Study on Dynamic e-Learning Environments

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CHAPTER 1

Introduction

1.1 Utilization of information and communication technology in education

Technologies like computers, smartphones and internet are already part of the young students daily life, they use it for many learning tasks, like doing the homework, search information about some topic, share information with other students, communicate with other students, and so on. The application of information and communication technologies (ICT) in education brought many benefits, and also enable various new possibilities to the teaching and learning process.

Technology can be used in education to improve the traditional face-to-face classes, as well as to make possible new types of education like online distant education. In the traditional face-to-face classes, the technologies can be used to allow the teacher to bring multimedia content to the classroom, like videos. Also can be used to create more interactive learning tools like “Snatoms!”, that is a magnetic molecular modeling kit, that allow students to interact and visualize molecules models in chemistry classes.

For online education, technologies can be used to fast distribution of teaching materials through internet. Emails, forums and instant chats can be used to create study groups, or even allowing the creation of communities that help the distant students to surpass the loneliness, or isolation feelings that distant students usually have by being studying alone. These communication features are also extremely important because they allow the students to communicate with the teachers, tutors, and other students, helping them to participate more in the learning process and help one another [1],[2],[3].

The utilization of technology in education can also result in blended learning, bringing together elements of traditional face-to-face education, and online distant education. This can bring benefits like, allow the students to send the homework through the internet to the teacher, creation of online assessments with instant feedback, distribution of additional content through the internet, and online study groups. These features can reduce the need of printed materials, and also the number of face-to-face meeting, reducing the costs of the teaching materials and transportation for students and teachers.

Nowadays, e-Learning systems are one of the most common ways to use technology in education, especially for online distant education, and blended learning. These systems are usually composed by a content management system (CMS), that is used to manage the users, courses, and the teaching materials being used in the courses. There are also communication features like emails, chats, and forums. The teaching materials are edited using the CMS itself or external authoring softwares, and then uploaded to the CMS. However usually these kind of technology is not operated by the teachers, the teachers only make the instructional design of the teaching materials and other content inside the system. The content edition, user support, and system management are usually accomplished by a different technical team.

However there are still problems regarding the utilization of the technology in the educational environments, and the problems can happen in any part of the process from the development to the implementation of an e-Learning project. The problems can also happen for a great variety of reasons, and the reasons can change from one place to another, depending on the local environment situation, users' qualification, users' community culture, and even by governmental laws.

In countries like Brazil the educational system guidelines created by the government requires that distance education projects also have some compulsory face-to-face activities, especially to evaluate the student's performance. This makes e-Learning projects that are completely based on online, or other distant education activities impossible in Brazil. In the Brazilian law it is possible to have online assessments, only if there were also face-to-face evaluation activities, and the face-to-face activities needs to be more important in the student's final grade than the online assessments. Regardless of how good a technology can be, there are still some limitations on how it is allowed to be used in education, to guarantee the efficiency of the course.

“The variety of expertise required to realize a successful online learning project will often include computing professionals, graphic designers, instructional designers, teachers/lecturers and administrators. Many of these individual participants have limited understanding or appreciation of the other disparate fields. This lack of appreciation and understanding reduces the effectiveness of many teams attempting to develop online teaching and learning materials” [4].

The fact that in many cases of e-Learning projects, the educational environment rely on hiring external companies, or groups to provide the technology, and the technical support aggravate the problem. Resulting in an even more distant relation between the technical development and support team and the educational environment. This usually happens due to lack of qualified staff in the institution that want to implement new educational technologies. This distance is a problem because it makes difficult to the development team to understand the real needs of the system users, and the real situation of the teaching and learning process.

One of the most important points in an e-Learning system is the accessibility. How are the users going to access the content and interact with other users when needed? Do the target users have the necessary skills and technologies to access and operate the system? It is important to evaluate these conditions not only on the side of the student users, but also on the side of the teachers and other supporting staff. There is a great number of teachers who are computer novices, who can do simple things like read and send emails, access sites, social network systems, watch video online. However it does not necessary mean that they know how to operate an e-Learning system, specially if they need to create or edit teaching materials for their students [5].

To work with technology in education the teachers need to master the elements present in the Technological Pedagogical Content Knowledge (TPACK) framework, that are the knowledge about the technology that is going to be used, the knowledge about the teaching and learning process, and the knowledge about the subject matter to be learned by the students. However the most difficult part is the fact that the three elements of the TPACK framework exist in a dynamic transactional relationship, and since the educational environment is continuously changing, every time one of these elements change, changes in the other two elements are necessary to keep the equilibrium [6].

Even if continuous training being a well known practice, and a possible good solution to keep the teachers updated and always prepared to the job market, and master the technological pedagogical content knowledge, not everyone is willing to afford new courses to learn more after years of study in the university to become a teacher, and in the current situation most of the teachers have to do this courses parallel to their work. This difficult situation makes great part of the teachers ignore the use of teaching technologies, and accommodate using only the technologies and techniques they learned in the university, to teach what he/she thinks is necessary.

Without the right qualification is difficult to the users to adapt to the changes in the educational environment. Problems can occur in any of the various parts of the process of development and implementation of the e-Learning projects. The distance between the end users and developers in this case, makes difficult to choose the right technologies to be used in the project, and complicate the preparation of the end users for these technologies.

These facts show that universities and other educational institutions still need help to successfully implement educational technologies in its courses. There is still need of research in this area to fully understand the problems, and to find solutions. The implementation of e-Learning projects face difficulties due to the constant changes in the educational environments, constant advent of new technologies, and new teaching and learning techniques regarding the use of the technologies. Also, the learning community is a important part of the educational environment that keeps changing, there are always new students, new teachers that are the users of the educational technology. It is also necessary to find a way to help these users to keep adapting themselves to changes in the environment.

1.2 e-Learning projects' problems and proposed solutions

As previously stated, the educational environment is continuously changing, in other words, it is dynamic. Over the corse of time new students and new teachers became members of the learning community and users of educational technology, also new technologies are developed and became available in the environment. As shown in Figure 1-1, over the time new users and technologies come to educational environments, in the educational environments the technologies are applied as e-Learning based on a infrastructure and a user support to enable the users to use the technology.

The technologies are applied depending on the objectives of the educational environment, varying from educational applications, contextually appropriated content distribution, or interactive contents. The technologies can also be used to create social networks between the users to improve communication. Through the feedback of the users is possible to understand if the technologies are really helping them in the learning process, or if there is some kind of problem.

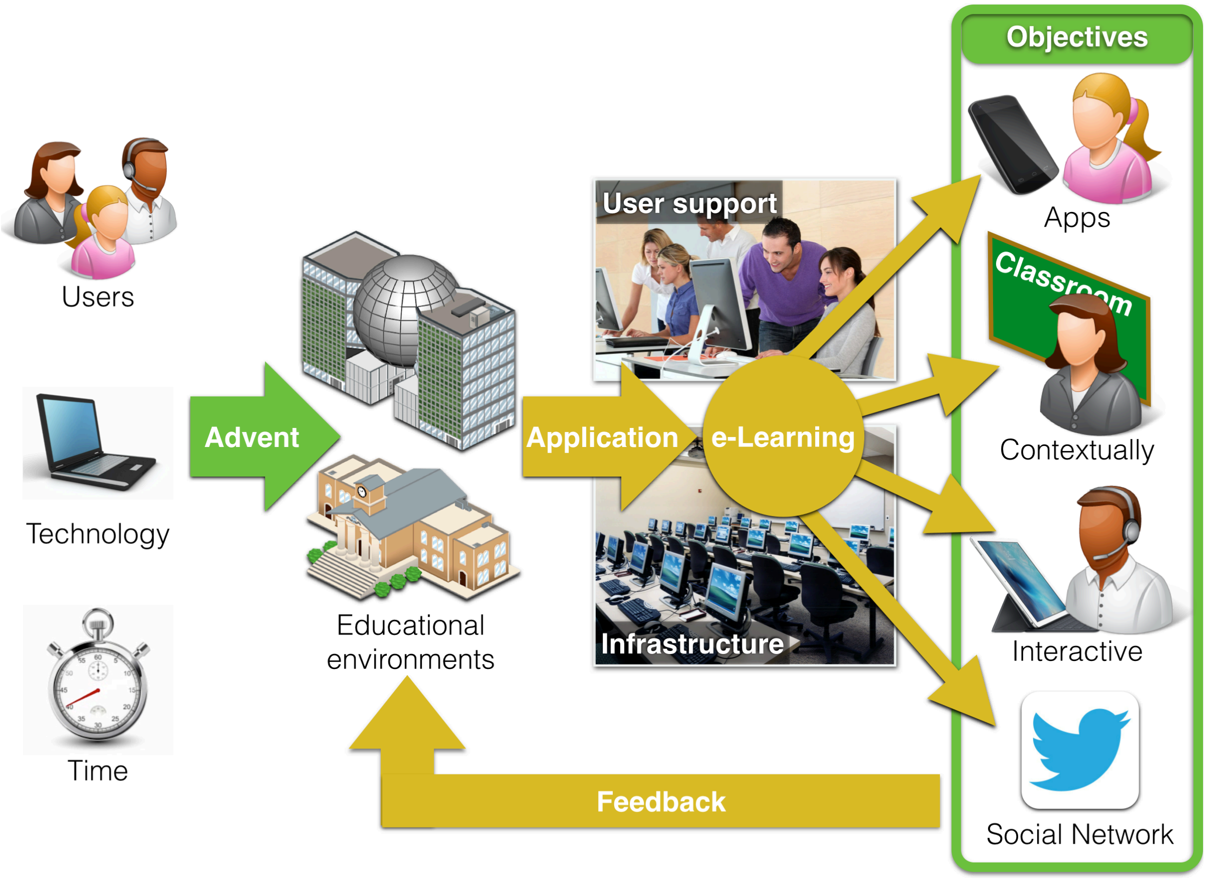

Figure 1-1. Research context.

The development and implementation processes of an e-Learning project are the yellow parts of the diagram in Figure 1-1, it starts from the analysis of the technologies to decide which ones are going to be used, and ends on how the users in fact use the technology. The decision about which technology use and how is really difficult, because it depends on various other factors beyond the technology itself.

The problems of an e-Learning project can start on the choice of the technology to be used in the project. Before choosing the technology, the educational environment experts need to analyze what are the problems, or possible improvements in the teaching and learning process, and how the community is being affected by these problems, and are going to be affected by the improvements. Therefore they are able to determine if the community really needs some kind of change in the teaching and learning process, check if the necessary technology is really available for the educational environment, and if the users can handle, or can be prepared to use the technology [7],[8].

In the case of young students the preparation is usually more simple because, they have more available time, more contact with the technologies in the daily life [9], However in the case of the teachers, the adaptation to new technologies is more difficult, because a great part of them are seeing the technologies for the first time, and the others who already know the technologies probable do not know how to use it for teaching tasks.

The educational environment need to have an infrastructure to provide access the technologies that are expected to be used in the learning tasks. The environment also need to provide user support to users, to help them to learn how to use the technologies for the necessary tasks, and solve technical problems.

The application of the technologies also needs to fits the users culture, in this case, the users learning and teaching styles. If the teacher needs to learn everything about new technologies and how to use it from the scratch, probably is more easy, faster and efficient, if the teachers ignores the new technologies, and continues to use what he/she already knows. Because he/she knows that it works, it was sufficient until now, and there is nothing to be afraid of.

In this case the technology is creating a new barrier to the teaching and learning process, instead of improving it. This problem is common e-Learning projects that are technology driven, in other words, the objective of the project is implement a certain technology regardless it will improve in learning process or not.

If the new technology do not bring an innovation that has a true meaning in the point of view of the user, the user will not adapt it, and the implementation of the e-Learning will fail. There are also problems regarding the utilization of the hardware in the environment space like, for example, a teacher who have the necessary skills to operate a computer and e-Learning applications, cannot be able to use them, because to use it in his class, he/she need to transport the available computer from the warehouse to the classroom, and install it all by himself/herself, but there is no viable time for this process during the class.

This kind of problem could be solved with support strategies like organizing support staff to make this kind of preparations for the teachers, before the class starts. Not only the teacher and the students, but the educational institution needs to be prepared, therefore it can provide the necessary conditions for the utilization of teaching technologies.

During the e-Learning project development, is necessary to create utilization strategies to help the users, like guide lines, therefore the users have a start point to understand what technologies are available, and what they are supposed to do with it. These strategies also can include guidelines to how the user support is going to happen.

Since the educational environment is dynamic, for a e-Learning project to survive the changes that happen over the time, it is necessary to find a way to continuously improve the system, adding new technologies, or substituting old technologies for new ones more appropriated to the face the challenges that appear. However a system that can be adapted to meet the new needs that come with the time, can only be useful of the users can still use it after the adaptation.

Not only the technologies need to be flexible, but the whole e-Learning environment needs to be adaptable. It is also necessary to help the users to follow the changes over the time, finding support strategies that can enable them to adapt themselves to the changes and keep using the system even after it changes.

This research is focused on finding approaches to create e-learning environments, creating a concept that is not dependent on specific technologies; rather focusing choosing flexible technologies based on the needs and objectives of the educational institution; technologies that can be improved or substituted over the time to meet the needs of the continuously changing educational environment.

It is also necessary to understand that the users are part of the environment, and to maintain the environment functional, not only the technology, but the users also need to the able to adapt to the changes including the technologies themselves. In order to survive the e-Learning environment needs to have all of its parts continuously changing together, in other words, it needs to be dynamic.

1.3 Content

The chapter 2 discuss about the research flow, research objective and related works in the field of e-Learning. How other researches and projects tried to create, or implement e-Learning systems, how the users and the learning environments react to these attempts. The concepts and results presented by these research were key factors to the development of the concepts and system designs in this research. The chapter closes with a comparison between the system concept developed in this research and the others, showing the originality and significance of the research.

The research is divided in three main parts, the chapter 3 discuss about the first part, the project Escola de Línguas Online (ELO). It is about the research project that gave start to this research, and also is the origin of the the Dynamic Teaching Materials (DTM) concept. The concept was focused on the problem of teaching materials outdated and out of context for the students. To solve this problem, an e-Learning system was created based on the DTM concept, in order to make the teaching materials dynamic, therefore they could evolve following the continuously changing learning environment needs.

The chapter 4 discuss the second part of the research, the project Skynavi. This part is about the utilization of the DTM in alternative learning environments like science museums, and learning subjects other than foreign language. The DTM concept was used to create an astronomy e-Learning content editing web application. The experiments in the science museum helped to solve several problems, and improve the DTM concept.

Chapter 5 discuss the third and final part of this research. In this part was created the new version of the DTM concept based on the results of the experiments in the first two parts. It shows some big differences from the first version of the concept like, the new concept cover all the e-Learning environment, not only the teaching materials, and is also see the system users as members of a learning community, instead of trying to deal with them as completely separated individuals.

The chapter 6, gives considerations about the research process. Explain the consequences that the research flow caused in the process, the successful, less than successful points, as well as unexpected factor that influenced, the research overall process. Finally, the chapter 7 is a discussion about the research findings, summarizing the problems, what was done to try to solve them, which problems were really solved, which problems remain, new possibilities that were found during the research, and suggestions about what can be done in the future.

CHAPTER 2

Reviewing Different Ways to Apply ICT on Education

2.1 Related researches

2.1.1 e-Learning systems and environments

For clarification, in this dissertation the expression "e-Learning system" refer to the set of hardware and software tools utilized for creation, edition, sharing, and accessing digital teaching materials, as well as the tools utilized by the users to communicate with each other during the learning process. The expression "e-Learning environment" refer to the educational environment where an e-Learning system is used as its main tool, or a support tool to perform the teaching and learning process. When a educational institution decides to create an e-Learning project to use educational technology, especially computer based technology, the institution needs to prepare its infrastructure to deliver the necessary educational technology to the teachers and students, creating the e-Learning environment. If students, or teachers access the system from their houses through the internet, in that case, during learning activities, their houses can also be considered part of the e-Learning environment.

After preparing the e-Learning environment, the set of hardware and software tools that compose the educational technology delivered by the educational institution is the e-Learning system. The set of hardware and software tools can include, but not limited to computers, projectors, text editors, slide editors, image editors, content management systems (CMS). There are many different tools and technologies that can be used to compose an e-Learning system, and many different ways that the e-Learning environment can make these tools and technologies available to the users.

Basically, the difference between the various e-Learning systems and e-Learning environment is which technologies are being used and how they are being used.

Based on the e-Learning research cases analyzed during this research, there is a list of the requirements considered basic for the e-Learning systems and environments that include:

- Users need to have access to computers, or mobile devices.
- User’s devices need to be able to connect to the e-Learning system server.
- The hardware and software technologies expected to be used in the learning process, need to be compatible with the devices the users have access.
- Asynchronous and synchronous communication tools.
- User management.
- Content management.
- Even computer novice users need to be able to learn how to operate the system.

These requirements define what kind of features the e-Learning system needs, also the infrastructure of the e-Learning environment, therefore they are the base of the e-Learning projects design guidelines. The design guidelines also are influenced by the educational objectives of the project, the technologies that are available, as well as users culture, and resources limitations.

The project objectives and available resources may be different in each case, this difference makes difficult the application of one e-Learning model for all kinds of situation, therefore explains existence of many different e-Learning models and tools, that were designed to fit in the unique circumstances of each case, "In four years of online learning a number of different online learning approaches have being tried. Each approach has its positive and negative aspects and appeals to different people”[10]. Even inside the same project, there may be the necessity of using different approaches to reach all the users in a satisfactory level.

Another difference between the e-Learning projects is the features that the projects offer beyond the basic requirements. These features vary with the situations of each project, for example, one project may require the users to know how to operate the necessary tools, before starting to use the system, however that are also projects that have a training support to novice users, to allow them to learn what is necessary as they participate in the project.

2.1.2 Other systems examples

As mentioned previously, the difference between the various e-Learning projects is which technologies they use to achieve the basic requirements, how the technologies are being used, and what features they offer beyond the basic requirements. Here is a list of e-Learning projects that are examples of different ways to use educational technology.

- Project 85321 Systems Administration, Department of Mathematics & Computing at Central Queensland University [11],
- Integrated online learning environment (OLE) [12],
- The acquisition and application of teachers' TPCK using iPad for e-Reading [13],
- Code-embedded mobile assessment (CEMA) [14].

These research projects show how educational technology can be used in many different ways, as well as to achieve different objectives, that can focused on the students, or on the teachers, or both. The technologies can be used not only to directly improve the learning process, but also to help teachers and students to find new and different techniques of teaching and learning, therefore they can uses the techniques that best meet their teaching and learning styles.

The research project realized on the subject 85321 Systems Administration, offered by the Department of Mathematics & Computing, at Central Queensland University, in Australia, was the first part of the research project that originated the OLE, and was held in 1996. This project had the objective to create an online system for distance education. The system was used to distribute the teaching materials, and manage the communications between students and teachers, and also encourage collaborative work between the students divided in small groups.

The project used a collaborative, online teaching method, because teamwork is an important skill necessary for the students in their job marked after finishing the course. The students were organized in groups, and all the teaching materials, including the textbook were developed to be distributed online. This approach was useful to reduce university cost with teaching materials development and distribution, also made the distribution faster. However, the student that wanted a printed copy of the teaching materials, had to pay the print cost themselves, there were also complains about the absence of face-to-face lectures for on campus students, and some problems with the mailing list for the group work. "Early indications are that the 85321 learning approach provides significant advantages over traditional teaching methods. This is especially true for distance education. On-campus students struggled with the new learning approach but this can be attributed to their lack of familiarity with independent learning" [11].

The integrated Online Learning Environment, also created by the Department of Mathematics & Computing, at Central Queensland University, had the objective of create an online learning environment, that used a system with technologies that were easy-to-use and aimed to enable the appropriate use of online learning by all Department units. "There is much more to online learning than converting lecture overheads and unit profiles into HTML and placing them on a server. An integrated online learning environment should provide support for tasks including, but not limited to, assignment submission, automated (self-)assessment, evaluation and both synchronous and asynchronous communication“ [12].

In this case the project also incorporated features for face-to-face classes, not only distance education. There were also staff of the Department that held small researches about internet and the application of ICT to learning at the time of the research. The project was not focused only on the teaching and learning process, but also on the development of other small projects about the technologies that were applied.

During the research, many approaches were used in order to solve problems found in the learning environment and system, some worked as expected and some were less than successful. "Just because an innovation is ‘good’ its successful implementation is not guaranteed. Innovations, particularly those that require significant departures from previous practice, are difficult and require significant effort to guarantee success" [12]. For both, on campus students and distance students, the approaches that were more near to the learning style they had before the project, were more likely to succeed. Distance students were fine with doing group activities and interacting through mailing lists, and the on campus students had preference to online lectures, for example.

The project for the acquisition and application of teachers’ TPCK using iPad for e-Reading held by the National Dong Hwa University, in Taiwan, had the objective of use technology to analyze factors that influence teachers learning about educational technology and how the teacher try to implement technology in his/her work. This project is more focused in using technology to help to understand how teachers work, and based on that try to find approaches to improve the learning process. However the research process also create changes in the teaching approaches by integrating iPads, video recording, and e-Reading activities to the learning process, that also helped the students to review their activities, clarify problems, and find ways to improve their learning skills.

The students could operate the iPad for the e-Reading activities and record videos, even with some problems with the video uploading task, students "expressed an increase in reading efficiency and personal reading interest" [13]. "The present study introduced the instructional site as the context, and used observation and discussion to conduct evidentiary confirmation of TPCK from general knowledge to specific knowledge, yielding more in-depth understanding for the research subjects. If TPCK is to be applied to professional development of teachers incorporating information into instruction, they need more concrete and in-depth understanding of the content and application characteristics of TPCK" [13].

The project CEMA was held in by Department of Information Management, National Formosa University, in Taiwan. The objective of the project was integrate already well known technologies, QR-code and tablet PCs, to improve the e-Learning environment of the Department that was already using Microsoft PowerPoint based teaching materials. The QR-code was integrated to the system to improve the assessment accessibility to the students, automatically check the answers, enable questions feedback, allow students to review questions and browse student's' score ranking. All using an online system accessed by students using tablet PCs.

The developed new assessment method, CEMA, could improve the students learning motivation. The teachers and students can have access to the assessment results immediately, and since the teaching materials and the assessment questions are matched, it is more easy for the student to understand the questions.

