in a structure of folders and detailed in sub-activities, which are lower levels of a hierarchy of activities, and also in a *function allocation*. The folder structure accompanies the user's browsing sequence. The activity highlighted in a red box is detailed in sub-activities, each of which contains a link to a *function allocation*. The figure presents the representation of a sub-activity so as to permit viewing of a complete representation, with folder structure, a tree of activity levels and *function allocation*, as described above.

- **Script**: the scripts were used in all the activities of a scenario course and were presented in two ways, as mentioned earlier, i.e., in the form of a story and in the form of a poster. Each activity in the reference model was represented as an act or a scene in the script. As mentioned previously, the traditional way the script was used led to passivity on the student's part. The new script is structured differently and its main objectives are to reduce the difficulties of understanding how to browse through the reference model, since an understanding of the model presupposes a certain mastery of the formalism of modeling, and to add the concept of deliverables based on documents to broaden the framework of the scenario, thereby complementing the vision of the PDP reference model. Thus, it is possible to add important concepts from some quite well-known reference models, such as Advanced Product Quality Planning (Automotive Industry Action Group, 1994) and *Project Management Body of Knowledge* (PMI Standards Committee, 1996), which, though not a PDP reference model, has several concepts that are useful along this process. In this proposal, the script simply summarizes each phase of product development, using the original structure, but emphasizes

the activities performed by the characters that are necessary for the generation of the deliverables of each phase, citing characters that carry them out, the forms of organization used for this purpose, etc. Details of the product design and development activities that were formerly in the script are now accessed through the reference model or made available through theoretical contents, as described under the following item.

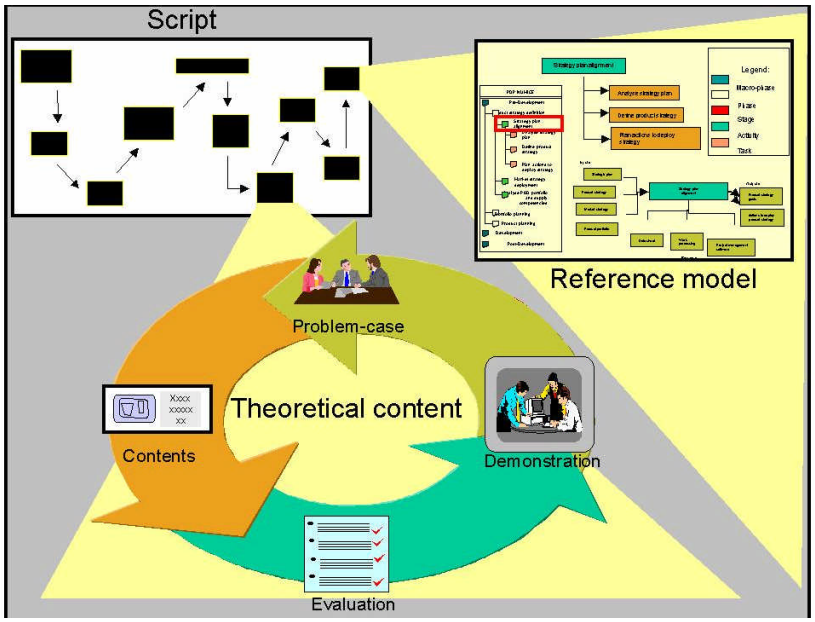

Figure 3 – Example of dynamic of navigation through a scenario course.