Most of the e-Learning projects need to use some kind technology to deliver the necessary features, however sometimes there is also the necessity to create original tools to achieve the necessary needs. Even if there are different project that developed the same kind of original tool, these tool are created to fulfill so specific necessities of their project environment, that is difficult that the same tool could be used in a different project.

2.2 Research overview

2.2.1 Comparing to related research cases

A model is "a simplification or approximation of reality and hence will not reflect all of reality" [15]. The e-Learning projects create models to use technology for education, based on the necessities of a specific time and space, that compound the environment where the project is held. Since the educational environment is continuously changing, the same model suffer the risk of not being successful, if applied in the same place in a different time, or in the same time, but in a different place. This happens because the necessities and problems that the e-Learning project was expected to solve, may not be present in different situations.

All the projects previously listed had to face different necessities, solve different problems, therefore had different objectives. Even comparing the case of the project 85321 and OLE, in the first one the project had only online students of only one lecture as targets, however in the OLE case, the project had to deal with face-to-face lectures too and more lectures from the same department, what created a whole new set of necessities to the project, that the approach, or model used in the project 85321 was not sufficient.

Table 2-1. Comparison between e-Learning environments and systems.

	Project 85321	OLE	TPCK using iPad for e-Reading	CEMA	DTM
Target learners	Online students	Face-to-face and online students	Face-to-face and online students	Face-to-face students	Online and offline teachers and students
Required computer experience level	Advanced	Advanced	Basic	Basic	Basic
System tutorials for users	System tutorials before the course start	System tutorials before the course start	System tutorials along the course	System tutorials before the course start	System tutorials along the course
Development technologies	Perl programming language HTML Usenet Eudora Majordomo Hypermail	Perl programming language HTML Usenet Eudora Majordomo Hypermail	Photocap 6 Facebook	Microsoft Visual Studio 2010, Eclipse, C# programming language, Android 4.0, Asp.Net 4.0, Microsoft SQL server 2008	Moodle Apache Flex Java PHP Mysql
Original tools and features	Hypermedia textbook editor Automatic email management Graphical user interface	Hypermedia textbook editor Automatic email management Graphical user interface	No original tools were necessary	Content management tool and mobile assessment system	Content management, content editing tools Graphical user interface
System operating platform	PC	PC	tablet PC	PC for management Tablet PC for access	PC

The table 2-1 show a comparison of the main characteristics of the four research projects listed above, and also include characteristics of the projects created using the DTM concept. It shows the diversity of the e-Learning environments and systems created in each case.

The project 85321 is a project focused on online learning, supporting a course that has no face-to-face lectures. However the OLE expanded its support to other courses that included face-to-face classes and used internet to distribute the teaching materials. All the other cases compared in the table support online and face-to-face lectures, except in the case of the CEMA that requires online mobile access, but only supports face-to-face lectures.

The TPCK using iPad for e-Reading and DTM are example of e-Learning projects that incorporate teacher training on its main objectives. In these cases the training of the teachers is not faced as a requirement for the teacher to participate the project, instead the teacher training is a constant part of it, and aims to help novice teachers to better understand the education technologies, and learn how to use them. The same infrastructure can be used to train the students as well, therefore reducing the computer experience level required in the beginning of the project to all users.

Most of the projects listed have PC as its main operating platform, the CEMA uses tablet PC for content access, however still using PCs for the management procedures. The TPCK using iPad for e-Reading project uses tablet PCs for all the procedures. The other projects do not support mobile access because these project start before the diffusion of smartphones and tablet PCs in their environments.

The situation of this research environments required solutions for some problems, and had some peculiarities that were not mentioned by any of the other previously listed research cases:

- Difficulties enforced by the education laws in the country.
- Request to use ICT in the curses, came from the students.
- Students refused to use the online system previously offered by the university at that time, due traumatic experiences with that system other disciplines.
- Necessity to faster content creation and update methods.
- Lack of qualified staff for the necessary tasks.

In countries like Brazil, in the laws that establish how the educational processes need to be realized, there are also guidelines for distance education. By these guidelines, projects like the project 85321 and OLE cannot be allowed in Brazil, because the students assessments and final examination are done by distance in these projects, "Systems Administration is learnt by doing. As a result the assessment for 85321 consists of four assignments worth 60% and a final exam worth 40%. In order to speed up assignment turnaround time the submission of assignments was performed using email. An automatic system was used to manage and track the submission of email assignments" [11]. However, the Brazilian law requires some kind of compulsory face-to-face activities and these face-to-face activities have to be more important for the student's grade evaluation than the distance activities [16].

Even if the final exam in the other two projects is done as a face-to-face activities, the online activities still more important in the final grade evaluation, and it goes against the Brazilian law. That kind of situation required DTM concept to be prepared to offer face-to-face activities along with the online features. Features like the ones present in the CEMA project can also be offered, however it cannot be the only way to evaluate the students, the project needs to offer other face-to-face activities to evaluate the student's learning.

Another peculiar aspect of the environment, was the fact that the project itself was idealized and started by the students of the university. Only after some time, it started to be supported by the teachers and became an official project of the Department of Foreign Languages and Translation. It happened because the students were having problems with the teaching materials used in the course, most of all the other alternative teaching materials that they had access were in the internet, or some kind of computer application, therefore they need a way to connect themselves and share what they could found in order to help each other to study.

Students also had problem with the online system that was available in the university before the start of the project ELO, specially because lack communication, management and maintenance problems. These problems added to the lack of qualified university staff for this kind of project, and extensive amount of time spent in bureaucratic procedure in the university was not good for the user experience of the students before the project. Therefore the project also had to reintegrate the students to the online learning.

For this reason, when the research started during the Project ELO, the e-Learning project had two main objectives, offer online learning, and also provide support for face-to-face classes, where the teachers could use the same contents available online. Observing the other researches and e-Learning projects, is possible to conclude that there are many different ways to use ITC to meet the needs of the educational environment and learning community. However the solutions on one project may not be appropriated if applied in a different time or space, because the educational environment is continuously changing.

Basically the solutions proposed by the other cases can be summarized in four main principles. First, analyze the problems and possible improvements that can be done in the educational environment. Second, based on the first analyses choose flexible technologies that can provide the necessary solutions, the technologies need to be flexible to allow the e-Learning system to be adapted to different situations in the environment. Third, create templates or guide lines to help novice users to understand how they can use the available technologies. And the last principle is, the application of the technologies need to fits the users culture, teaching and learning style.

Building the scenario of the Project ELO following this four principles, is possible to say that, we in fact made a first analysis to understand the need of the support for online learning and face-to-face classes, and since the mobile devices like smartphones were not available to the users at that time, support to mobile learning was not necessary for the project at that time. Moodle was chosen as the main technology to build the system, and since the Moodle is an open-source software, it is a flexible technology that can be customized for specific needs of the project.

The two principles are followed without problems, however the other two were not possible, because the Moodle interface were completely different from anything any participant of the project had seen before for teaching or learning, the right type of templates could not be created, because it was impossible to customize the Moodle interface to make it usable during face-to-face classes without making the system looses some other necessary functionality.

In fact it was not possible to find any other system that alone could meet all the four principles. However since the Moodle is an open-source software there is still the possibility of customizing it to be integrated to other systems that have the necessary functions to allow the support to face-to-face classes, and mobile learning in the future.

However there is still the problem of a system that can be adapted to meet the new needs that come with the time, can only be useful of the users can still use it after the adaptation. Not only the technologies need to be flexible, but the whole e-Learning environment needs to be adaptable, including the users. It was necessary to reorganize the e-Learning environment, therefore it could overcome the implementation challenges, and also become dynamic to adapt to future needs that could come over the time.

2.2.2 Originality and significance

The objective of the research became, create an e-Learning environment that allows not only the e-Learning system to be adapted to new needs, but also have infrastructure and support strategies, that allows the users to adapt themselves to the new technologies and functionalities of the system. The creation of a dynamic e-Learning environment.

To achieve that the development team decided to follow the idea of implement a system created using multiple integrated system. Since there is a limit of how much a open-source software can be customized until it starts losing functionality or became unstable, instead of using one big system that is responsible by all the tasks, the development team analyzed the which functionalities were necessary for the environment, and subdivided the system in small parts using different flexible technologies that could be connected and work as one.

The decision of the technologies cannot be done only by relying on the results of past studies about the technologies, because these results may not be appropriated for the current situation of the educational environment, and also may not be related to the teaching and learning process [18]. This analysis needs to be done together with the learning community to guarantee that the chosen technologies are really appropriated to solve the problems in the environment, and are not going to become more barriers instead.

The subdivision of the system, and utilization of the different technologies at same time, allowed the implementation of all the necessary functions to offer support to online learning and faca-to-face classes, however, since the system have more functionalities and use different technologies at the same time, the users need more technical support, and also need to spend more time to master the technologies.

Students and teachers' inability to handle the technology used in the project is one of the main reasons of e-Learning projects failure [17]. To try to avoid this problem, it was also necessary to invest efforts to create strategies to help the users to adapt themselves to the necessary technologies, and also keep them prepared to the advent of new technologies, or other changes in the environment.

Following the ideas of diffusion of innovations and constructivism. It is more easy for people to understand and accept if the information is contextualized, and the changes, or innovations have a real meaning in their lives. The support strategies were not focused in the technical support done by the development team; rather in community learning and knowledge exchange workshops done by the users themselves. Instead of having an expert explaining using technical terms, it is easier for a novice user to understand an advanced user, like a classmate, talking using examples based on the real learning tasks they have during classes. This approach can smooth the initial learning curve for novice students, and since the courses also had face-to-face classes the students could focus on the face-to-face classes, and gradually learn the technologies as needed by the course.

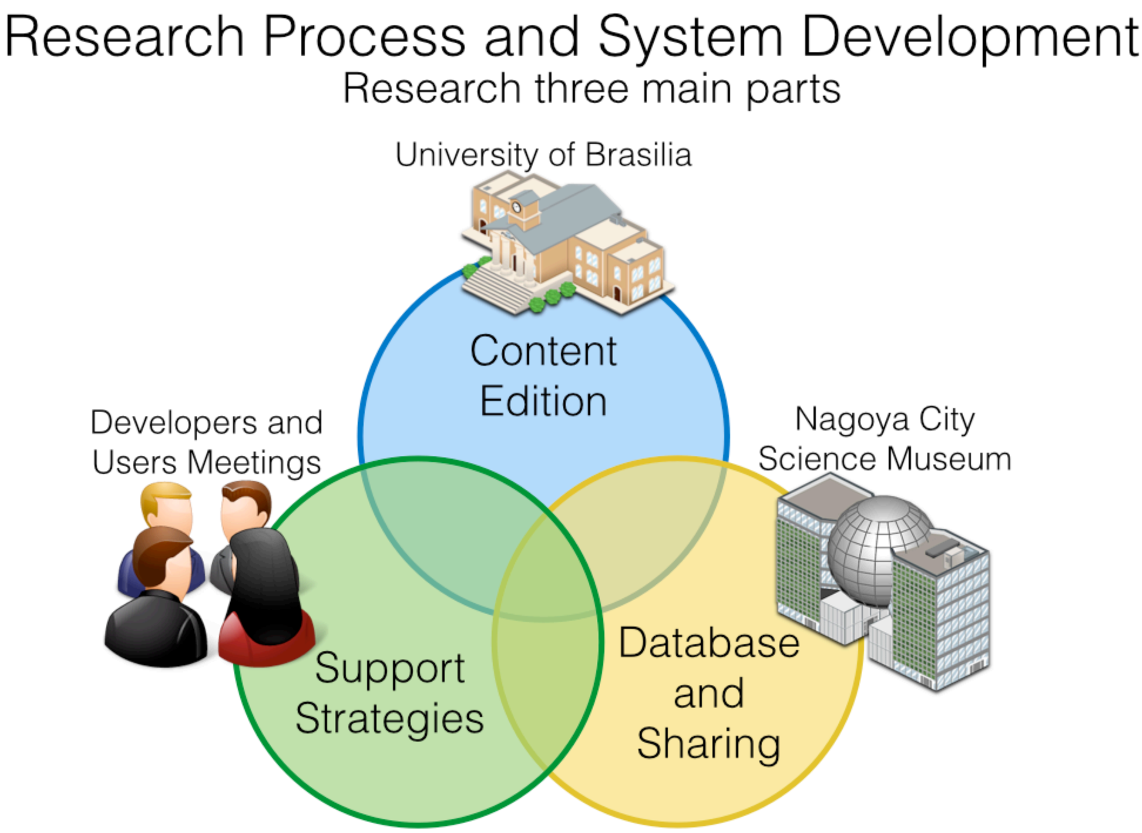

Figure 2-1. Research areas.

The subdivision of the system created on the Project ELO, also reflects the research process, and system development process done in the research, as shown in the Figure 2-1. The system was basically divided in three parts, one for the interface and content edition, another for the database, content management and sharing, and the last one for the creation of the support strategies.

The blue part is the part of the research about the creation of the interface and system functionalities necessary to allow the creation of the necessary contents used by the teachers and student in the e-Learning projects. This part of the research happened in the University of Brasilia, Brazil, as a part of the Project ELO, and had the objective of creating a system used to allow the teaching materials to evolve, being adapted to the changes in the environment.

The yellow part is the study about the content database, content management, and sharing system used to help the users to have fast access, update, or recycle content as templates to create new content. This part of the research happened in the Nagoya City Science Museum, where the system was used to create astronomy learning content used in museum’s planetarium, exhibition displays, and also published in the museum’s website, newspapers and magazines.
The green part was the part of the research responsible by the creation of the support strategies. This part of the research happened mostly in parallel to the other first two, since it was responsible by the creation of the support strategies created during the projects. The creation of the strategies happened during various meetings between the development team and the users during the research, and was also based in various interviews with the users.

The support strategies were focused in the creation of guidelines to help the users to not only use the technology, but how to learn more from it as they used the system. Also strategies to help the users to organize themselves in order to exchange their knowledge, and strategies to help the users in offline situations like setting the classroom to use the system in face-to-face classes.

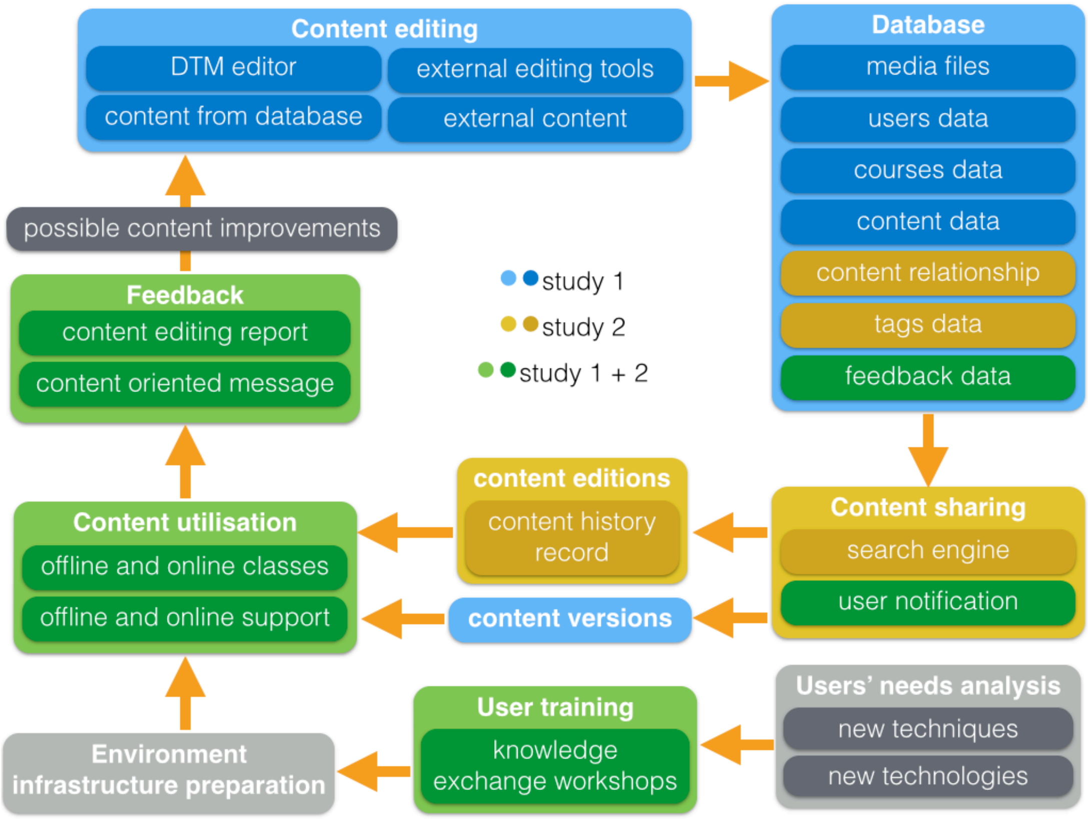

Figure 2-2. DTM system overview.

The DTM concept can be applied to help in the development and implementation of an e-Learning project. The figure 2-2 show the overview of a system created based in the DTM concept, the blue elements are the element of the system concept created during the first part of the research, the yellow elements were created during the second part of the research, and the green element were created during the third part of the research.

The grey element in the Figure 2-2 are part of the system development and operation process, however are not part of the system itself. They correspond to the advent of new techniques and technologies, how these technologies are related to the user needs, and the preparation of the environment infrastructure to make these new techniques and technologies available for the learning community. Each part of the research is explained in details in the following chapters.

CHAPTER 3

An Approach to Make Teaching Materials Evolve

3.1 Introduction

Usually the development of an e-Learning project has the objective to use ICT to improve the teaching and learning processes, or to solve problems faced in the educational environment by the teachers, or students. These improvements or problems can happen in many different parts of the teaching and learning processes, for example, in how the teaching materials are created, how the teaching materials are used, which kind of teaching materials are used in the class, which communication medium the teachers and students use to communicate with one another, they able to use the required resources for teaching and learning, and so on.

In the beginning, the project ELO was developed to try to solve problems regarding the teaching materials used in the undergraduate Japanese language teaching course of the Department of Foreign Language and Translation of University of Brasilia, in Brazil. The main problems with the teaching materials faced by the students of this course were:

- Outdated teaching materials.
- Teaching materials write in other languages different from the students native language.
- Students needed more teaching materials to exercise and review the subjects of the classes.
- Students needed an easy way to share the alternative teaching materials they could find.

To solve these problem, the first idea was create e-Learning system that has online content editing and management features. The teachers could use it to create new teaching materials to substitute the outdated ones, teaching materials in the appropriate language for the students, and also additional teaching materials for the students to exercise and review the subjects of the classes. The system also could be used by the students to share the alternative teaching materials and content they found, and also organize forums to discuss and study in groups.

However after some time trying to develop an online system with the necessary features using general CMS, like Moodle, the development team faced new problems, especially regarding the use of this kind of technology by the teachers. Even the teachers that had enough experience using computers to create teaching materials using the application like, PowerPoint, could not operate the CMS. The student also had problems with the graphical user interface (GUI), especially regarding the navigation inside the system.

Not only the CMS interface, but the a great part of the e-Learning teaching materials also have design problems. There is also a lack of e-Learning teaching materials designed to be used during classes; most of the materials are designed to be used for distance education, being accessed online and displayed like web pages. However this kind of presentation is not good when the teacher needs to show the teaching materials to the students using a projector, especially if the resolution of the projector is 800x600 pixels or lower. The content do not fit in the screen and the teachers need to scroll through the page to show what he/she needs to the students, it is impossible to have a general view of the content without the content in the screen getting too small. Therefore teachers have problems using it during classes, limiting them to only the use of videos, audio and slide presentations, which leads to a underutilization of the computer [19].

To solve these and various other problems in the implementation of the e-Learning system. The development team needed to create original tools for teaching materials editing and sharing, and new strategies for the users to organize themselves and use the system. The approaches used to solve the problems faced by the development team and the users gave origin to the DTM concept. The concept was used as the base of the design of an original application called, Dynamic Teaching Materials System created by the project development team.

This original application was created to allow the users to easily create new teaching materials, update the teaching materials when necessary, create different version of the teaching materials, and automatically share all the content inside the system in real time. The system showed good results allowing the users to easily create interactive multimedia teaching materials using only a GUI, however there still possible improvements, in the interface, editing and sharing features, and utilization strategies.

3.2 Project background and research field

The project ELO started with three undergraduate students of the Japanese Language Course of the Department of Foreign Language and Translation of University of Brasilia. They had the idea of develop an online system to help solve problems the students of the same course were having, especially regarding the teaching materials being used in the course. Until that time all the teaching materials provided by the university were printed textbooks, audio CDs, and some other additional exercises in separated papers.

The first problem with these teaching materials is the fact that they used vocabulary that were too old for the students, there were words like "typewriter" used as sample vocabulary, and most of the students did not know what a typewriter were because when they were born there were already computers, they never had a chance to see a typewriter. There were other vocabularies like "cassette tape" and "tape recorder". Even the subject of the course is Japanese language, and in fact this kind of technology still being used in Japan until now. In Brazil this technology is no longer produced since a long time ago, and most of the students have never seen these objects, and even with the translation written in the textbook they cannot understand what they were.

Another problem faced by the students was teaching materials written in languages different from the students native language. This kind of teaching material has two problems, one is the language itself, since the translations and explanations of the teaching materials are in a language different from the student's native language, the student needs to first understand the content on the teaching material in the other language, then translate it to his language to really understand the meaning of the content in the the teaching material. If the student already have proficiency in the other language used in teaching materials, maybe the student can understand it without many problems. However is the student do not have proficiency in the other language, he/she cannot understand the teaching material.

Another problem with this kind of teaching material is the fact that, it is probably an imported teaching material, and they were created focusing on their domestic students, who live in their own socio-cultural context and may have different needs from the students of other countries. "Examples and analogies that make perfect sense to an Australian student may mean nothing to a student in Singapore" [20]. Therefore these teaching materials can be out of context for the student in another country, attending to different needs and study objectives than the real one present in the classroom.

The three student that had the idea of creating an online system started the project by themselves in August, 2007, renting a web server and learning how to install and use Moodle. Approximately three month after, the students had their own Moodle online, and some samples of content that could be used as teaching materials and accessed through the internet. After this preparation the students presented the project to two of the Japanese language teachers, that were the teachers of the first basic level class, and one of them was the head of the Department of Foreign Languages and Translation at that time.

The teachers agreed and decided to try to use the online system on the next semester, specially because the system could be used to facilitate access and the distribution of more teaching materials to the students, and also help with the communication between the students and teachers. Since part of the students of the course were already using mailing lists to create groups of study and share additional teaching materials they found on the internet, the online system could also be used by the students for this kind of purpose.

The teachers also helped the students providing a minimal infrastructure to continue the system development. Until then, the development was being done by the students at home. The lack of university staff qualified for this kind of task made the students continue the development all by themselves. The extensive time spent in bureaucratic procedure in the university, also forced the project to continue using a rented web server instead of using the university's server to host the system. The utilization of a rented server allowed the students to have free access to the server and install all the necessary features, and upload all the necessary content as they need without problems, in time for the next semester. That kind of task using the university's server could take months for each needed feature and content.

When the next semester started and the system was presented to the students, many of them were not comfortable with the idea of using Moodle for online tasks, because they had some traumatic experiences using the online system offered by the university at that time in other disciplines, that was also based on Moodle. However after explain that the course was going to use a different system independent from the university's system, and demonstrate how the classes and content were organized inside the system, the students agreed to try to use it.

When the system started to be used in the first semester of 2008, the development team also started workshops to train students, teachers, and tutors how to use the system, especially to try to prevent the problems faced by the students previously when using the university's online system. However other problems also started to appear, especially regarding the Moodle interface, content management, and content editing features, as well as the necessity of the teaching materials also be available to be used in the face-to-face classes by the teachers, and not just for online access.

Facing this situation the development team needed to create a new approach to fulfill the needs of the e-Learning environment. The utilization of an online system can be the solution of the problems the students had before, however the implementation of the online system itself brought a new set of needs to the environment that also needed to be meet in order to fulfill the project objectives. These new necessities included not only the development of the necessary system features, but also training the teachers and tutors to use the necessary technology, and the creation of strategies to organize the project human resources and system utilization.

3.3 Dynamic teaching materials concept, first version

There are many problems related to the teaching materials in an e-Learning project, in every part of the process. The problems start from the creation of the teaching material and goes until its utilization by the teacher in the classroom, or by the student accessing it online. To solve these problem the e-Learning environment, and the e-Learning system need to be well prepared, to guarantee the necessary infrastructure and features for the users, and the users also need to be prepared to use these resources.

In order to develop really effective e-Learning environment and system, is necessary to make the true potential of the computers as a learning tool accessible for the user, and create utilization strategies to help them organize themselves and use the computers in the classroom, or for online activities at home, in a really meaningful way, instead of just using the system to transmit course documents to the students [21].

Usually the teaching materials are static, that means, the teaching materials are created following a model that was created by observing a group of students in a given space and time, and the teaching materials is designed to meet the needs and educational objectives of this group of students. However there are new students who come periodically, and even if they are from the same region and have the same age of the students before them, the historical, social and cultural background of the new students are not necessary the same, as well as their educational objectives may change from the previous students. This situation highlights the problem of how much a teaching material continue suitable to new student over the years. The teaching materials need to be updated to match the necessities and objectives of the new students.

Intelligence is a “biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture” [22]. “Constructivism provides ideas and principles about learning that have important implications for the construction of technology-supported learning environments. One of these implications is the need to embed learning into authentic and meaningful contexts” [23]. Therefore using teaching materials focused on the students' social and cultural context can be more effective, because these materials have content that are familiar and really have a meaning to the student, and also teaches subjects that have meaning in the students' life.

There is also the case of teaching materials that are in a different language than the students and teachers mother language. That situation creates a barrier that forces the teachers and students to, first study a different language, and then became able to use the teaching material. When the teachers find some kind of problem in a teaching material, they can request updates for the teaching materials. However static teaching materials usually are also difficult to be updated.

For example printed books, or PC applications distributed online or in CDs. This kind of teaching materials need an extensive time consuming process to be updated, which the publishers and editors need to evaluate all the requests made by the teachers using these teaching materials, and decide requests that are really worth to create a new edition of the content. However the editor and publisher are not the people who are in fact using the teaching materials in the classroom or online.

This creates a situation where the staff in charge of creating and editing the teaching materials do not know the real necessities faced in the learning environment, and the teachers do not know the limitations of the technology used to create and edit the teaching materials they are using. Therefore it takes time to the two sides understand what are the problems, what changes need to be done, and what is really possible to achieve concerning these problems and the available technology. The three main problems with the creation of new editions of static teaching materials are:

- The teachers cannot know if their requests were granted until the next edition of the teaching material is published.
- Probably the next edition will only be published in the following year, missing the students that really needed the updates.
- Usually the teachers and the students need to pay the price of the whole teaching material again in order to get the updates

Web-based systems need to be adapted and evolve following an educational environment that is continuously changing [24]. However, most teachers do not have programming knowledge, therefore they cannot change the system itself, however they have the knowledge necessary to understand the changes necessary to content inside the system. Therefore to the development team, making the teaching materials dynamic was found to be the best solution to make necessary changes and make the teaching materials evolve following the educational context. The dynamic teaching materials are teaching materials that can evolve because their content can be easily created, updated and shared in real-time by the teachers, or tutors. All the new content and new ideas to be taught can be shared between the teachers, therefore the teaching materials are always suitable for the students' needs.

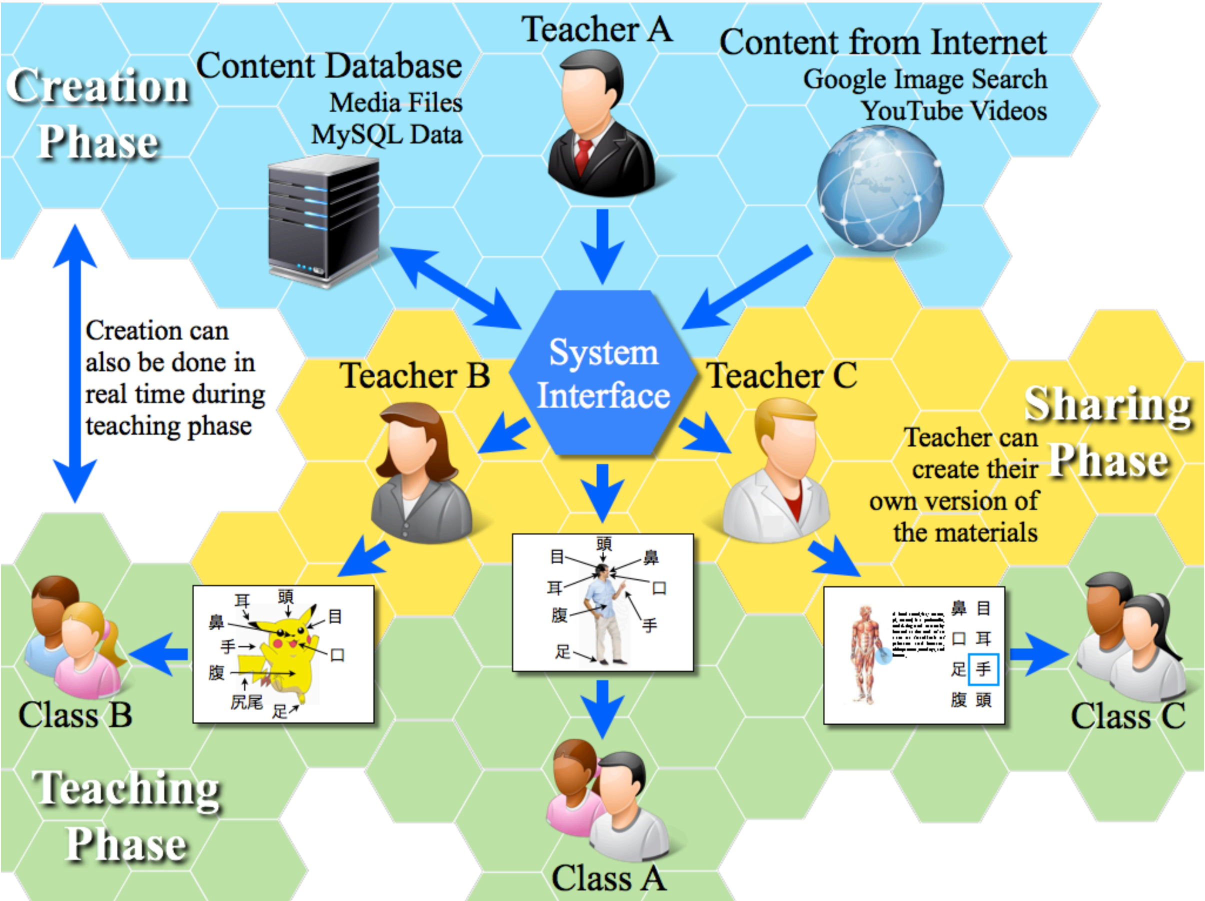

Figure 3-1. Dynamic Teaching Materials cycle.

The Dynamic teaching materials concept main objective was solve the problems of teaching materials, outdated or out of context for the students, creating teaching materials that could evolve and be adapted to follow the continuously changing educational environment. Also help the teacher to create interactive multimedia teaching materials that really use the computer potential, instead of just using digital version of the classroom teaching materials. However to achieve these objectives there were many other problems, like the ones previously stated, that needed to be solved as well.

The main idea of the Dynamic teaching materials can be expressed by three words “creation”, “sharing” and “teaching”. The teacher can use the system to create his/her own teaching materials, share these teaching materials with other teachers, and also teach using the created teaching materials. Another important feature of the system is that, the teacher can edit teaching materials created by other teachers, in order to create his/her own versions, which are more suitable for his/her classes. Following this concept an e-Learning system needed to have four main features:

- Real time WYSIWYG (What You See Is What You Get) editing interface for interactive multimedia teaching materials.
- Content sharing.
- Content edition and version management.
- Interface compatible with classroom projectors.

These four features are the necessary features to achieve the dynamic teaching materials system utilization cycle. As showed in the Figure 3-1, the utilization cycle have three main phases that are, the creation phase, the sharing phase, and the teaching phase, each one needs at least one of the previous listed features to be possible.

The creation phase is the first phase of the cycle, delimited by the blue part of the Figure 3-1. In this phase, the teachers can use the system interface to create interactive multimedia teaching materials, using content from their computers, or linking content from the internet like images and videos. The teacher can access the teaching materials from any computer with internet access, and make real time updates, or create different version of the content, or create new teaching materials using old ones as a template. When finished all the teaching materials are stored in the system server database.

After being stored all the teaching materials are automatically shared, starting the second phase of the cycle, the sharing phase. All the teaching materials stored in the database can be accessed by any user of the system. The students can access the teaching materials to study, and the teachers can access and use them during their classes, suggest them to their students, or create their own version of the teaching materials when the teaching materials need some kind of change to better meet the needs of the classes.

The third phase is the teaching phase, that happens when a teacher uses the teaching materials stored in the system database in their classes, or the students access them to study online. During the class the teacher can evaluate the teaching material, and see if there is any problem with it. The students can also give feedback to the teacher during the class, or using any of the communication features of the e-Learning system.

The third phase closes the cycle. After receiving the feedbacks, the teachers can use them as base to improve the teaching materials if necessary, returning to the creation phase. It is really important that the e-Learning system has an editing interface that the teachers, or the tutors are able to use. The system also needs to allow real time editing, that means, the teachers or the tutors need to be able to make changes in the teaching material even during the classes to guarantee that the updates reach the students that really needed them. All the changes can be done in real time, stored in the system database and automatically shared with the other users. Therefore everyone can always have access to the latest version, or edition of the teaching material.

For example, the teacher A showed in the Figure 3-1, creates an original teaching material to teach kanji characters related to the parts of the human body, after saved in the database the teaching material can be accessed by the other teachers. Teacher B is also a Japanese teacher, however in her case, she is teaching

Japanese for children. Teacher B also needs a teaching material about Japanese kanji related to the parts of the body, and after seen the teaching material created by the teacher A, she decide to use it in her class. However, since her class are for children, teacher B decide that should be better if she changes the image of a person in the teaching material, for an image of a cartoon character that the children in her class like to see. She can easily use the system editing interface to search the necessary image and replace the old one, save her version of the teaching material in the database and left everything ready for her next class.

After using the teaching materials, both teachers can individually continue to update their version of the teaching materials, creating new improved editions of their own versions of the teaching materials. The updates on the original version of the teaching material created by the teacher A, do not affect the updates of the teaching material version created by teacher B, and all the different versions and all the editions of each version will be stored in the database, therefore is the for some reason need to review or recover some content used in the previous updates, they still can access it through the system.

The creation of different versions or new editions of a teaching material can be done, in order to create a similar teaching material, but in a different language, or focused on a different target audience, as well as to make some kind of improvement with better visual, or add interactivity. This approach allows the teachers themselves to update the teaching materials based in the students they have in their classes in real time, making the new edition of the teaching materials reach the students that really need them, teachers can create different versions of the teaching materials to be used in different classes. Also allow the teaching materials to be shared between other teachers, and teaching materials can be used as templates or be merged to create new ones.

However to guarantee an efficient use of an e-Learning system based in this concept, the e-Learning environment needs to offer the necessary infrastructure, training, online and offline support to the users. Since the teachers can use teaching materials created by other teachers, novice teachers can observe how the other teachers create the teaching materials, start creating versions changing only the part they need, and after they get used to the system features, the novice teachers can start creating their own original teaching materials if necessary.

3.4 Dynamic Teaching Materials system development and features

In the beginning the development team tested various e-Learning systems and content management systems like Moodle, Joomla, eFront and Dokeos, most of which are open source systems. Regarding the needs outlined by the project team, the systems do not differ much in their features and limitations, as can be seen in Table 3-1.

Table 3-1. General and open source e-learning systems comparison.

	General e-learning systems	Open source e-Learning system
Cost	High	Free
Customizability	Limited when possible	More freely customizable, however makes the system unstable
Content editing interface	Hypertext editor focused on web designer	Hypertext editor focused on web designers
External content compatibility	Has compatibility problems	Has compatibility problems
Content sharing	Limited	Limited
Use in classroom	Limited by the interface	Limited by the interface

The development team decided to use an open source system especially because the cost, and the customizability, since all the system presented equivalent limitation in the other aspects, the possibility of customize an open source system could be a solution for these limitations. The Moodle was chosen as the base of the e-Learning system, because it was the only system that the development team were familiar with, and Moodle also have a great online development and support community.

The Moodle's normal features for creating content had serious problems in the interface for novice users: since the interface is focused on web designers, the content editing is mainly done in a hypertext editor. The hypertext has a WYSIWYG interface, however this interface did not cover features for interactive content, therefore to create interactive content the user needs to have some programming knowledge, which is not common for novice or casual users.

Moodle also already had a great library of add-ons and plugins at the time the project started. The idea was used Moodle as base for the users and courses management, and customize it installing the necessary add-ons and plugins to solve the limitations of the system. However after some tests the development team realized that the Moodle itself, the add-ons, and the plugins are too much unstable. There were several cases of add-ons, and plugins installation that caused problem in the system, like one plugin had conflict with another one installed before, and the previous installed plugin stopped working, even in cases that the two plugins were used for completely different tasks. There were also cases of plugin and add-ons conflicting with Moodle themes, or templates.

The development team also thought about the utilization of external authoring tools, to create the teaching materials packages following formats like SCORM (Sharable Content Object Reference Model). However there were many compatibility problems in the system when using this kind of package as well. SCORM and the IMS global learning consortium are “specifications” rather than “standards” [25]. This causes a serious compatibility problem between the authoring application and the e-Learning systems. Because there are many different version of the SCORM packages, if the teaching materials was not created with the exactly same version that is installed in the e-Learning system, the content is not displayed the correctly.

Moodle also had problem regarding the compatibility of the system backups when used through different version of the Moodle. Therefore the development team decided to use only the users and course management features of Moodle, because that was the only part of the whole system that really was stable, even through different version. The teaching materials and other content needed to be created using a tool that should be more accessible for the teachers and students, and also need to be flexible and compatible with other systems, if there were the necessity of the changing to another version of Moodle, or to other CMS.

Because the project's e-Learning system needed to be able to handle interactive multimedia content creation, fast sharing, and real time updates, the development team decided to create an original teaching materials editing tool, because any tool that have the necessary features was found at that time. Adobe Flash, Java, HTML, and PHP are in the technologies that the development team tried to use to develop teaching materials, and editing tools, however the Apache Flex was chosen to the development of the real time editing tool. Apache Flex have basically the same features the Adobe Flash has, however it is a free open source framework, and also more light and suitable for web applications than Flash.

Since there were complains from the teachers and students about the Moodle navigation features, Some customizations were made in the Moodle navigation bars and menu system to prevent the users from getting lost in the system. However most of the custom interface was created using Flex, not only the teaching materials editing interface, but the content browser inside the courses' pages and the interface to use the teaching materials in the classroom. The main idea of the content browser was allow the teachers to access all the content related a given course without the necessity of navigating to a different page.

Normally all the content inside a Moodle course page is displayed as a list of links, the user needs to click in the content link to open a different page that finally displays the content. However navigating through pages using a 800x600 pixels screen is difficult because the portion of the pages that are really visible in that resolution is limited, and this eventually causes the content to be displayed incorrectly. The necessity of navigating to another page to show the content was also a problem because of the internet speed and stability in the classroom, sometimes the content took too much time to open, or even could not be open.

The purposes of the content browser created in Flex were:

- Make all content fit in the 800x600 pixel resolution projector screen, or at least guarantee that the content will be displayed correctly.
- Allow the course content to be accessible and displayed on the course main page.
- Organize the course content by topic.
- Once the content browser was open, most of the content could be displayed even without internet connection, due the pre-loader feature.

The Flex content browser also have links to content like assessments created with the Moodle. Even with the complex editing interface, the Moodle was the best tools for creating assessment at that time, especially because it question feedback feature, the user scores database. In this case the assessment was open in a different page like any other Moodle content.

Before the real time editing interface was completed, the teaching materials were created using Macromedia eXtensible Markup Language (MXML) templates. These templates have the interface and interactive parts of the content pre programmed by the development team, the teachers and tutors only needed to insert the necessary texts and images URLs between the code tags. Due to the necessity to copy and paste the code tags in the right order, and it needed to be done in a normal text editor it was a little difficult for novice users. However many teaching materials, even interactive teaching materials were created using these templates.

The design of the teaching materials real time editing interface had two main challengers. First, allows the teachers themselves to create and edit the e-Learning teaching materials in a reasonable amount of time, in order to enable the changes to really reach the students that needed them. Second, create a GUI for editing interactive multimedia content. Features like a WYSIWYG interface are really important to implementation an e-Learning system because it helps the integration of the necessary technologies [26].

"Novices tend to have limited knowledge and will often make assumptions about what to do using other knowledge about similar situations" [27]. Therefore the development team decided to create an interface similar to what the users have in their computer OS. That helped the users because they were familiar with the basic interface operations, like use a double click to open a file folder. The utilization of the user's prior knowledge about operating a computer helped them to have a more intuitive experience even if they are using the system for the first time.

Since a great part of the teachers and tutors were familiar with Microsoft PowerPoint slides, the development team decided to organize the teaching materials as slides, and group them in folders to organize the courses. In other words, the slide folder is like a textbook, and each slide is a page of the book, however different from a normal printed textbook, the slides could have interactive multimedia content.

After getting the feedback from the teachers, tutors, and students, the development team decided which kind of interactive features where necessary for the teaching materials, and tried to create an interface to allow the users to create the multimedia content, and add the necessary interactivity without the necessity of programming language knowledge, only using the graphical interface. To allow the creation and management of different version, and updated editions of the teaching materials, the editing interface also needed to be connected to the system database to store the teaching materials and the information about the relationship between them. The real time editing interface, and the teaching materials version and edition management together compound the Dynamic Teaching Materials system.

The DTM system was created as a separated web application, that runs inside Moodle, identify the users using the Moodle login information, however have its own database to store the teaching materials data. Flex applications cannot communicate directly with the web server database, therefore PHP was used to link the Flex interface with the MySQL database. The Figure 3-2 show how the technologies used in the development of the system were integrated.

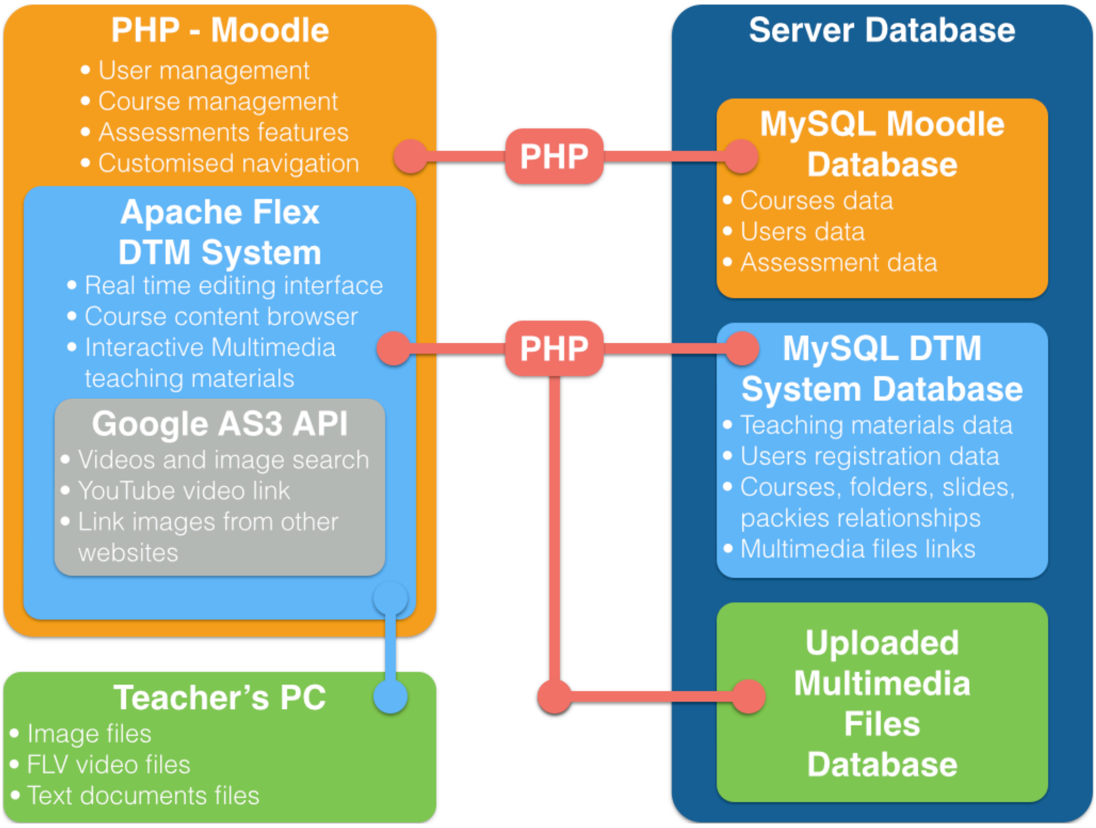

Figure 3-2. DTM system technologies diagram.