Figure (3) shows a basic navigation structure of the user in a course that employs the new concept. The student navigates through the scenes of a fairly brief script. All the scenes allow access to the PDP viewing function through the reference model, as mentioned in the previous topic. In addition, some scenes contain links to theoretical contents, structured as described below. In short, the script has been constructed to maintain the earlier narrative structure, since there is scientific evidence that the use of narrative involving characters improves student assimilation (Serrano, 2002).
- **Theoretical Content**: as mentioned above, the original scenario used presentations, group activities and a narrative script as teaching elements that depended on the public's profile. A given content on the "knowledge map" or activity of the "reference model" was first studied through the script's narrative and then aspects preselected according to the participants' profile were broached in greater depth through presentations or experiences. The new proposal allows the teacher to use articles, books or any digitalized content in undefined quantities. The teacher can customize a study plan according to his teaching objectives. This tool has been dubbed 'self-study sub-function'. Three other types of available content are: a demonstration sub-function of the concept; an analysis sub-function of a problem situation; and an evaluation sub-function, as depicted in Fig. (3). The demonstration sub-function of the concept shows a practical example of the concepts involved using scenes based on a specific script that describes how the "model company" solved a problem that arose during the development of the "sample product", using the new concept. This sub-function has basically the same concept as the script of the original scenario. The analysis of the problem situation sub-function shows the problems relating to the concept and the various alternative solutions the student can choose to solve them. If the alternative chosen is correct and relates to some information technology-based solution, the user can observe a simulation using software that demonstrates the use of the system. If the alternative chosen is incorrect, the user will be asked to choose a correct alternative. Instead of a correct alternative, as in the demonstration, the problem situation offers several possible alternatives, each resulting in a percentage level of performance in relation to a maximum that is established according to the best practices found in the references. The evaluation sub-function consists of questions about the contents studied in the previous ones. The demonstration of the concept and the analysis of the problem situation provide functionalities to replace the "experiences" (present in the original scenario) and to complement the self-study. The differences between demonstrations and problem analyses are related to the student's level of participation in the results of the situation presented to him. The new scenario utilizes the concept of reasoning based on cases, which, according to Kolodner (2000), is founded primarily on the supposition that cases and examples are useful to help solve problems through analogical reasoning. Demonstrations are used to combine a requirement inherent to this approach, which is to show how specialists solve problems.

Whereas the holistic vision in the original scenario was supplied to the student using a script, the new concept allows users access to a global vision of the PDP through both the model and script elements. This procedure allows elements to be added to the representation of the development process, such as the already mentioned deliverables, as well as document templates, best practices, check-lists, and others. These are aspects that, if inserted into a reference model, would render it extremely complex, and if made available in a script, would make it really tiring. Returning to Fig. (3), one can see that it shows a vision that summarizes the use of the reference model, the script and the theoretical

content in the Internet-based scenario. In it, the user begins navigating in the course through the “script” and accesses “theoretical contents” in a specific scene that contains some concept he is interested in. These “theoretical contents” are structured so that the user can navigate among them, using the resources and benefits of hypertexts, as mentioned earlier. Returning to the central “script”, the user may be interested in accessing information about some other scene. If this interest is merely informative, he has the possibility of accessing the reference model, in which information, resources, responsibilities and other aspects relating to the scene are described in a structured form. The correspondence between “script” and “reference model” allows all the scenes to have a related model screen.

- **Community**: the original scenario used the script and the characters as a way of providing a common environment through which the students could interact with each other and with the instructors. The example provided by the scenario was, so to speak, a starting point for discussions about the PDP. The new scenario is based on the e-learning concept, which adopts spaces of participation based on chat-rooms, forums, murals, online teachers and related tools. These tools, however, do not allow groups of students to enter deeper into the learning relation by sharing files, experiences and knowledge, based on a code of ethics defined and accepted by the group (Terra, 2002). The proposed scenario adopts the concept of Internet-mediated communities of knowledge and uses a link with a knowledge management (KM) tool to enable students to establish longer term relations with each other and to build knowledge that can later be incorporated into new courses.

Figure (4) presents the concept of the new scenario. All the elements of the new scenario are in a database used by teachers to compose courses and by students, through computers connected to the Web, to take the courses which they propose to study. The reference model is now also used to carry out training, as stated earlier. Future improvements foresee the integration of the other planning elements in execution time, which will contribute to minimize one of the negative aspects presented earlier: the user’s passivity in the application of the scenario’s courses.