The system used the Moodle for the user management, courses management, and creation of assessments. The navigation inside Moodle was customized, after the user login, the Moodle only shows the courses the user is registered in the main page. An additional toolbar was created by the development team to add useful links, and submenus. This additional toolbar was always visible through all the Moodle pages, useful links and submenus included, direct links to other courses the user was registered, links to send messages to teachers, tutors, and technical support, links to tutorials, news, and other important content shared by the users. The additional toolbar was a dynamic, meaning that, the links displayed by it changes from one user to another, and also could change depending on the course the user was accessing.

The DTM system interface, replaced the content browser created previously. When the user opens the course page, the DTM interface is loaded, and the Moodle send the user and course identification data to the interface, therefore it can load the right set of teaching materials, that are associated to that course in the teaching materials database. For the teachers and tutors of the course the interface also showed the icon for the system settings. The system settings were used for manage the teaching materials, inserting, or removing teaching materials from the slide folders.

As showed in the Figure 3-3, there was a total of 10 slide folders per course. One icon for file archives, and one icon for file upload, in the case the teachers needs send any kind of document to the students. The system setting could be accessed by the course configuration, and the user configuration icons. There also the user manual access icon to show the users how to use the interface, and samples of teaching materials to explain the interactive features and how to create them. And there was also an logout icon, for the case the user accessed the system directly from the desktop Adobe AIR version application, without accessing the Moodle.

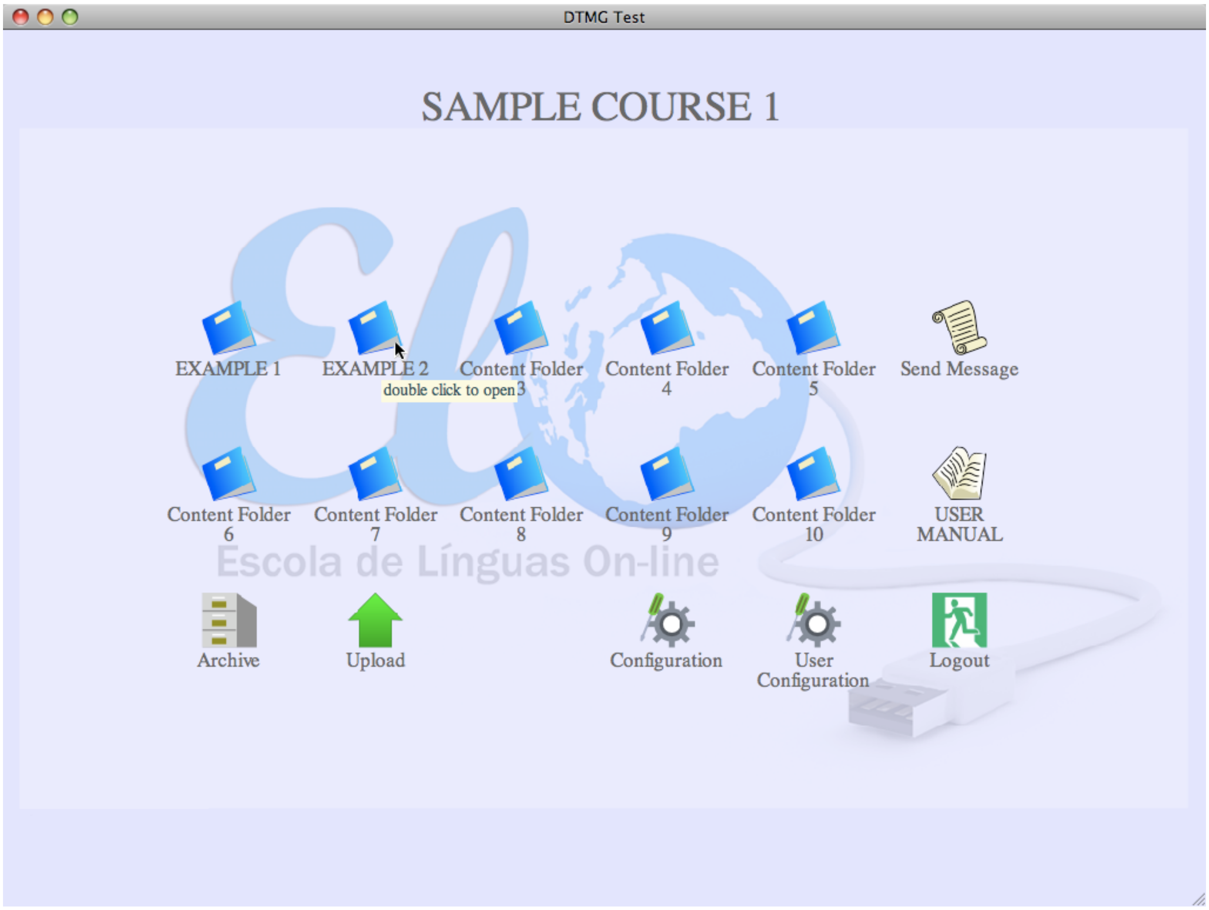

Figure 3-3. DTM system interface main page.

The interface works like in most computers OS, the folders open with double clicks, right click is used to open the context menu, and do actions like rename the folders. The text fields and buttons, also works the same way, the user just need to click a text field to be able to type in the necessary information using the keyboard, and click a button to confirm or cancel some action. When the user opens a slide folder, the first slide of that folder is automatically displayed. If the user moves the cursor next to the upper border of the slide, the navigation bar is displayed, this bar show the name of the slide, the number of the slide in folder, how many slides are in the folder, the navigation controls to go to the next, previous, or a specific slide in the folder. For the teachers and tutors, there is also a checkbox to turn on and off the edition mode, to edit or create a new slide inside that folder.

All the edition and interactivity configuration could be done using the options in the navigation bar, and the context menus of the slide, content inside the slide as shown in Figure 3-4. The navigation bar had the options to edit the slide itself like, change the background color, name, order position in folder, remove the slide, or add a new one. The slide context menu had options to add new content, or paste a copied content, and a option to save the slide.

Figure 3-4. DTM system editing interface.

The content inside the slides were controlled by objects called "packy". These objects represents not only one, but a small package of content, and also were used to held the configurations for the necessary interactive features of the content. The different content inside a packy were used to represent the different states of interaction. For example, a text word that changes to an image showing the meaning of the word when the users clicks. In this case the packy holds two content, the first is the word, the second is the image. The packy also holds the configuration that says it needs to change from the word to the image if it receives a mouse click. The different types of content a packy can hold include:

- Text
- Tables
- Image
- Shockwave Flash (SWF) files
- Flash Video (FLV)
- Link to youtube video

The Packy Edit Panel shown in the Figure 3-4, is the packy configuration panel. It holds all the necessary options necessary to configure the packy interactivity, including how it responds to user's input, and how a packy can interact with other packies in the same slide. The ID field shows the ID number of the packy in the database, if it is stored in the database, the name of the packy, the influence valor, used for interact with other content, the number of the packy content that is currently being edited, the type of the content, the interaction color, also used for interaction with other content, the max number of content inside of that particular packy.

The last part of the configuration options have a text field and the search checkbox. The text field changes its function depending on the type of content, it can hold the url address of an image, or the words of a text content. However with the image and the youtube video type of content, this text field can be used as a search box if the search checkbox is checked. In this case the words inserted in the text field are used as keywords to search for images or videos. A thumbnail preview of the results is displayed in a sub panel under the configuration panel. The cancel button is used to cancel the changes to the packy, if any, the save button is used to save the packy in the database, therefore it can be used in other slides later, and the OK button is used to confirm the changes done to the packy.

The user's inputs that the packy can respond are limited to mouse clicks, and drag & drop actions, however as a packy can influences other packies in the slide, there are many possible results for these actions. According to the feedback from teachers, tutors, and students, the necessary interaction features were:

- Make a packy changes its content after a mouse click, one or multiple times.
- Make a packy changes its content after dragged and dropped in the correct slide area.
- Make a packy changes its content if it enters in contact with another packy.
- Enable a packy to displays different content, depending on which other packies are in contact with it.
- Use a packy as a button, that when clicked changes another packy content.

There are some sample of the teaching materials created using the DTM system. These samples show how the packies can be configured to create different types of interactivity, and how they can be applied to create teaching materials.

Category Counter

Figure 3-5. Dynamic teaching material sample, Category Counter.

The Category Counter is a teaching material focused on the counting system of the Japanese language. There are some specific suffixes that need to be used after the numbers when counting objects, and these suffixes change depending on the object type. For example to count objects like apples, the suffix "KO" is needed, and when counting glasses of water, the suffix "HAI" is needed. In the case of the Figure 3-5, this teaching materials was created by using 10 packies, each one holding 10 images, each image shows objects, and a label in Japanese with a number referent to the number of objects displayed by the image, and the suffix related to the type of objects. Each one of the packies have images referent to one type of object, and every time the user clicks a packy, it changes its image, going from the image that only show one object, until the image that shows ten objects. The user can click the packies to see how to count the ten different types of objects from one to ten.

Another possible way to create this teaching material is using the drag & drop feature. In this case there will be ten copies of the same packy holding the same image of an object type, then another packy is necessary to be used as a counter. Then the user can configure the counter packy to react if in contact with the other packies, and count how many packies are in contact with it using the influence value property of them, in this case all the packies has influence value of one. Based on this information the counter packy can display the correct label with the number of objects, and the type of object decided by the interaction color property.

Kanji Displayer

Figure 3-6. Dynamic teaching material sample, Kanji Displayer.

The Kanji Displayer is a really simple teaching material used to introduce new vocabularies to the students. As showed in the Figure 3-6, the teaching material has some packies in the left side, each one with a kanji written in it, the kanjis can be just text or images of the kanjis. In the right side there is a packy that is used to display an image. The packies that have the kanjis, also have a reference image link property, if it is dragged and enters in contact with the displayer packy in the right side, the displayer packy reads the reference link property of the kanji packy, displays the image.

Since all the packies can have different influence values, another way to configure this teaching material, is given a different influence value to each one of the kanji packies, link an ID number, and when it enters in contact with the displayer packy, the displayer packy show the image based on the influence value. This approach can also be useful to show images for words that are composed from more than one kanji. This kind of teaching material can also have different version that use different kanjis, or even words that do not use kanjis.

Joshi Drag

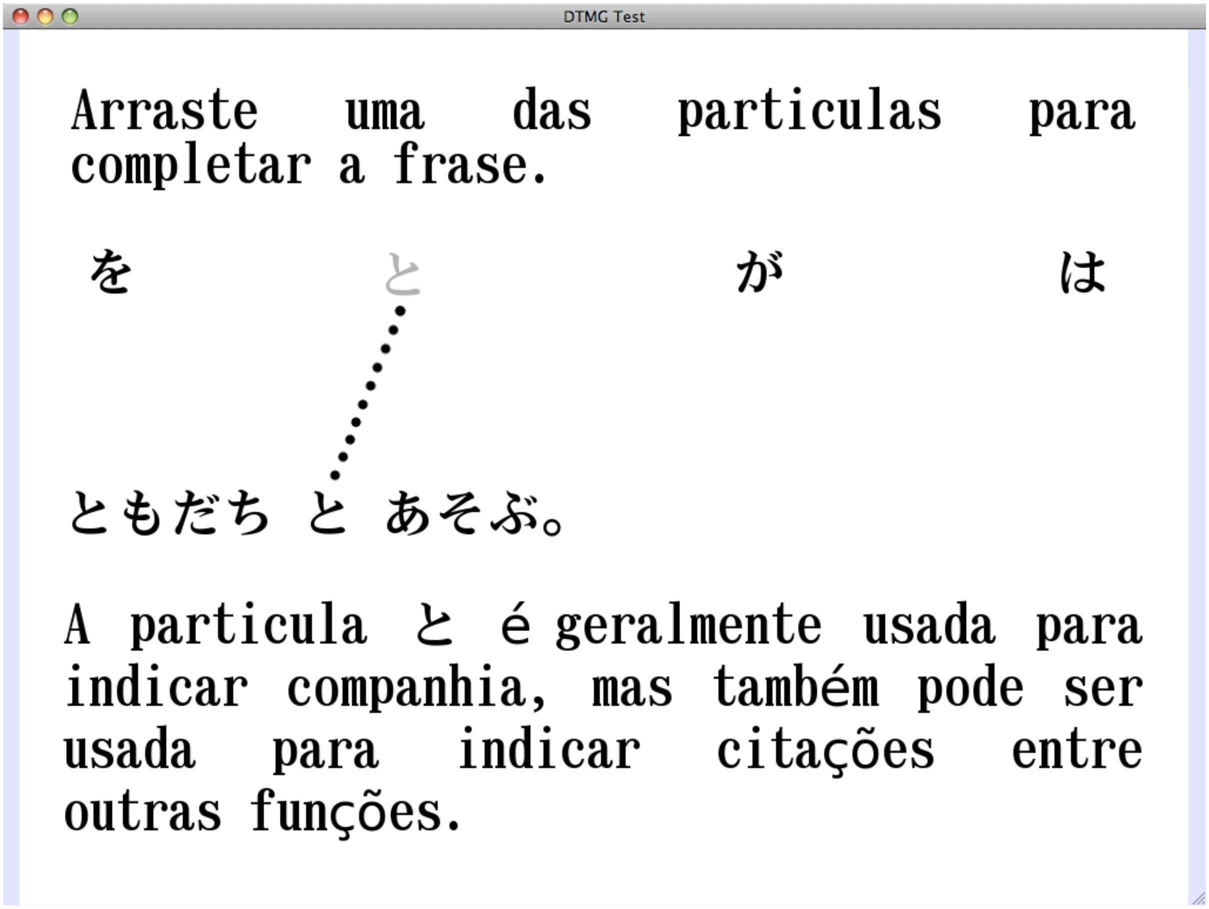

Figure 3-7. Dynamic teaching material sample, Joshi Drag.

This teaching material is used to show how the meaning of the sentences in can change by only changing the prepositions. In the case shown in the Figure 3-7, the user needed to drag the preposition, and drop it near the sample sentence, after that an explanation about the preposition the users dragged is shown. The explanation changes depending on the preposition that was dragged. This teaching material can also be easily created configuring the prepositions as buttons, therefore the user only needs to click the preposition to see the explanation instead of dragging and dropping it.

All the interactive features can be used with all content types. Even with videos. The possibility of using SWF files also allows that interactive content created externally with Adobe Flash or Apache Flex to be used inside the slide. This feature can be used to insert interactive content that need more complex interactive features, in the case of advanced users that know how to program.

After a finishing the edition of a content, or creating a new one, the packies, slides and slide folder can be saved, and its information stored in the database. Basically the database of the DTM system includes the following tables:

- Users data table, to store which courses each user is registered.
- Courses table, to store information like course ID, name, teacher, tutors, and slide folders.
- Slide folder table, stores folder name, author, creation date, and list of slides associated to it.
- Slide table, stores slide name, background color, author, creation date, list of inserted packies.
- Packy table, stores name, author, creation date, interaction settings, and content information.

All the content in the database have a reference to who created it and when. Basically the courses are a set of slide folders, that can be accessed by a defined group of users who are registered to it. The slide folders are a set of slides, that is like a book, and each slide is one page of the book. The slides are a set of packies that are configured to display some kind of content. The packies are a set of content that can be interactive responding to user inputs, and also react to each other, resulting in a change to the content displayed.

The slide folders, individual slides, and packies can be shared between users, and used in different courses. At this point of the development the system did not have and content search engine yet, what the access to content created by another user a little difficult, however if the user knows the desired content database ID, or the name, the content could be loaded directly using this information.

After loading a content from the database, the users could make any kind of alteration if necessary and save a new version of the it. This process could be done with any content inside the database, slide folders, slides, and packies. Slide folders could be shared between courses, like to teachers adopting the same textbook for their classes, and if the author of the slide folder did some kind of update to the slide folder, all the courses sharing it, are automatically updated.

Even the shared packies could be automatically updated across all the slides that shared the same packy, however in the case of the packies, since the interaction configuration is much specific for the context of each slide, this feature was usually is not necessary. Unfortunately the development of the content search engine and the edition and version tracking features could only be completed during the development of the Skynavi project. These functions are necessary to allow the users to have faster access to the content in the database, and also visualize different versions, and older, or newer editions of the content.

3.5 Evaluation tests and results

Since the university did not have human resources to help the project, the senior students of the courses that were also the tutors of the basic classes had to organize themselves to handle the necessary tasks, and participate the workshops related to what they agreed to help. All the students that participated in the project were volunteers, most of them had at least basic skills to operate computer, some of them had advanced level skills. The tutors were organized in pairs, one tutors for online tasks, and one tutor for offline tasks. In the beginning test was conducted with a smaller group, just six Japanese teachers, twelve tutors, and one hundred and forty students in nine lectures.

After some time the project expanded to cover the other languages of the Department, and other research projects started to happen in parallel, but using the same base e-Learning system. Not all the teachers using the e-Learning system created in the project ELO were using the DTM system features to create and manage their teaching materials, however they were using the navigation interface, utilization strategies, and tutors support strategies developed by the project ELO team.

From the beginning, the system has being developed in collaborative work between the development team and the users; whenever possible there were interviews and reunions conducted between the users and the development team to discuss the system's performance, what features were being really useful, check if there were anything to be fixed or changed, and why the changes were needed.

The teachers and tutors gave their evaluation of the system in interviews after using it in face-to-face classes, and in online support activities. The test was focused on new navigation interface for using the system in the face-to-face classes, what kind of teaching materials the teachers really needed to be created or edited, and to evaluate the necessity of tutors helping teachers to prepare and set up the necessary equipment to use the system in the classroom, especially in the case of teachers with little experience with computers. The table 3-2 shows some details about the users, and lectures that used the e-Learning system.

Table 3-2. University of Brasilia evaluation test environment.

Test period	from February 2008 to April 2009.
Development team	8 members
Languages	Japanese, Spanish, French, English, Italian, Portuguese and German. Total of 7 languages.
Lectures	55 lectures, graduate and undergraduate level.
Teachers	25 teachers.
Tutors	2 per teacher, total of 50 tutors
Students	2907 students
Total of users	2982 users

The new navigation interface implemented in the content browser created to substitute the original Moodle interface, solved the problem teachers and student had navigating the platform to access other content in the same course. Before with the standard Moodle interface, the users could view the courses and the content inside the courses as lists of links, but sometimes the lists became too long and it was difficult to find the content, difficult to see which one was used in the class for revision, and also difficult to see which content were related.

The new interface had all the content in one screen, the interface allowed the content to be accessed by using menus and submenus, organized by topic, no need to navigate to different pages or areas of the online system. The new interface also helped the teachers when using the system in face-to-face classes because the projectors had a screen resolution of 800x600 pixels, that is smaller than the displays the users had, and the new interface was designed to fit this smaller size; since no navigation was needed after entering the course page, the teachers had all they needed on the screen, saving time when showing the content.

Even the teachers who had experience with computers stated that the support of the tutors to set up the equipment in the classroom was essential, since in University of Brasilia the number of classrooms equipped with computers and other multimedia equipments is very low; almost every time, the teachers had to bring the equipment and set it up in normal classrooms, which is very time-consuming to do alone, and is unfeasible taking into consideration the total available time for the classes.

Regarding the types of teaching material needed by the teachers, the most required types for the face-to-face classes were text with images to illustrate the meaning of new vocabulary, animations or videos to illustrate action verbs and dialogue examples; for grammatical explanation the most popular content were interactive content that, for example, showed how the use of different grammatical forms changed the meaning of the sentence as the user moves the mouse cursor through the available options, and teaching materials with animations that show step by step how to write the Japanese characters.

The Moodle was basically used as the base of the system, especially for the course management and users management features. However the assessment creation feature was also really important. The assessments were also ones of the most successful types of content, because of the questions feedback feature. The student could do automated (self-)assessment, and get the evaluation results and feedback explaining the right and wrong answers immediately after submitting the answers. The only problem with the Moodle's assessment feature is that, the interface to create the assessments is the most complex and not intuitive part of the whole Moodle interface, and the number of users able to create assessments in Moodle was very restricted, even inside the development team.

The test results were very good, especially for the stage of development that was focused on solving the problems the teachers were having with the Moodle interface. During the tests, the teachers were responsible for the instructional design of the teaching materials, however most of the content was developed by tutors that had experience with computer, or were trained by the development team. Because a great part of the teachers did not had available time to participate the workshops, and the real time editing interface was still in development.

The results also showed to the development team, the importance of features like the WYSIWYG real time editing interface. Until this moment the teaching materials were created using MXML templates created by the development team, these templates were not much flexible, however they held the basis of the necessary interface to use the teaching materials in the classroom. The templates allowed the teachers and tutors to just insert the necessary content of the teaching material between the script code tags to show what they wanted in the screen, therefore even without programming language skills, they could edit the content.

Editing the content with the templates were not a very difficult task, because all the necessary programming part was done by the development team, and every time, some kind of new content type was needed the development team created a template for it, and the teachers and tutors only have to copy and paste the template in a text editor, and write the necessary text or insert the image urls. However since it was not a WYSIWYG interface, and there was also the necessity of copying and pasting script code tags involved, the teachers and tutors were afraid of using it. From July 2009 to December 2011, there were also small evaluation tests to help the development of the WYSIWYG real time editing interface, and the edition and version management features.

After all the tests, the system had good approval from the language teachers; they made comments like "the system was really good because we can do almost everything with just some mouse clicks", "the real-time editing makes the system work like an electronic blackboard" and "the creation of different versions of the content allow us to have a specific content that better meet each situation, or context needs”.

However there were some problems, because at the time of the tests, the system did not yet have a teaching material search engine; the teachers needed to know the teaching material name or the ID number to load it from the database. It was difficult for the teachers and tutors to know what kind of teaching materials were stored in the database, they need to ask one another to know what teaching materials were created and if there was someone creating something new. Since the number of teachers participating the project was not so high, and everyone were working together, this situation was not a big problem, however it was a problem that needed to be fixed.

The edition and version tracking feature needed to be create to show the relationship between the teaching materials were also not completed. This feature is necessary for the users to understand if a given teaching material have any newer or older edition, or if there are other versions of the teaching material, that could be used in different situations These unfinished features could have made the system and the teaching materials more accessible for the users, especially in the first part of the tests, however the main objective of the project that was, create an e-Learning system that allowed the creation of dynamic teaching materials was accomplished.

3.6 Conclusion

The project ELO started with a simple objective of helping teachers and students facing problems with outdated and out of context teaching materials. However the decision of using an online e-Learning system to solve this problem, caused the project to expand to greater proportions, that were not expected by the creators. However this situation also opened to the developers a whole new set of possibilities to improve the teaching materials and the teaching and learning process, and solve problems that were not noticed before.

The peculiarities of the educational environment of the Department of Foreign Language and Translation of University of Brasilia, guided the project development team through a series of challenges. These challenges included the original project objectives of creating the basic tools necessary allow the teaching materials to be adapted to the current necessities of the teachers and students who are using them, and also create this tools using technologies that are accessible to the users.

Every time a new educational technology, or a new teaching approach is introduced to the educational environment, it is inevitable that the users need to some time to prepare themselves, learn and get used to it. Even with a perfect system, the teacher cannot forget why he/she is there. A lack of preparation on the part of teachers can be important factors hindering the development of e-Learning projects [17]. “The Internet is a professional development tool for teachers” [28].

Continued teacher training is very important in order to allow teachers to be able to handle any situation. To help this situation the development team tried, as much as possible use technologies that the learning community are already familiar with, or at least are similar to what they are used to use in their daily life, not only in the work, but also to do other things. Therefore the users can have more contact with the technology and use their prior knowledge to use it more naturally. The diffusion of a technology is a processes that takes time, the development team also needed to find approaches to smoothly integrate it, and also let the users learn as they understand the potential and why it is necessary, creating a smooth learning curve for the novice users [29].

Even if the Dynamic Teaching Materials concept was focused only on the teaching materials, to really be able to implement it effectively in the e-Learning environment, the development team needed to create a series of strategies, like user guidelines to help the users to organize themselves, and help each other to be able to use the system. It is possible to say that the learning community composed by the teachers, tutors and students willingness to participate and improve their own learning environment, was a really important factor for the successful implementation of the project ELO.

Starting from the point that the project itself started from students, and not from the university, since the beginning the learning community knew, that there were problems that needed to be fixed, and they were willing to help. The way the development team and the users organized themselves occurred quite naturally because both sides understood the necessities of the environment and the benefits it could bring to the users.

The design of any e-Learning project should consider analyze the learning community environment first, understand the real needed of the community, and then see which technologies are available for that community, and suggest which ones can be used as solutions to their problems, focusing in "provide the tools not the rules" [12]. The development team should be focused on make the technologies accessible to the learning community, and support them to understand the potential and the possibilities the technologies have. However the community itself needs to be able to understand which technologies are more suitable to itself, and how they will be used.

The Dynamic Teaching Materials System had a good approval from the participants of the project. Even with the problem that not all the desired system features could have being completely developed in the part of the research, the development team succeeded in developing the basic tools necessary allow the teaching materials to evolve, following the necessities of the continuously changing educational environment. The results of the evaluation tests realized in this part of the research were used to create improvements not only in the e-Learning system, but in the Dynamic Teaching Materials concept as well, to incorporate the necessity of the creation of strategies and user guidelines in along with the learning community to help the diffusion of the new educational technologies and techniques.

CHAPTER 4

Managing Astronomy Dynamic Content

4.1 Introduction

The project Skynavi is the second part of this research. In this part the development team evaluated the utilization of the DTM concept in alternative learning environments, like a science museum, and used the DTM concept to develop a web based application to create teaching materials for different subjects other than foreign language learning. Due to the complexity of the content necessary for this project, the creation of a new system was necessary, to handle the project needs and achieve the objectives.

This project was also used to continue the development of the DTM system, specially for the features that could not be completed in time for the previous tests during the project ELO. Features like the content search engine, and the edition and version tracking. The creation of these features also made possible great improvements in the system database.

The Nagoya City Science Museum was chosen as the research field for this part of the research, because this museum has a different theme every month, and the content displayed in the museum's displays, and museum's web site need to change, or be adapted for the current theme. This situation creates the necessity of various different versions of the content being displayed by the museum to its visitors and website users.

For the museum, the connection with educational institutions is also important to develop and encourage innovations. These innovations are necessary to solve problems faced by the museum curators and visitors, and also to create new types of experiences to the visitors, allowing the visitor to have a more deep, enjoyable, and fruitful experience [30].

The Nagoya City Science museum was also having problems to create content with explanations about stars visualization, and the International Space Station. This kind of content need really precise data for getting the correct position of the stars. A wide range of specialized applications for astronomy can be used to create really precise simulations for star observations. However before the Skynavi project, the museum curators needed to get the stars' position data from this kind of application and using an image editor like Adobe Photoshop, redraw the image of the sky in a way that the visitors of the museum who are not astronomy specialists could understand.

To solve these problems, the idea was to create an application that could directly read the output data from a simulation application and allow the curators to configure the rendering of the output image to create an image that the museum public could understand. The application also had features to allow the curators to insert symbols and labels to do any necessary explanation about the stars and constellations showed in the image, and also make indications about the time people should look to the sky and expect to see what the image is showing.

The DTM concept was used specially for features like the content management and search engine, including content edition and version management, content edition and version tracking, and sharing. These features helped the museum curators to create different versions of the content, updated content when necessary, and also use the same content for various purposes, like display information in the museum's displays, lectures held in the museum's planetarium, posts in the museum's website, and publications in news and magazines.

As happened in the project ELO, the development team worked all the time side by side with the volunteer museum curator that participated the project, discussing about the necessary features and its reasons, and also getting feedback about the system utilization. The curators' knowledge was essential for the development of this project and the design of the application.

After the development team worked with museum curator to develop and test such a system, the curators could create the necessary educational content at least two times faster than they could using regular astronomy applications and image editors, and they were also able to easily create a content database and reuse any content to create different versions, updates, or use a content as a template to create a new one.

4.2 Project background and research field

After the evaluation tests of the project ELO, the development team started using the test results to improve the DTM concept and the system developed in University of Brasilia. The team also had to finish the development of some features that could not be completed during the first party of the research. The development team also started to think about the possibility of using the DTM concept to teach different kinds of subjects, subjects other than foreign language teaching.

To use the DTM concept for different subjects, the development team needed to find a new research environment that needed the features offered by the DTM concept and also had a different learning subject. Since the DTM system itself does not establish the subject of the teaching materials, the users have freedom to decide it, and create interactive multimedia teaching materials using content intended for the desired subject.

Most of the multimedia teaching materials are composed different content that include, text, images, audio, and video. The same features used by the teachers and tutors in University of Brasilia during the project ELO can be used in the same way to create teaching materials for other subjects. It only depends on what is written in the texts, or what is shown by the images. For example, the category counter teaching material sample presented in the previous section, can easily be used in a mathematics class as it is.

The interactive features of the system can be assembled in various different ways to achieve many kinds of results. The interactive features created during the project ELO are not limited to the subject of the teaching materials, however they were created only based in the needs of the language teachers, therefore the use of the system for the creation of teaching materials for different subjects, may reveal the necessity of the creation of new kinds of interactivity features, that could be applied or not in other different subjects, depending on how much specific to the subject the feature is.

The Nagoya City Science Museum as any other science museum had many types of visitors, and many of the visitors are not scientists, or specialists in the subjects regarding what is being displayed in the museum. The Nagoya City Science Museum is also the place where is localized the Brother Earth Planetarium, the world's largest planetarium dome with 35 meters in diameter. The planetarium is used for many kinds of events, from projection for general public about with explanations about astronomy and how to observe the stars, to astronomy lectures for kids in many different grades.

The Brother Earth Planetarium and the astronomy floor of the Nagoya City Science museum have a peculiar characteristic as is written on its website [31] (Figure 4-1), “there are new themes every month, as well as public projects that featuring different kids' hours for different grades. There are many fun programs.”

Figure 4-1. Nagoya city science museum planetarium themes webpage.

The necessity of creating multiple version of the content to meet the needs of multiple types of visitors, and multiple themes makes the Nagoya City Science Museum a good research field for using and evaluating the DTM concept and the new system features. The museum environment needs to keep updating, and creating different version of the content also for the different media it uses, like the website, news and magazines.

Inside all kinds of learning content that the museum curators need to create, this research was focused in the content about stars and the International Space Station observation. Basically this kind of content is used to explain when and where the ISS will be visible in the sky, which direction the person needs to look to see it, and also uses the stars and constellations visible at the same time as a reference to help finding the ISS in the sky.

To create this kind of content really precise data is necessary to get the right position of the stars in the sky in the specified time and space. The necessary data is usually generated through simulations. A wide range of specialized applications for astronomy can be used to create really precise simulations for star observations. Google Sky, Sky Guide, and Solar Walk are examples of applications that can generate two-dimensional (2D) images or three-dimensional (3D) scenes to observe the stars in 3D space. These kinds of applications are very useful for specialists; however, the images they create can be confusing for non-specialists, especially because many stars that cannot be seen by the naked eye have being displayed.

Since a great part of the museum's visitors are not astronomy specialists, the museum curators need to edit the output of this kind of application and create a content that the museum public can understand. The main problem for the Nagoya City Science Museum curators was that they needed to edit the application's output and create the learning content by hand using an image editor like Adobe Photoshop, therefore a really time consuming process, because the curators needed to redraw the entire image, with only the necessary stars, adjust their sizes and add the explanation labels.

As there was no application for this kind of task, to solve these problems, the idea was to create an original application based on the DTM concept, that could read the output data from the simulations and allow the curators to configure the rendering of the output image, therefore the image could be directly generated with only the necessary stars in the right position and size, then the curators only need to insert the explanations labels.

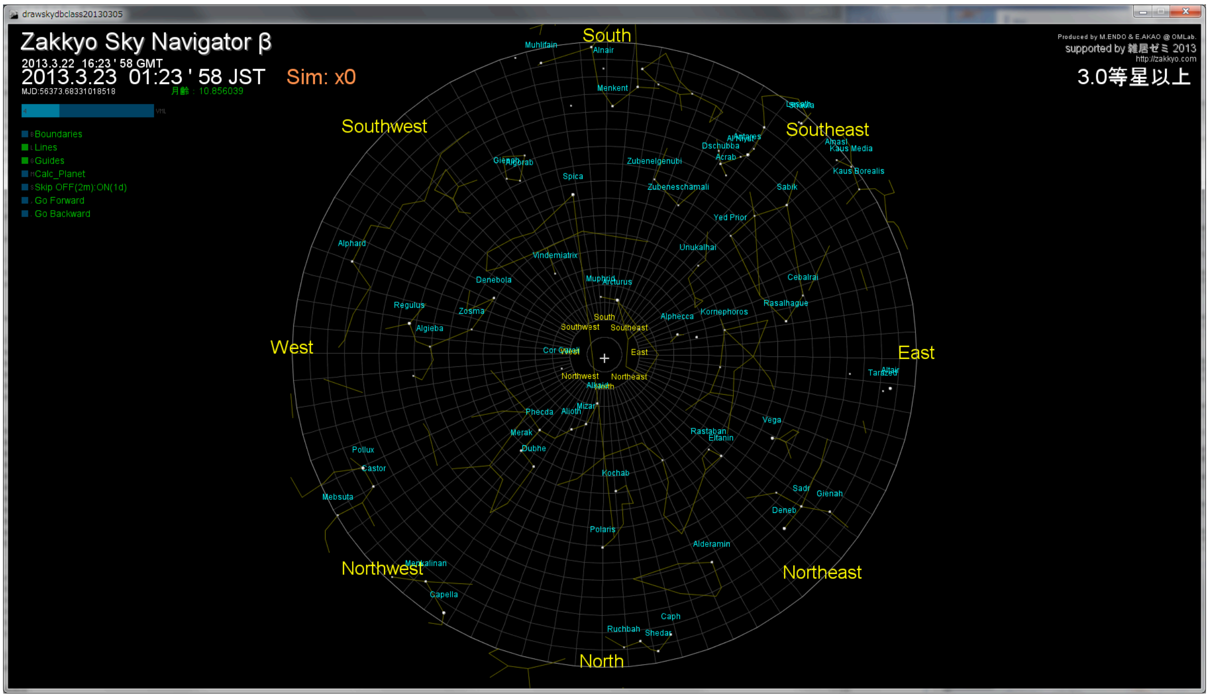

Figure 4-2. Zakkyo Sky Navigator main screen.

There is a seminar that occur in the Nagoya City Science Museum once a month called, Zakkyo Zemi, means sharing seminar in Japanese. In this seminar there are many presentations of teachers and students from different universities that are doing researches concerning the development of applications that can be used in the museum or mobile applications for science education. In this seminar was presented an application called Zakkyo Sky Navigator (Figure 4-2), that is a simple sky simulator. If this kind of application was integrated to the Dynamic Teaching Materials System, it could solve the problems faced by the curators when creating the contents mentioned previously.

The curator and chief of the astronomy section of the Nagoya City Science Museum was also helping in the development of the Zakkyo Sky Navigator, there was the opportunity the curator and the Zakkyo Sky Navigator developer to work together with the DTM concept development team. Therefore the Zakkyo Sky Navigator was chosen as the base application to generate the necessary simulation data, and the development team focused on creating an original application to read the simulation data, and also the necessary interface for configuring the output image rendering and insert the necessary symbols and explanation labels.

4.3 Skynavi system design and DTM concept improvements

The system developed in the project Skynavi is focused on image content that the museum creates to show where and when the International Space Station can be seen in the sky like a star. To create this kind of content, the museum curator needs to use the Zakkyo Sky Navigator app to run a simulation that calculates the position of the stars in the sky on a specific date and at a specific time and location on the earth. Next, the simulation output data is loaded by another application and used to generate an image that represents the vision of the starry sky on the specified date and at the specified time and location.

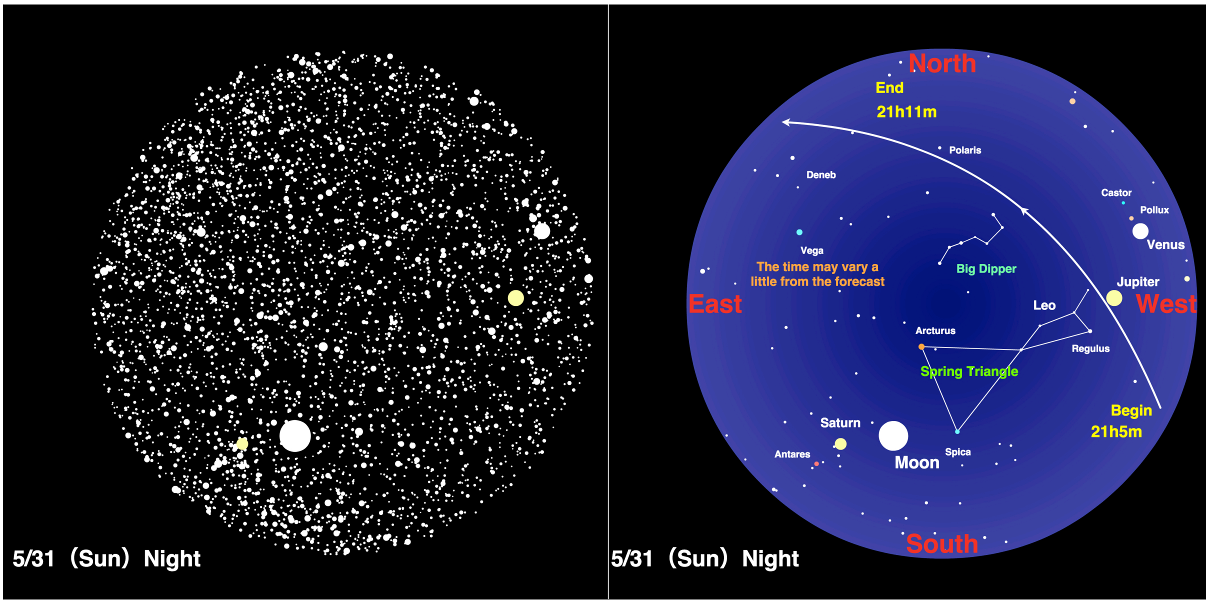

Figure 4-3. Comparison between raw simulation data and final image.

Figure 4-3 shows the image generated with the raw simulation data on the left, and the desired final image that can be used as learning content on the right. The problem is that the simulation raw data generates an image that has many more stars than the naked human eye can really see, and the curator also needs to add symbols such as arrows, add labels to provide explanations, and highlight certain stars and constellations to make it easier to locate where the ISS will be passing in the sky.

The DTM concept was used to create the application that reads the simulation data and has the interface to apply the necessary filters, save configurations, and insertion of the symbols and explanation labels. The system database also followed the DTM concept design to allow the creation and tracking of content editions and different versions, realtime edition and automatic sharing.

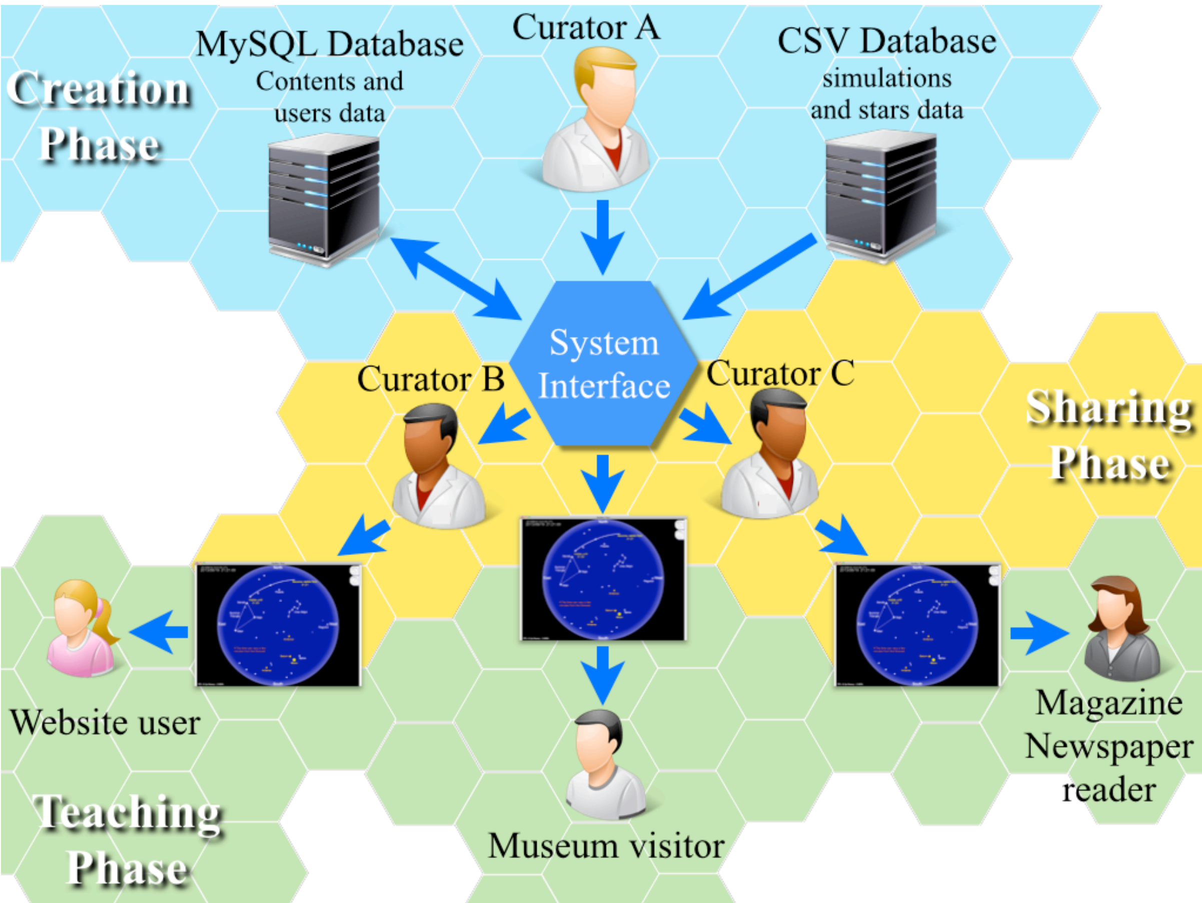

Figure 4-4. Skynavi system operation cycle.

The Skynavi system also have the same creation, sharing, and teaching cycle that the system in the project ELO followed. However in this case instead of different teachers, there are different museum curators, and instead of different classes, there are different means of communication that will be used to distribute, or allow access for the content created by the system. The creation phase is different because of the type of content being created is different, and the applications necessary to do this task have some different, and new features.

The creation phase has five main points, the generation of the simulation data, upload the simulation data to the web server, configure the filters, insert the necessary explanation, and store the content in the database. The application used to generate the simulation data is a desktop application, this application outputs the data as a CSV file that can be uploaded to the web server using a FTP client. The application used for configuring the filters and insert other necessary text labels, or symbols, is an web application stored in the system's web server and is connected to the system database. After completed, the content is stored in the database.