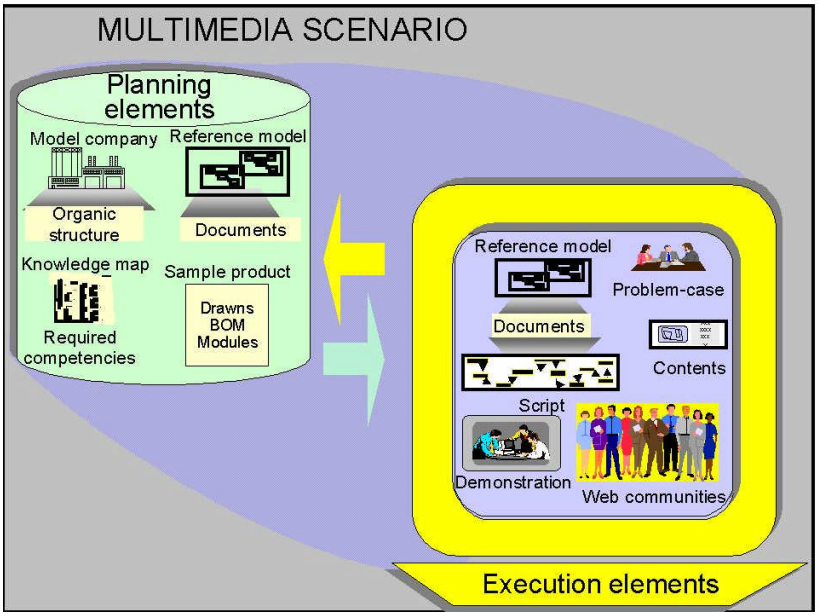

Figure 4 – Concept of new scenario.

4.2. How the new concept reduces the limitations of the first scenario

The limitations identified in the original proposal of the scenario were used as a guide in the development of the new concept. Table (1) lists the limitations presented and the solutions proposed to solve them.

Table 1. Strategies to solve the scenario’s limitations

Limitations	Solutions
High cost of execution	If the student wishes, the scenario can be executed in CBT without the need for instructors or teachers.
The courses require physical attendance	The courses can be taken without the presence of teachers, using only a computer Terminal and the Internet.
The use of games increases learning but also costs	Same as above. In the new scenario, a high level of learning can be achieved at an affordable cost.
The scripts were built with only one solution for each problem presented	The original script was adapted to the new scenario with the function of demonstrating the theoretical content. Additionally, the analysis of problems uses alternative scripts with several solutions, each resulting in a different score for the student, based on the degree of understanding of the best practices reported for that activity.

The high costs precluded small and medium sized companies from training their professionals	The costs incurred in planning the courses are divided among a much larger number of students, resulting in a reduction of the unit cost per student.
The reproduction of the scenario for undergraduate courses was limited by the fact that the script was too specific	The new approach intends to allow the course to be reproduced for different areas of engineering, for which purpose examples of complex systems are used (involving more than one specialty), such as mechanical-electronic products. Moreover, the new scenario allows students to navigate around the content through the reference model, which has a generic character.
Time-related limitations of the course participants	Professionals and undergraduate and post-graduate students can plan their own schedules and study times.
Scheduling of time and activities that render the course tiring	The new proposal does not require the student's present at any given time to carry out the activities, a given content can be visited and its theoretical elements accessed according to the student's interest and time availability.
Lack of practical examples or use of examples far removed from real situations	No educational approach can foresee every possible practical situation for a given content. The new scenario seeks to enable students to create Internet-mediated communities in which they can discuss their experiences and share knowledge. Upon conclusion of a course, the student can create theoretical content, such as demonstrations and problem analyses, using the functions available in the library and make it available to a specific group.
Deficiencies in the application or planning of group activities	One of the main problems in the application of group activities in the original scenario originated from poor time planning. The new proposal does not, in principle, include group activities, which, however, is possible through the use of Internet-mediated communities.
The way in which the stories and scripts are used causes passivity on the part of participants	As mentioned above, students could create their own stories based on their personal experience. Moreover, students can choose appropriate solutions in the problem analysis function and also comment on them in tools such as murals, forums, talk with us, etc.
The quality of the scripts' narrative use and the large number of concepts relating to the global vision of the PDP depend on the instructor's experience and knowledge	The instructors' knowledge and experience will make up the content of the courses and scripts or reference models on the planning level. Therefore, all the courses carried out using such content will be leveled by the best instructor in that specific subject.