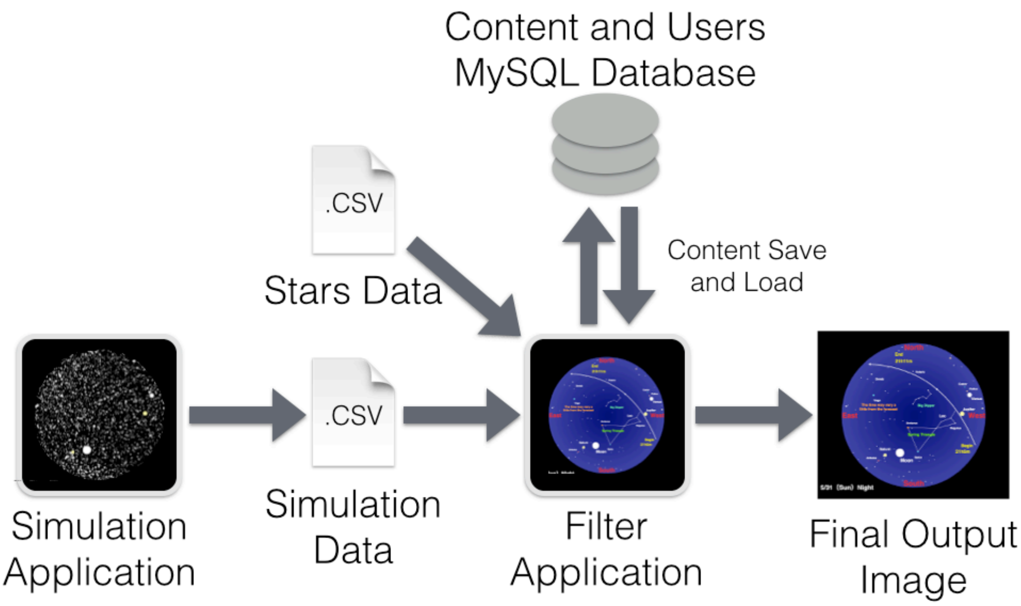

Figure 4-5. Skynavi system diagram.

In the beginning, the idea was to make only one application that could perform a simulation to get the position of the stars and apply a series of filters to adjust the stars' visibility, size, and other necessary settings. However, this kind of simulation is really complex, and the museum curator did not want the algorithm and source code of the simulation to become open-source in a Web application, but the results of the simulation could be shared without a problem. Therefore, it was decided to divide the process using one application for the simulation and another to apply the image filters and then to insert explanation labels and symbols.

The Zakkyo Sky Navigator is used to create the simulation data, the system have a simple interface where the user, adjust the desired date and time of the observation, then the application generates the output CSV file with the data from the simulation. The CSV with the simulation data is then uploaded to the system web server using a FTP client. The filter application loads two kinds of CSV data files, one is used for general stars' information, to create the stars objects inside the application. This file is a CSV version of the Yale Bright Star Catalog, with information like stars' names, constellations, and magnitudes. The other kind of CSV file loaded is the files with the simulation data, this kind of file only have the star ID to be matched with the ID from the Yale Bright Star Catalog to identify the star, and the position of the star on the screen.

The filter application has a GUI to allow the curators to generate an image based on the simulation data. After the image is generated, they can then apply a series of filters to regulate sky color, visibility of the stars, and also the size of the stars. There are also features to draw constellation lines, indication arrows, and insert explanation labels. When the curator is done with the content configuration he/she the download the content final image from the server directly from the application.

The filters of the filter application were created based on the Nagoya City Science Museum curator's astronomy knowledge. Before the curators was able to create the learning content using an image editor, because he knows which stars are suppose to be visible, which stars are not visible, which stars need to be highlighted, what makes some stars look bigger than others do, and other details necessary to create the final image. Therefore, the filter application have an interface to help the curator to apply his own knowledge as filters to the simulation results and generate the final content image.

After finishing the filters configuration and inserting all the necessary symbols and explanation labels, the content can be saved in the system database, to be reused afterwards. Like a dynamic teaching materials, the contents created with the Skynavi system, can be accessed later for any necessary update, create different versions of it, or even used as a template to create a new content. In the case of the Skynavi project, the possibility of using a content as a template, was the most important feature brought by the DTM concept.

The reutilization of existing contents is really important for the creation of new content in any area [32],[33],[34]. The use of templates is an important feature to create this kind of content because it speeds up the process of creation images, specially when the curator needs to create a sequence of images that use the same stars, but observed in different times, or in a sequence of days. This kind of image sequences can be created using the same filter configuration, or at least the configurations are close. Before the curator needed to create all the images from zero, one by one. However, now with the template feature the curator can create the configuration once, and apply it in various different simulation data to get the desired result.

Comparing to the system used in the project ELO, some improvements were done changing some parts, or creating new features. The graphical interface was improved by changing the bitmap graphics for vector graphics as shown in Figure 4-6. The graphics were useful to allow the interface to adjust itself in various different screen sizes and resolutions. The utilization of vector graphics also made the creation of the interface assets easier, and allowed the creation of new types of menus and panel like the side panels that compound most of the filter application interface.

Previous slide save panel made using external bitmap images for composing and displaying the panel itself and the buttons.

New slide save panel made using ActionScript 3 internal graphics API for for displaying the panel itself and the buttons with vector graphics.

Figure 4-6. Comparison between bitmap and vector interface graphics.

There were also improvements in the database design that allowed the creation of the tag system, search engine, and edition and version tracking features that could not be finished during the tests in University of Brasilia. These features are important to enable fast access to the contents stored in the database, the creation and use of templates.

During the project ELO, the teaching materials were stored in the database without direct references to versions, and every time a teaching material was updated, it was overwritten in the database. The information about the previous edition was lost, unless the teacher or tutor had made a backup manually, saving the teaching material as a different version before the update, or saved the new updated edition as a version. Therefore there was not possible to retrieve the past editions of the teaching materials, only the different versions.

With the new database scheme, along with the content configurations data, there is also information about edition and versions relationship. As shown in Figure 4-7, the database now also stores information regarding if the saved content is an updated edition of other content, or if it is a new different version of other content. This allows the database to store information about all content editions and versions that were created over time, past editions of the content can also be retrieved.

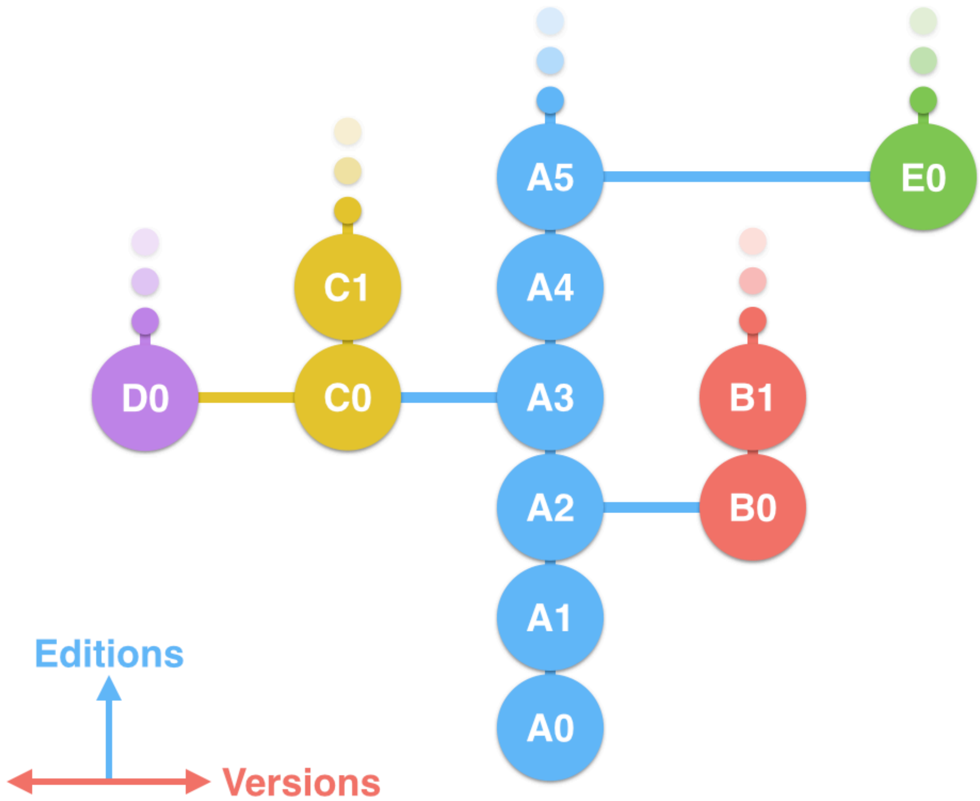

Figure 4-7. New content relationship diagram.

Every time a content is changed and saved in the system database, it can be saved as a new edition, or a new version. An edition is when a content is changed in order to improve it, like correction some problem, or add more examples, therefore it generates an updated edition that is meant to be used the same way the previous one. A version is when a content is changed in order to make it suitable to be used in a different situation, like a translation to another language to be used by student from a different country, this change generate a new version of the content.

In the sample of Figure 4-7, a teacher created the content A, the first edition of this content is represented as A0, it is a completely original content, that do not have any kind of relationship with other content. Over time the content A is updated to insert more detailed explanation about its subject, generating a new edition A1. In the database A1 has a reference to the content A0 as its original edition. This update process can repeat as many times is necessary to a content to be updated, generating new editions like the A2, A3 and so on. All the new editions will have a reference to the content A0 as its original edition, and the editions are organized in chronological order.

Continuing with the sample in Figure 4-7, there is a vertical line connecting the content A2 to the content B0. This line shows that there is a relationship between this two content. The vertical lines connect content that are versions, in this case the content B is a version of the content A, and reason why the line is connected directly to the content A2 is because, B is a version of the content A that was created using the edition A2 as template.

When a version is created, the reference in the database holds the relationship information that indicates which content was the original version, and which edition of the original version was used as a template to create the new version. The versions can also have editions, as they may need to be updated over time. The update of versions are independent of the updates of its original version contents, as shown the the Figure 4-7, after A2 the content A continues to have new editions, that has no connection with the edition B1 of the content B.

Any content in the system can have multiple versions, like content A, has three more versions, the content B, C, and E. These are all different versions, and can have independent updates that generates new editions of each version. There is also possible content like the content D, that is a version of content C, that is a version of content A. In this last case, the content D do not holds a directly reference to content

A, however since the content C has its reference to content A, the system can track the whole evolution path from content D to A passing through C, to find the real origin of the content if necessary.

The edition and version tracking feature is useful to understand what happened to a content over time, how the content needed to be altered to meet the new necessities that appeared as the content was used in different situations. Also helps to retrieve content used in the past, and allow the creation of version created based in specific editions that are more compatible to the purpose of the version.

The new database scheme also hold references to the tag system. The tag system allows the author of a content to mark the his/her content with tags, these tags can be used to identify, or describe the content, giving information about the author, kind of content, the target students the content was created for, suggestions about how to use the content, and so on.

The tag system also allowed the implementation of the search engine, the tags are used as keyword by the search engine. This feature allow the users to search content in the database using keywords referent to the type of content, subjects, author names, etc making the access to the content much easier than was in the project ELO. result list of the search engine also has options to show a list different versions or other editions of a content listed in the results. Helping the users to find any content, and even access to any version, or edition of that content.

4.4 System operation and features

To create a new content using the Skynavi system the curator needs to first use the Zakkyo Sky Navigator to generate the simulation data, based on the forecasted date and time of the observation. In this case there is a simplified version of the version of the Zakkyo Sky Navigator that is used exclusively to generate the data regarding the position of the stars inside the observation range.

The Zakkyo Sky Navigator is and simple application created using the Processing framework, and programmed in the Java, that runs offline in the curator's PC. The curator only needs to set the date and time, making the clock go forward or backward using the keyboard keys ">" and "<," respectively. When the desired time is set, the curator can push the "0" key to output the data in a CSV file. The CSV file is named with the date and time set in the simulation in the format YYYYMMDD_HHMMSS.csv; for example, if the simulation date is set to May 31, 2015, at 21 hours, 8 minutes, and 10 seconds, the name of the file will be 20150531_210810.csv.

The content of the file is a simple list of the stars that were inside the simulation screen with their database index, X and Y positions, and magnitudes for normal stars. In the case of the Sun, Moon and other planets in the solar system, because they do not have a database index neither magnitudes, the index is replaced by the "#" character, followed by a solar system index number: 0 for Sun, 1 for Moon, 2 for Mercury, 3 for Venus, 4 for Mars, 5 for Jupiter, 6 for Saturn, 7 for Uranus, 8 for Neptune, and 9 for Pluto. The last two numbers are the X and Y positions. After generating the CSV file, the curator can upload it to the system web server using a FTP client.

After finishing the upload of the simulation data, the curator needs to access the filter application. The filter application is a web application developed using the Apache Flex framework, programmed in ActionScript. The application has also some PHP scripts to support communication with the system server for loading and storing data in the MySQL database, and also help reading the files in the CSV files database.

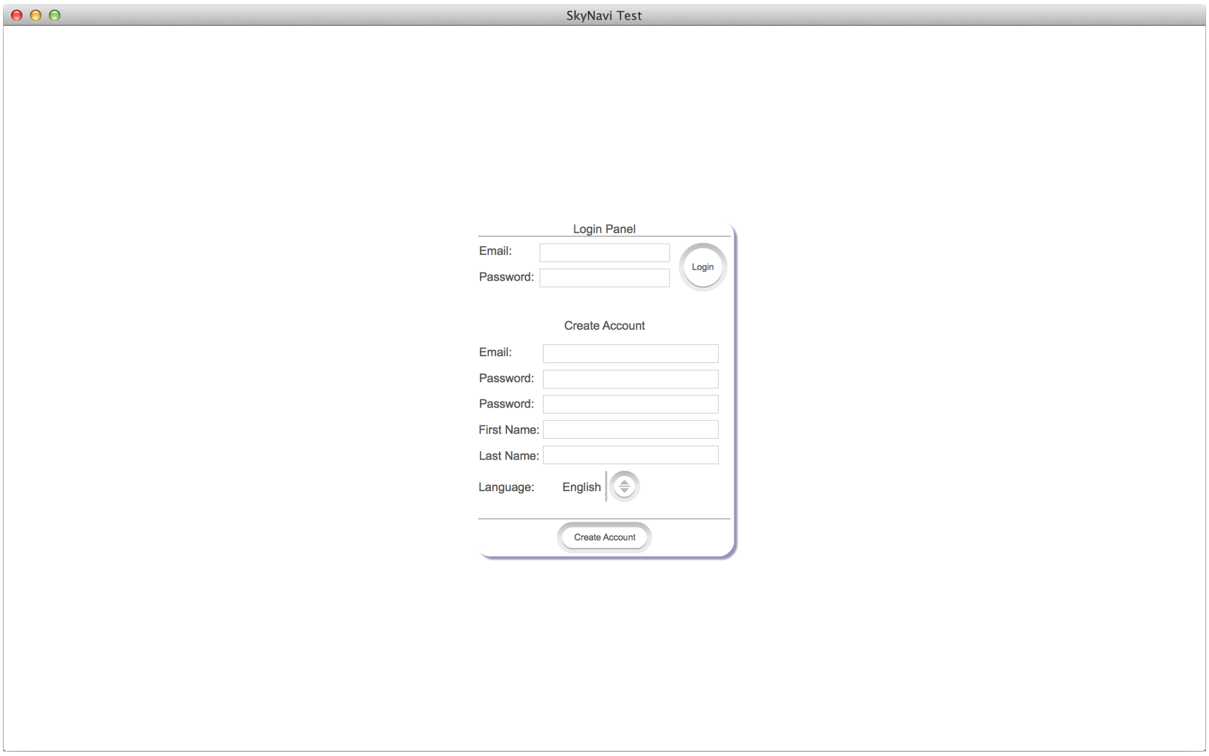

Figure 4-8. Filter application main screen.

The first time a user access the filter application, he/she needs to create and user account. The account hold information like the user email, password, and name. The user can also select a language between English and Japanese, this language will be used as default interface language every time the user login, however the language can be changed when the user is using the application later. The account is necessary for the system to register who created the content, and also make some kind of update, changes, or create content versions. The name of the user can also be used as a keyword in the search.

After creating the account the user can login using their email and password, and start creating the content. When the user completes the login process the application loads the stars data CSV file to create the necessary star objects. Then the user can uses the clock to localized in the upper left corner of the screen to open the time list and choose the desired simulation data, as shown in Figure 4-9.

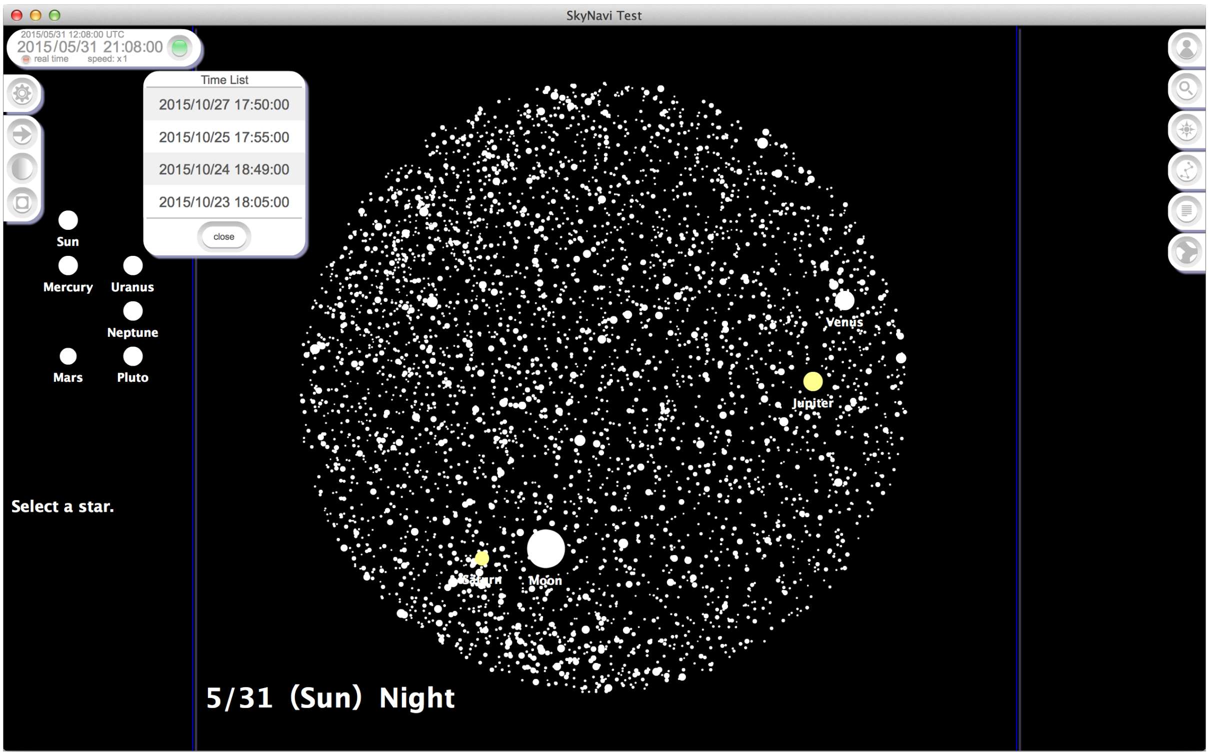

Figure 4-9. Clock and time list used for loading simulation data.

Originally, the idea was to allow the user to use the clock to set any date and time; therefore, the application could do the simulation and show the stars on the screen. However, because the simulation function has being moved to the other application, the user only needs to click the green button that appears when the mouse cursor is near the clock and choose the desired date and time from the time list that appears. After choosing the date and time, the clock is automatically set, and the simulation data related to the selected date and time is loaded. The simulation data have a list of the stars that are in the view range and their positions. After loading this data, the application displays all of the stars in basically the same way, but there is a slight difference in the sizes based on the stars' magnitudes. The planets and the moon each have a predefined size, and the moon phase is calculated based on the date and time of the simulation.

As shown in the Figure 4-9, there is a series of buttons on the right upper side of the screen, and also on the left side under the clock. These buttons are used to open the panels that hold the content edition interface and other features like interface language change, load and save content, search engine, and logout button. All the button are inside a side panel, when necessary the after clicked the button makes the panel expand to show more controls that are used to edit the content, or access other features.

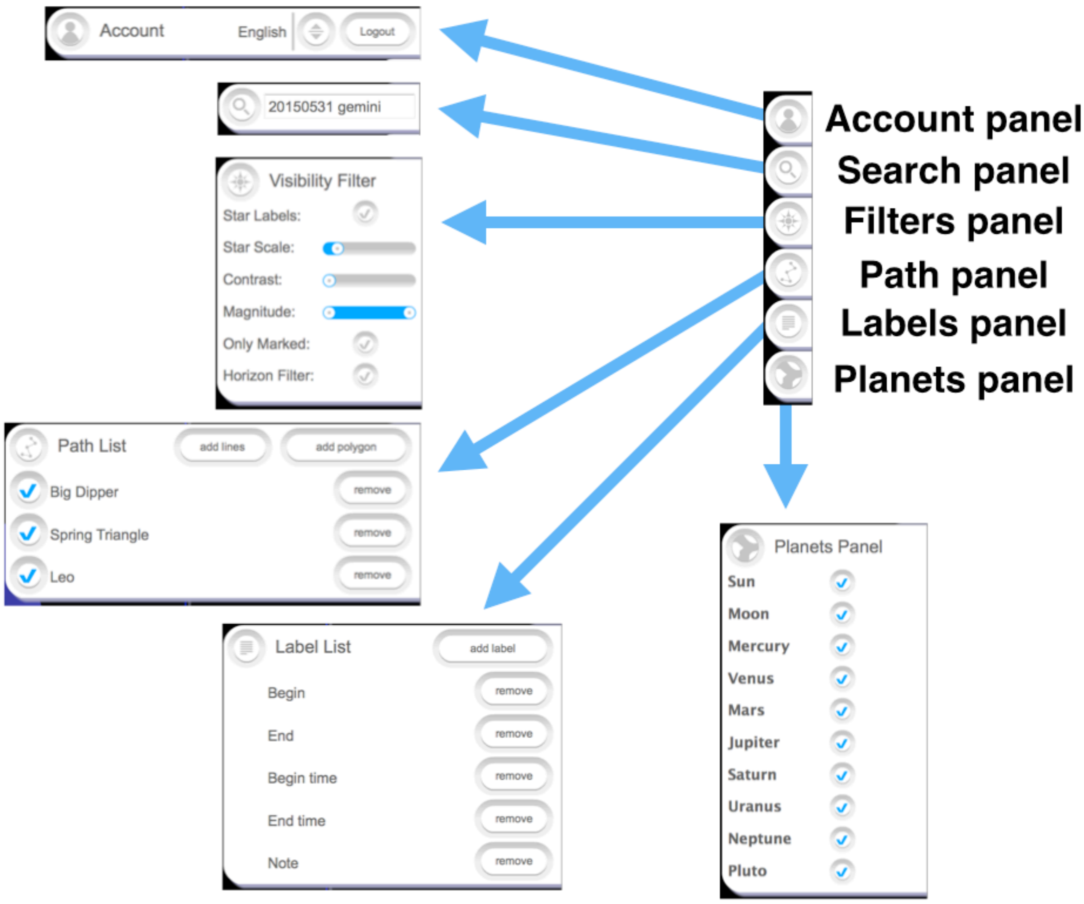

Figure 4-10. Right side side panel buttons and panels in expanded state.

The account panels has the buttons used to change the interface language and the logout button. The search panel when expanded shows the text input box for the user to enter the keywords for the search. The filters panels, hold the controls to configure the stars visibility filters. The path panel hold the controls to create and manage the lines used to draw constellations. The labels panel have the controls to create and manage the explanations labels and other text labels inserted in the content. The planets panel, hold the buttons that control the visibility of the Sun, the Moon, and other planets in the solar system.

After loading the simulation data the user can start configuring the visibility filters. These filters were created based in the Nagoya City Science museum curator's astronomy knowledge, and are used to control the visibility of the stars in the sky image create using the simulation data. Since the simulation data only holds the position of the stars, the curator needs to configure which stars are visible, and how much they are visible based in various aspects like, time of the day, season of the year, light pollution, etc.

As can be seen in Figure 4-10, after expanded the filters panel has six controls, each one for one kind of filter. The three more important are the magnitude filter, the contrast filter, and the star scale filter. The star scale filter is controlled by a slider control that ranges from -1.46 to 7.96. The slider has two values: a minimum value and a maximum value. Basically, the user sets the values in a range between -1.46 and 7.96 using the minimum and maximum sliders. Only the stars with magnitudes inside the minimum and maximum range are displayed. This filter was the first feature asked by the museum's curator, and probably is the most important because it defines the range of the visible stars.

Before, the curators had to separate the visible stars one-by-one in the image editor, but now, they only need to move the sliders to the desired values, and the system separates the stars automatically. Because the stars’ visibility is directly related to their magnitudes, and because the curators know the magnitude range that can be seen with the naked human eye in the different observation situations, it is much easier and faster to simply select the minimum and maximum magnitude values than to have to check the magnitudes of the stars one-by-one to determine if the stars are visible.

The contrast filter is used to create a contrast effect among the stars. The filter is controlled by a slider control that ranges from 0 to 1; a normalized value that defines the intensity of the contrast effect. This filter is used to simulate the effect of the brighter stars obfuscating the other stars. Without this filter, all of the stars appear to have almost the same size, even with their magnitude differences. The contrast filter works based on three values: the contrast intensity, the minimum magnitude, and the maximum magnitude set in the magnitude filter. Basically, the system retrieves a normalized value of the star magnitude inside the minimum and maximum magnitude range, finds the contrast level by multiplying it by the contrast intensity, and then multiplies the size of the star by 1 minus the contrast level. The result is, the stars with magnitudes equal to the minimum magnitude value set in the magnitude filter remain the same, and the stars with magnitudes higher than the minimum become smaller based on the how close they are from the maximum magnitude value.

This filter is also very important to the system. Before, museum curators needed to spend a lot of time making changes to the star sizes one-by-one, by hand, in the image editor because they needed to check every star's data to see how much bigger or how small a star should be compared to the other stars. Now, because the system already has these kinds of data, it can automatically calculate the sizes of the stars based on the filter settings.

The size scale filter changes the overall scale of the stars' sizes. The filter has a slider control that ranges from 0 to 100; the selected value multiplies the original star size calculated based on the star magnitude. This filter is used to adjust the scale of the stars in the final image if the user needs stars to proportionately look bigger or smaller depending on what he/she is explaining or wants to show. This filter is generally used to adjust the size of the stars when the stars get too small after the application of the contrast filter for example.

The horizon filter is a really simple filter; it has only an on and off button. When turned on, the filter hides the stars that are less than five degrees higher than the horizon line. Those stars are usually so low in the sky that they cannot be seen because of the terrain or the city buildings, for example. In the case of this kind of content, the horizon line means the border of the blue circle.

The star label filter is a simple filter that shows or hides the stars' name labels. This is useful when the number of visible stars is low. The user does not need to turn the star labels on or off one-by-one. The only marked filter is used in the case the user wants only a small group of stars to be visible, independent of the magnitude range, the user can mark the stars he/she wants using the stars context menu, and then turn on the filter.

Sometimes there are specific configurations that needs to be applied only in individual stars, specific configurations that go beyond the filters features, or specific cases that can not be applied to all the stars at once. For these cases the user can use the context menus of the stars showed in Figure 4-11.

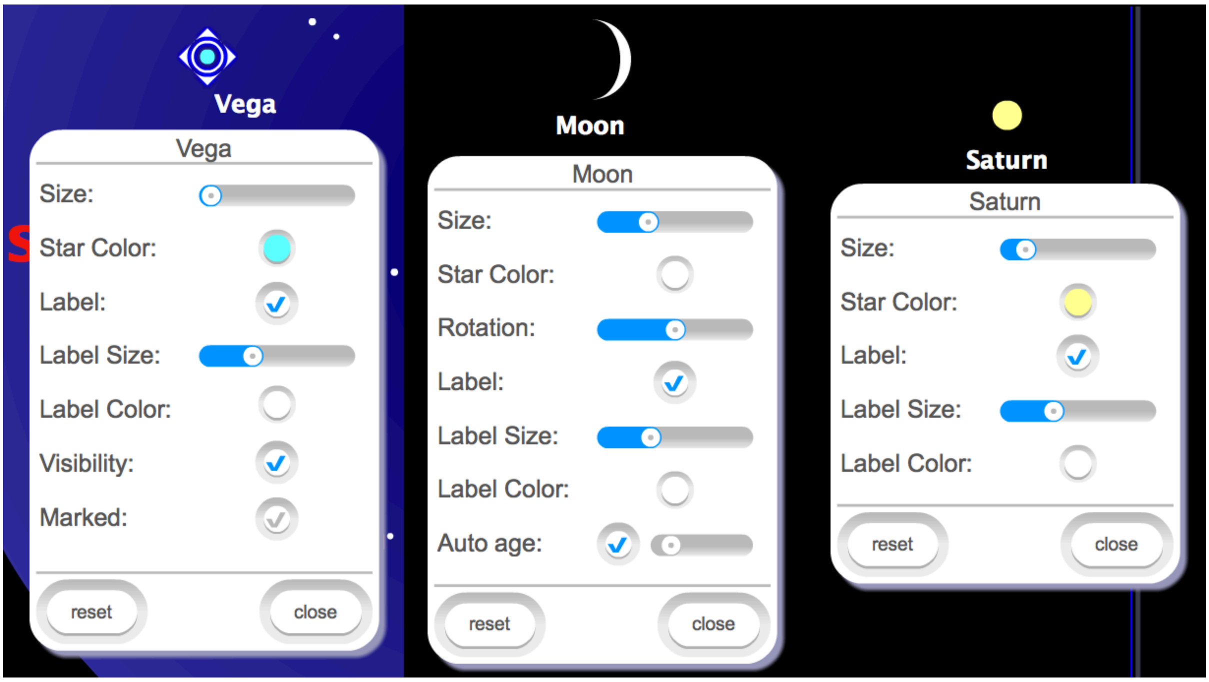

Figure 4-11. Star context menus.

The Moon, the Sun, and the other planets in the solar system also have a menu similar to that of the other stars, but in the case of the moon and the planets, they are not affected by the general filters. Therefore, all of the necessary settings need to be adjusted using individual context menus. The simulation application can calculate the positions of the moon and the planets, but defining how they are visible from Earth is a really complicated task because their magnitudes change as they move in relation to Earth. Therefore, the museum curators in the current research study opted to do this manually themselves when necessary.

The controls present in the context menu of the planets are common to all other context menus, however the Moon and the other stars context menus have some additional controls, that are different from the other menus. The common controls are used to make more precise adjusts to the size, change the color, turn on the name label, change the size of the name label font, and change the color of the name label. The additional controls in the star context menu are used to make that star visible or invisible, independent of the other filters, and the option to mark the star to make it visible if the only marked filter is on.

The additional controls of the Moon context menu are used to make additional adjustments that go beyond the filters and simulation data. Usually the Moon phase is calculated by the system clock when the auto age control is on, however the user can turn the Moon's auto age off the set the Moon age by himself/herself, if he/she notices that is something wrong with the automatic feature. The Moon also needs to be rotated match the real position of the Moon in the sky, until now the simulation data only generates the X and Y position of the Moon in the screen, the curators needs to set the rotation manually.

The Moon can also be dragged; this feature was useful because sometimes the moon can get in front of a star that was an important visual reference in the content. Therefore, the museum curators asked to make the moon draggable to help to make the image easier to understand, even if that meant the Moon position would not exactly match its position in the real sky.

Using the controls in the path panel the user can create and manage the representation of the constellations. The constellation database is being created as the museum curators use the application. They are registering the constellations as needed when creating the content. When the user needs to show a constellation that is not yet registered in the database, he/she can register it by creating a new star path object. The star path object is a simple object with a list of the stars that are used as references for drawing the lines of the constellation. To create a new star path object, the user only needs to choose the reference stars in order. The order is important because the application will follow the list order for drawing lines between the stars. After choosing the stars, the user needs to open the path panel and click on the "add lines" button or "add polygon" button. The difference between the two is that the "add polygon" button will make an extra line connecting the last star of the list with the first one, thus making a closed polygon.

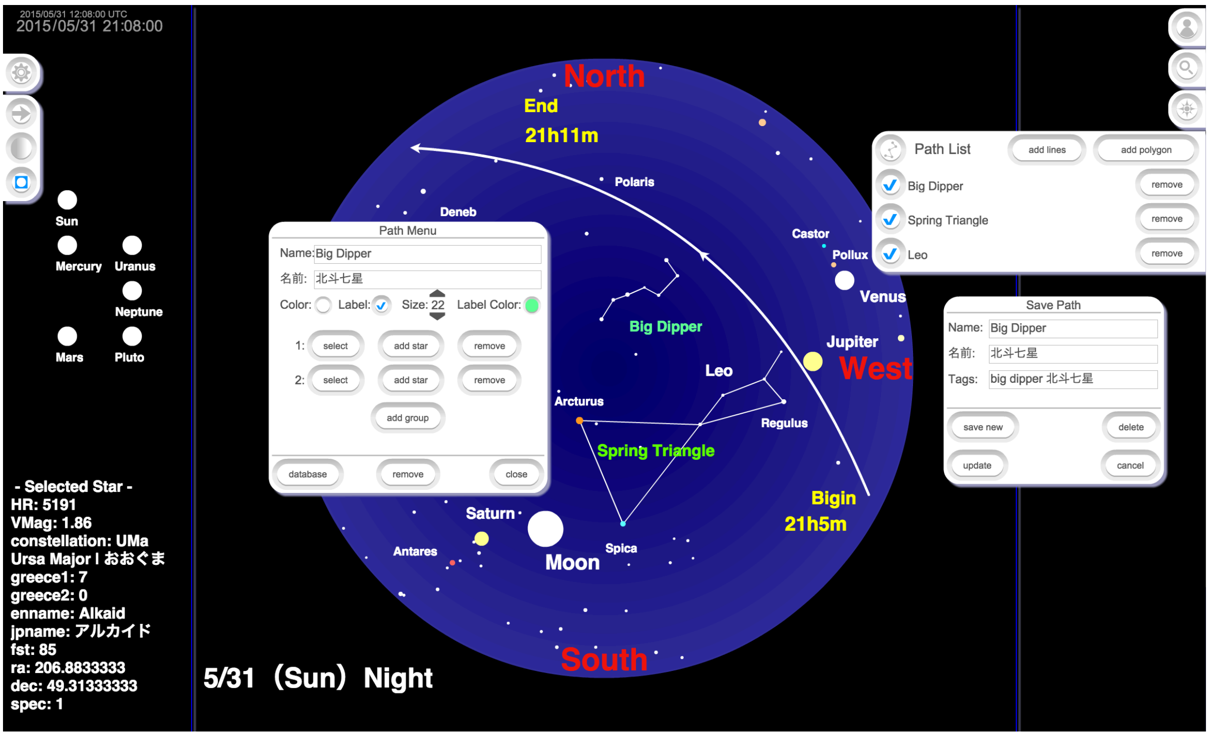

Figure 4-12. Constellation menus.

After adding the star path to the content, the user can make some changes to the path using the path menu (Figure 4-12). The user can, for example, change the lines' colors and show or hide the constellation name label. The user can also register the created path in the constellation database using the menu. Because the constellation lines are drawn using the stars as references, the same database entry can be reused in any situation in which the constellation is visible, regardless of the position of the stars on the screen. In other words, the same star path object can be used in any content that shows the constellation it represents. Before, curators needed to draw the constellation lines by hand in the image editor every time; now, they only need to set the constellation once.

To insert the necessary explanation about when and where the ISS can be seen in the sky, the user can insert text labels and draw lines, curves, and arrows. The text labels are usually simple text messages used to explain the time interval when the ISS can be seen, and an arrow is used to show its trajectory in the sky. Since the labels appear with a certain level of frequency; however, because they can change a little depending on the content, these labels are stored in the MySQL database as templates. When needed, the user can load the template label from the database and only change the necessary part.

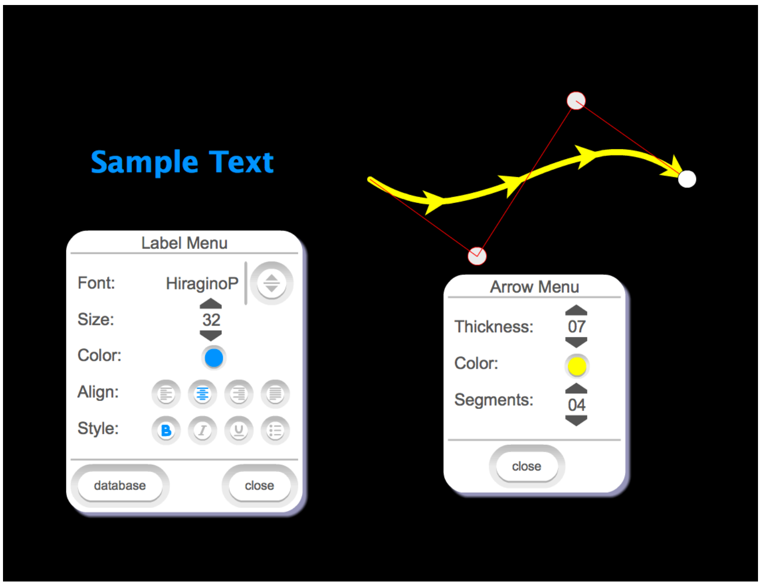

Figure 4-13. Label and arrow context menus.

The user can add a label to the content using the button add label in the labels panel (Figure 4-10), the labels panel also hold a list of all labels present in the content. The user can remove the labels clicking the remove button on the side of each label in the list, by selecting the label and pressing the delete key. The label context menu have options to control the text, font, font size, color, align and style, and these options works like any other text editor.

The arrows can be inserted in the content by clicking the arrow button on the left side of the screen under clock. after clicking this button the application enters in arrow mode, the next place the users clicks inside the content will be used as the arrow origin, after clicking the user can move the mouse to make an arrow from the origin point to the current mouse position. When the user is finished positioning the arrow, he/she can click again to finish the arrow. The arrow context menus has controls to set the arrow thickness, color, and number of segments. The user can also drag the arrow, or just click the arrow to show the control points, the circles connected by red lines. These controls can be dragged to change the arrow direction, or make it bend.

On the right side of the screen under the arrow button there are two more buttons that are the gradient button, and the mask button. The gradient button is used to reveal the controls used to set the background color, used to simulate the sky color. The mask button is used to turn on the mask that hides everything that is outside the observation range, cropping the content image in a circle, the mask also have labels for the cardinal points. The mask context menu have controls to set the color of the cardinal points labels, and the color for the content area outside the observation circle.

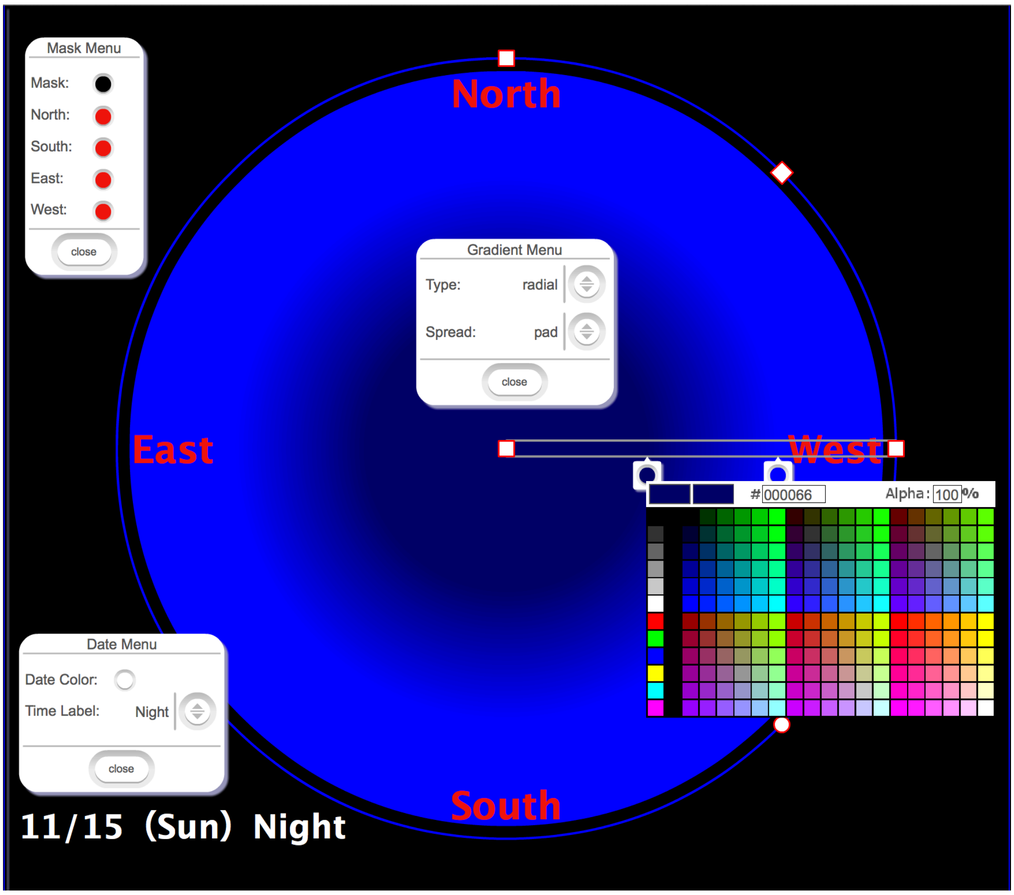

Figure 4-14. Mask and sky gradient controls.

There is also a labels that shows the date, and part of the day when the observation is suppose to happen, for example during the evening, night, or dawn. This label also have a context menu to change its color and the Time label of the part of the day the observation is happening. The gradient context menu is used to change type of the sky gradient, there are two possible options, radial and linear, and the user can also set the spread type choosing between, pad, reflect, or repeat. The user can add more colors by clicking inside the gray rectangle and dragging the colors to change the colors' positions and order. The red circle and squares can also be dragged to adjust the rotation angle, width, height, and scale of the gradient. The background color can be changed to mimic the sky's visual condition as expected by weather forecasting and other visual factors.

Almost all the action executed by the user can be undone, or redone. The undo and redo feature is important to help the user test and compare configurations, and also to return to a previous state when some kind of mistake is done. However of the DTM concept this feature is the base of a future feature that could not be completed yet. The undo and redo feature works tracking all the actions the user did when operating the application, the idea is to record this actions with the content itself to allow other users to reproduce the content creation steps, therefore the novice users can in fact see the content creation process afterwards, and learn how the content was created.

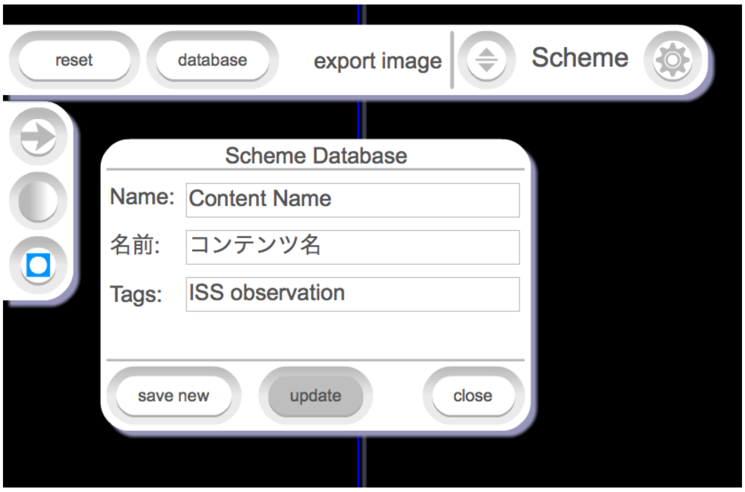

Figure 4-15. Content export and save menus.

Above the arrow button, there is the scheme panel (Figure 4-15), this panel is used to save the content, or to download it as a JPEG image. After the user has finished configuring the filters, inserting the labels and arrows, setting the background color, and completing other possible necessary tasks with the content, he/she can save the content in the database. In addition to the explanation labels and the constellations, the overall content settings can be stored in the database. The application saves all of the filters' settings, all inserted labels and arrows or lines, and the individual settings of all stars, the moon, and the planets as well as the background gradient configuration. When saving, the user also needs to insert the content name and then tag the content with keywords.