Table (1) shows that practically all the limitations of the traditional scenario can be solved or reduced by the new approach. The new scenario has limitations based on a lower level of interaction among students and between them and the teachers than in the physically attended scenario. Moreover, studies on the use of e-learning sites have demonstrated that there are a series of challenges to be overcome for the satisfactory execution of courses on the Web (Testa, 2002). However, the potential improvements provided by the Internet are still considered superior to its deficiency as an educational tool. The next section presents an application of the concept of the new scenario as a way of providing a view of the above-mentioned concepts.

5. Conceptual application of the new scenario

This section describes one of the modules produced in the elaboration of the concept of the new scenario. A general outline is given of the "model company", the "sample product", the organizational context of the "sample product's" development process and, lastly, of one of the passages of the "script", from which theoretical contents are derived about engineering change management (ECM) like defined for Horta (2001).

The part used to exemplify the new scenario takes place in the product and process design phase, when the design and process engineering teams work together to harmonize the product's drawings with the injection mold production process. The elements of the Web scenario are described below, starting from the principle that the user will begin navigating through the script, passing on to a study of the available theoretical content about the theme of engineering change management. This content is made available on the screen regarding the scene that shows the design and process teams working on the MICEOPTO's drawings.

- ***SCENE 37 of the script*** – Revision of the process plan: Mr. Sabino Sequence has finally reviewed the assembly process of the mouse, based on the characteristics of size, weight, volume and specificity of the materials employed. An evaluation of the process tolerances has already been done at this point and an initial version of the programming in CAM and CAPP used at NUMICE and its partners has been developed and validated by the PDT (product development team).

As can be seen, the initial script simply lists important activities of the model. Scene 37, as can be seen in Fig. (5), contains theoretical content focusing on the engineering change management that is made available, which is briefly described below.

- ***ECM – self-study***: involves four texts and tests for each text. In the first two texts, the ECM concept is contextualized using the concept of simultaneous engineering. The first text is part of a master's dissertation containing a historical evolution of simultaneous engineering definitions and the concept adopted by NUMA. The second text describes the main elements of simultaneous engineering, such as methods and applications, systems

utilized, organizational structures that capacitate it, in which the ECM concept is located. The third text consists of an article presented at a congress, presenting the different types of information flows of engineering data. Lastly, the fourth text, extracted from another master's dissertation, describes the activities commonly performed in the implementation of ECM procedures in general.

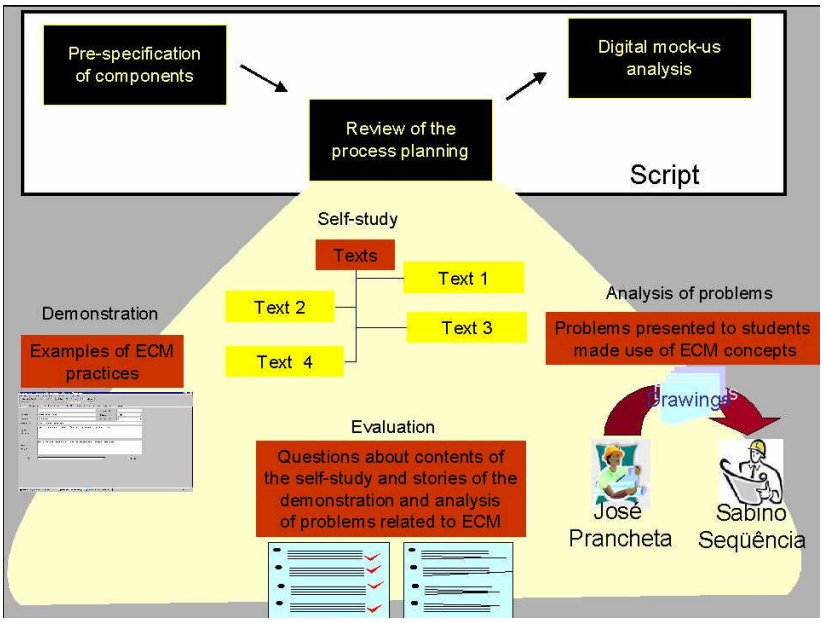

Figure 5 – Example of integration among the elements in a specific content.

- ***ECM – demonstration***: the demonstration tells the story of how the solution was found for a given situation that occurred during the development of the MICEOPTO, which was based explicitly on the ECM concept. The following description briefly describes the situation:
  - During the development of the mouse, Ms. Gláucia Lux, a Miceopto specialist in optic systems, finds that the new lens developed by the company could be employed successfully in NUMICE's new mouse. Ms. Lux talks with NUMICE's designer, Mr. José Prancheta, explaining the need to alter the use of the new lens. Mr. Prancheta tells Ms. Lux that this slight modification can be done rapidly; however, according to the company rules, any alteration in design must be previously approved by the PDT. Using his e-mail system, Mr. Prancheta accesses Colabora, a support system for NUMICE's engineering change workflow and, in the Initial menu, he creates an engineering change request, addressing it to the Workgroup composed of the MICEOPTO project PDT. The subject of the request is "new optic lens technology" and its origin is recorded to monitor the process. The story continues until the PDT reaches a consensus, deciding not to accept the suggestion for the first version of the MICEOPTO and calling the partners for a meeting to sign an agreement to adapt their designs to this new technology in the following versions.
- ***ECM – analysis of problems***: narrates a situation in which the drawings used for the design of the injection mold are inconsistent with the current drawings of the design of the plastic cover of the MICEOPTO. If the student accesses the problem situation after having followed the demonstration and studied the texts, he will be able to make the proper decisions. The following passage summarizes the proposed problem situation:
  - After completing the drawings of the mouse cover, José Prancheta, NUMICE's designer, sends them to process engineer Sabino Sequence, who designed the injection mold and planned the mold's production process in silicon. However, in a meeting of the design team and engineering, it was decided to modify some of the drawings. After altering the drawing, Mr. Prancheta sent a memo to the entire engineering team informing them about the alterations that had been done. For some unknown reason, Mr. Sequence did not receive the memo and therefore did not modify the process plans. This failure was only discovered when the mouse prototypes were being produced with the rapid prototyping mold. The problem analysis continues until the situation created is solved by the development team. For this purpose, the user takes on different roles in each decision to be made. A series of alternatives are presented for each decision, some of them incorrect, others right, but with different score levels.
- ***ECM – evaluation***: the evaluation consists of closed and open questions about the contents presented above. As can be observed, the elements "demonstration" and "problem analysis" are presented in the form of a script with a solved (demonstration) or a proposed situation (problems analysis).

As can be observed, the elements "demonstration" and "problem analysis" are presented in the form of a script with a solved (demonstration) or a proposed situation (problems analysis). The two forms of usage of the script under the new concept were presented in the above example: as the central element responsible for supplying an interesting and

simple to understand flow for the PDP of a generic company focusing on the aforementioned holistic view (in this sense, it can be replaced by the view of PDP through the reference model), which was represented here by the text of scene 37, and as an element used to present situations directed at teaching some PDP concept or activity, according to the texts of the demonstration and the analysis of problems (in this sense, it can be complemented, but not replace, by the reference model).

6. Final considerations

An Internet-based integration scenario was described as a new concept to be utilized in the education of undergraduates, post-graduates and professionals in product development techniques. The development of the new concept was based on the limitations found in the approach used previously, as well as on the potentialities of the Internet as an instrument of corporate education and training. The application of the concept has already begun and its results will be systematized and compared with the statistics of the applications of the original scenario. As explained herein, we hope to attack the limitations of the original scenario with the resources offered by e-learning, as well as by the adoption of new forms of usage of the script and the reference model, in addition to the adoption of case-based reasoning as a planning method for the educational modules.

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