The database entry of the content also has columns for the content author, date of creation, and content relationship reference. To access a content stored in the database, the user needs to use the search panel on the upper right side of the screen. After inserting one or more keywords and pressing the enter key, the system shows the results of the pieces of content that match the inserted keywords, if any. The search results also include explanation labels and constellations; therefore, the user can use the same search box to search for any kind of content in the database.

The search filter organizes the results, showing the newer content pieces first. The user can also search for newer or older editions of a given content by clicking the updates button under the content name in the results list. A new panel will open showing all of the updates of the selected content. The versions button will also open a new panel showing all of the content pieces created using the selected content as a template. That allows the users to have access to all updates and to all versions of all of the content pieces and also to understand the relationship between them and examine how the content pieces have changed over time.

4.5 Evaluation tests and results

To evaluate the system, a series of tests and meetings were conducted with the Nagoya City Science Museum curator and chief of the astronomy section beginning on November 7, 2014. During the meetings, the development team discussed with the museum curator problems concerning the creation of the ISS observation content and possible ways of solving them.

Since there was no specialized app to create this kind of content, the image were based in the output images of the heavens above site application. The output image was used as base layer in photoshop and new layers were created in the top of it to redraw the necessary stars in the right size. There were also different layers for the final background, explanation labels, lines and arrows. The curator created a predefined list of brush sizes to represent the most and the less bright stars, however he still need to check every star which one was the most bright, which one was the less bright, and also how much the stars between these two will change in comparison with the others.

The main problem that the curator faced was the time spent on creating the content. To solve this problem, the development team created features in the system that automated some of the content-creating processes that the curator had to do by hand using an image editor—for example, drawing or erasing stars.

In the first two months, the tests were focused on the application’s interface. After the museum curator explained the desired system features, the development team needed time to adjust the interface and to fix problems because the curator usually had time to meet the development team in person only once per month, and most of the communication was done by email. During the tests, the curator who was the main tester already had some knowledge of programming and image editing. This helped to foster communication and a mutual understanding during the development process because both sides knew their necessities and limitations.

There are only three people in charge of creating this kind of content in the museum, the other staff still using the photoshop technique until the first stable version of the Skynavi is completed. More tests still need to be done for the interface, a really easy to use interface is important, and the interface needs to be consistent to the way the user works, therefore the interface makes sense to them and they can use it naturally [26],[35]. Those curators who do not have this kind of specialized knowledge about image editing will probably try to use the application in different ways, and because even the order of some processes is important in the application, they may have some problems with the interface.

After the main interface of the filter application was finished, the curator stated that he needed 30 minutes to create the first image using the system. For the second one, he needed only five to ten minutes to create a new image from scratch. When creating images using Adobe Photoshop, the curator spent about 20 minutes per image, as the images could not be combined or used as templates for new ones. Every image needed 20 minutes; now, only five to ten minutes are needed to create completely new images, and the possibility of combining or using other content pieces as templates and reutilization of the filters to create new images can make the process even faster.

That makes the process of creating the content using the Skynavi filter application at least 50% faster per image. In a process that involves multiple similar images the overall process can be even faster since only the first image will be created from scratch, all the other image will probably share the same, or use very close filter configurations and explanation labels created based on the ones used in the first image. Table 1 shows a time comparison between the content creation process done using Photoshop and Skynavi in a situation where multiple similar images needed to be created to show the sky of four consecutive days, all the images have size of 2400 by 2100 pixels.

Table 4-1. Time comparison between multiple similar images processes.

Image	Time with Photoshop	Time with Skynavi
first	20 minutes	10 minutes
second	20 minutes	5 minutes
third	20 minutes	5 minutes
fourth	20 minutes	5 minutes
Total time	80 minutes	25 minutes

The implementation of the content database and search engine was also an important factor in improving the speed of the content-creation process. The database allowed the user to store the content configurations in the system database and to reuse them as templates to create new content, combine two or more content pieces, and reload and update content. This was not possible before because the curator had only the finished images and Photoshop files with the image elements divided in layers.

In order to create new content for a different date and time, even if the visible star and explanation labels were the same, a new simulation output image was necessary to get the correct positions of the stars. Therefore, the curator could reuse the explanations labels layers, however needed to edit the new layer of stars from the beginning again. Now, the curator can load the new simulation data and apply the desired filter configuration and explanation labels from the database, a process that should take seconds instead of minutes.

The filters and the database made the process much faster, but there are some problems when using the interface in computer the small screens, like 11 inches, because of the size of the interface labels' font. Even if the system is not being used on mobile devices due to the large difference of screen sizes a responsive interface design may be necessary to solve this problem, However since the problem is the real size of the screen, and not the screen resolution in pixels, the standard approach of the responsive interface design that is based in the screen resolution is not enough for this case.

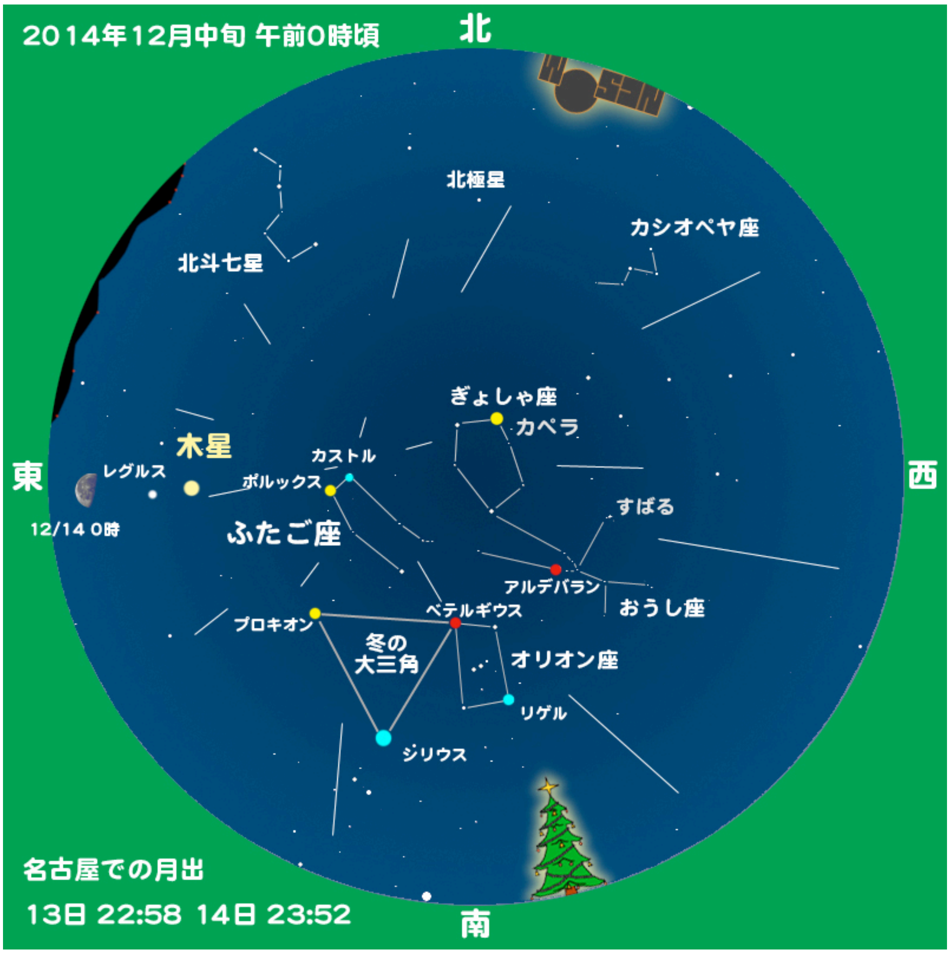

Figure 4-16. Christmas-theme content.

During the tests, the only content that the curator could not create using only the Skynavi was a content for an observation near Christmas Eve (Figure 4-16). It was not possible because in this specific content, the curator wanted to use Nagoya city christmas decorations as references to help to orient the sky observation. For this, it was necessary to insert some extra images on the horizon line to show the direction of the city's christmas tree and the Nagoya City Science Museum. In this case, the curator created the base observation content using Skynavi and edited the final image using Photoshop afterward to insert the images of the Christmas tree, the museum and the mountains.

The feature of inserting images could be created for the filter application, or the same feature of the DTM system in the project ELO, that also allows searching the images from the internet could be used, however the curator did not requested this feature to be inserted before creating this content. The image inserting feature could also be useful for inserting images, more complex symbols, and representations of the constellations visible in the content to help in the explanations, however it was not necessary for any of the other content.

These kind of contents are usually posted in the Nagoya City Science Museum web site, in the area featuring study and astronomy news on the ISS. However these content are also used in planetarium presentation, lessons, used in displays inside the museum, displayed in the museum's library, and also used in newspaper and television news. As mentioned earlier, the content is used to explain when and where the ISS can be visible from Earth. The final content image is very similar to the images previously created using Photoshop; however, the creation process became much faster and also allowed the curator to create a content and template database and to easily update the content when necessary.

4.6 Conclusion and future works on Skynavi

In the development of the Skynavi system the users' knowledge was one of the essential points of the system design. The development team working side-by-side with the users can allow the team members to better understand the users' situation and the context in which the application will be used. Testing the application with the museum's curator during the application development process, allowed the development team to adapt the application in order to better fulfill the museum's needs and also the research objectives. Changes such as dividing the system into two applications had both bad and good consequences; for example, the overall process became slower than expected. However, it also opened the system up to new possibilities that had not being enabled before.

Having the simulation data provided by an external application, allow the filter application to get simulation data from different sources, as well as the Zakkyo Sky

Navigator can be improved to output the simulation data in different formats to allow the data to be used by other different applications to different tasks. This kind of feature can be useful in situations that the Skynavi system is being used in a collaborative research that the different teams need the same kind of data, but in different formats, or need to test data from different sources.

The Photoshop approach to create the content did not allowed the creation of a structured database the Photoshop itself do not have this kind of feature, and the only remain of the creation process was the image itself. There is indeed a folder based storage of the image files, named by date, and sometimes the explanation labels and arrows layer inside each image file could be copied and pasted to create new images, but there was no real database or search engine, therefore reuse content created in the past the curator also need to spent much time to find the content that could be used.

It is accurate to say that the system had a good evaluation, as the amount of time necessary to create the content was the main problem for the user, and with Skynavi, this time was cut in half at least. Some content still cannot be created using just Skynavi. However, the part of the content that cannot be achieved using Skynavi has no relationship with the curators' astronomy knowledge. It is related to very specific cultural aspects of the region and local environment that were beyond the focus of this research study. The system also allowed the team to create and test an improved version of the database and search engine used in the dynamic teaching materials system. The improvement allowed the user to track the evolution of a content and see how it changed over time; it was also used to help to create other content.

Now the Skynavi is being used only for contents related to the ISS, however it can also be used for other contents related to sky and stars observation, like observation of constellations, or phenomenons like lunar eclipse. The improved database and search engine are an important step in the next part of the research study. The possibility of tracking the evolution of the content and seeing how it changes over time can also help the user to understand why the content changes over time. For example, if a user uses tags or comments to describe what is new in the updated version of the content and why the updates were made, maybe other users can learn through his/her experience and get some advice about editing content. The creation of this kind of community learning among system users can allow them to evolve and to become better content creators as they use the system and learn from other users' experiences [4].

CHAPTER 5

Adaptation to e-Learning Through Community Learning

5.1 Introduction

This part of the research study has the objective of implement the results of the evaluation tests done in the other previous parts to improve the Dynamic Teaching Materials concept and system. The application of the DTM concept in the project ELO and Skynavi was focused on the contents being created and in the process necessary for the content creation. The objectives of the two projects were achieved, however there are still improvements that can be done and problems that were disclosed and still need to be solved.

In the previous parts of this research study, there were successful and also less than successful points in the implementations of the DTM concept, and also in the DTM system. In both cases there were also unexpected factors that helped the successful points, or were the reasons for the less than successful points. These less than successful points, and the unexpected factors indicate that the necessity of revise the DTM concept, therefore it can in fact cover all the necessary aspects of an e-Learning environment creation, and all the aspects of an e-Learning system development.

The first version on the DTM concept could successfully create the necessary functions that allow the teaching materials to be dynamic, allowing the teachers themselves to make the teaching materials evolve following the changes of the educational environment. Also allowed interactive multimedia teaching materials to be created using only a WYSIWYG interface, making unnecessary the direct use of programming languages by the system user for this task.

However the DTM concept neglected the fact that the system users compound a community, the learning community, dealing with each user as an isolated individual, that has his/her own isolated necessities independent of the rest of the users. This fact was the main reason of most of the less than successful points, and unexpected factors during the DTM concept creation, system development, and system implementation.

The revision of the DTM concept has the objective of expanding the concept, therefore it can cover all the users as a learning community. There is a necessity of analyzing the benefits the ICT can bring to the e-Learning environment before implementing it, the situation of the users, the situation of the environment, and how it is going to be used [36],[37],[38]. The result of this kind of analysis can help in the creation of strategies to help the users organize themselves in order to better prepare the e-Learning environment, take advantage of the technologies, as well as create support strategies to help novice users to smooth the initial learning curve. Strategies like the creation of offline and online support teams, as happened in the project ELO.

The revision of the concept also affects the DTM system because it makes the system development focus more on users communication features. Communication features not only for the classes subject learning process, but also to facilitate users to exchange their knowledge about the system, and content inside the system. Features to improve the user's feedback, and help the users to discuss about what should be the best solution for a given problem, how not only the content, but also about how the system itself could be improved when the community faces some new challenge.

Developing a concept that is more focused creating an e-Learning environment based on the learning community necessities, how to make the technology available to the community accessible, and how to make the community able to handle the technologies, can be much more effective than just creating isolated systems that solve isolated problems. The learning community should be able to learn and evolve by itself, instead of being dependent of an external group, or company to solve the community's problems.

5.2 Summarizing possible concept and system improvements

The previous version of the DTM concept and system have successful points that still can be improved, unsuccessful points that led to problems that need to be solved, and also some unexpected factors that helped in some points, and became barriers to other points. These facts created the necessity of a revision of the concept in order to make the concept achieve its full potential, solve the remnant problems, and expand it to cover all the necessary aspects of the e-Learning environment and system development.

The successful points that still can be improved include:

- Interactive multimedia teaching materials editing interface.
- Sharing features.
- User communication features.
- Tag features.
- Search engine.

Some changes in the DTM concept can lead to improvements in the editing interface. Before, the interface was focused on the dynamic teaching materials and its internal features, with very limited support to external content. However the system needs to be prepared to the fact that, there are other systems being utilized by the users for content creation, that they are familiar with, and they want to use the content they have already created. Therefore the interface needs to be flexible to support these external technologies. In this kind of cases the DTM system cannot guarantee the real time editing feature, however the edition and version management can still be applied to the whole teaching material.

Regarding the sharing features, the system in fact allow all the content stored in the database to be accessed by any users registered in the system. However the problem is when a user creates a content, the only way this user have to notify the other users that there is a new content, or a new edition, or version of a content, is manually using the general communication tools that the users use for any other kind of communication. Since in the case of project ELO all the content was directly related to a course, and the number of users in each course was low, features like mailing lists or forums were enough. However the users that were not registered to that course, but have interest in the subject could not know about the new content, unless he/she gets a directly message form the author.

The DTM system did not have any internal communication feature, and did not have any kind of support to the external communication features, like emails and instant chats. This limitation did not caused problems for the users since most of them were already familiar with emails and mailing lists before the project start, however when the users need to talk about a specific feature or a specific content, should be more useful if they could like the message to the content, or feature, therefore the content authors and the development team can be aware if there is some problem that need to be fixed in the content, or system feature, improving the feedbacks.

The tag features and search engine are features that need to be created together with the user community, because they are directly related to the way the community organize itself and how the users operate the system. The development team cannot decide which tags are going to be used in which kind of content, and which search filters are needed to show the appropriated results for the users. Even if there are already some search filters and tags created in the system, there will always the necessity of new tags and new filters, because of the advent of new types of content and new working techniques, and the system needs to be flexible to support these new configurations in a meaningful way for the users.

The unsuccessful points include:

- Content management.
- Feedback features.

Is possible to say that the content management was unsuccessful on the side of the user, because there was no feature in the system that allowed the user to manage his/her content, or content created by other users that he/she had interest, all the content management was done automatically by the system. The user could create new editions, or versions of any content, however the user could not control the content access, and also could not create private content folder to organize and have faster access to contents of interest, or for example, organize his/her own contents in folders, or packages, to let other users know that there are more content related of to a specific topic, or more content of the same type.

Due to limitations in the communication features, all the feedbacks needed to be done using the normal communication tools. The problem with this situation is that the feedback message is not directly linked to the content, or system feature that the feedback is about. Since there are many editions and many versions of a single content, and all of them can be accessed at the same time, if the user that gave the feedback do not specify which edition and version of the content he/she is writing about inside the feedback message, the content author, or the development team cannot know which one message is about. Therefore the system needs internal communication features, or at least a way to store a reference to the specific content, or feature being the subject of a feedback message.

The unexpected factors include:

- Support team strategies.
- Students participation in the system development.

- Students participation in the content creation.
- Learning community using the system development and content creation as extracurricular activity.
- Presence of closed source features.

The most unexpected factor in this research was the participation of the learning community, especially students, during the project ELO. The participation of the volunteers students in some parts of the system development and content creation was essential for the speed that the system could be implemented. Also helped to prevented naturally serious problems that the development team could have with human resources management.

The students' willingness was a really important factor to motivate the whole learning community to use the system, also helped the community to understand the necessity of this kind of system, and the benefits it brings to them. The support team strategies were a key element to the creation of the necessary infrastructure to implement the system, specially regarding offline tasks. The workshops were also important to allow the creation of situations that encourage the users to share they knowledge about some technology, and at the same time learn from the other users about different technologies they did not mastered yet.

This knowledge exchange is important because an e-Learning system can be really big, and complex, regardless how easy to use is the user interface created by the developers, or how advanced are the users. There are always new technologies, and new techniques to use the technologies, therefore there is always something new to learn. Allowing the users learn from other users experience can be a really good solution for smoothing the initial system learning curve.

The interest of the students in participating so deeply was also because of the opportunities that this kind of extracurricular activity could open. Generally the university does not have lectures about educational technology, and teaching materials creation as a mandatory lecture in the courses. Therefore the system can also help the users to get knowledge and experience in this kind of tasks, that are also important to help them become more prepared for their future jobs.

During the development of the Skynavi system, the requirement of the museum for not making the simulation part of the process open source, caused changes in the system design. This requirement made the system that was supposed to be completely online, to be divided in half offline and half online. This situation made the overall process of operation the system slower, however opened new possibilities for the simulation data management.

Another important factor for the revision of the DTM concept was the advent of new technologies like HTML5, and the diffusion of the smartphones, also the fact that the technologies like the flash player that was really important to the development of the system until now, are losing support and probably will not be the available for the users in the future. The concept needs to be less dependent of specific technologies, and more flexible to allow changes like the incorporation of new technologies, and also the replacement of the technologies being used.

There are many technologies that can be used for the same tasks, the DTM concept needs to be focused on the necessary tasks, and allow the technologies to be chosen in the application of the concept in a given learning community, allowing the learning community to see what technologies are available to its case, and pick the one that is more suitable for the community needs.

5.3 Revision of the DTM concept

The objective of the DTM concept was create an e-Learning system that allows teachers to create interactive multimedia teaching materials in real time, allows teachers to share these teaching materials, enables the teaching materials to be accessed from any place with an Internet connection, and allow the teaching materials to evolve, being adapted to follow the continuously changing educational environment. However to implement such system, the e-Learning environment needs to be prepared to offer the necessary infrastructure, and the users need to be prepared to operate the system's technology.

Since the preparation of the e-Learning environment, and the training of the users are inevitable problems, especially when the e-Learning project is introducing new technologies. The e-Learning projects need to offer some kind of assistance, or solution regarding these problems in order to be successful. The development and configuration of the e-Learning system is a really complicated task, and requires advanced ICT skills to be accomplished. The teachers cannot be in charge of this kind of task, however the teachers need to be able to operate the system, and also orient the students in how to use the system to complete the necessary learning tasks [39].

The teachers and students, need to be able to operate the system, and also understand when there are changes in the educational environment that requires new system features, or some kind of update. Therefore they can give feedback to the developer about the fact that the current technology is no logger enough to handle the situation, and discuss possible solutions.

To help solve the above problems, the DTM concept needed to be revised, giving origin to a new version of the concept that covers elements of the e-Learning environment, instead of being focused only in the e-Learning system, and the teaching materials created with it. Another reason that lead to this revision of the DTM concept was the advent of new technologies that were not available when the project ELO started. This new technologies brought a whole new set of possibilities, that cannot only improve the previous concept, but also enable the creation of new system features, teaching and learning techniques.

Not only because a technology is more advanced, have some potential advantages means that the implementation of this technology is going to be successful, and will improve the teaching and learning process [40]. Is necessary to make an analysis to determine the problems that need to be solved, if the technology really can be used to solve the problem, the impact that this new technology in the e-Learning environment, and is necessary to implement strategies of use together with the technology.

The new concept is also focused in the creation of strategies and techniques to help the teachers, and students to organized themselves to take more advantage of the system features, and smooth the learning curve for novice users. Allowing users to learn more about the system, teaching techniques, and technologies as they use the system, through feedback, workshops, and the employment of utilization patterns. This can help users to learn from the experiences of colleagues who have more experience.

The strategies are important to raise the feeling of community between teachers and students. This community atmosphere help teachers and students to engage in continuous, or lifelong learning. The lifelong learning can be really important in their lives, making them better workers, more active citizens, also contributes to their well being, and also help them to understand and adopt innovative ways of work, especially when it is done in a contextually appropriated way [41].

Since the workshops are focused in the contents and technologies that the teachers and students are using during the online and offline classes, this study became an authentic, or real-world experience for them, with a direct practical application. Providing this kind of experience is really important to the learning process [42],[43], helping teachers and students to engage in learning activities with a true meaning, and that can be really useful in their daily life.

Due to the diffusion of smartphones, and several security issues with the Flash Player plugin for Web browsers, Flash Player may not be available in the near future, therefore technologies like the Apache Flex framework need to be replaced by new technologies like HTML5 to provide the necessary accessibility and compatibility. However the concept cannot be dependent of some technology, the learning community needs to be aware the technologies available for each task, and which one fits better to the community needs.

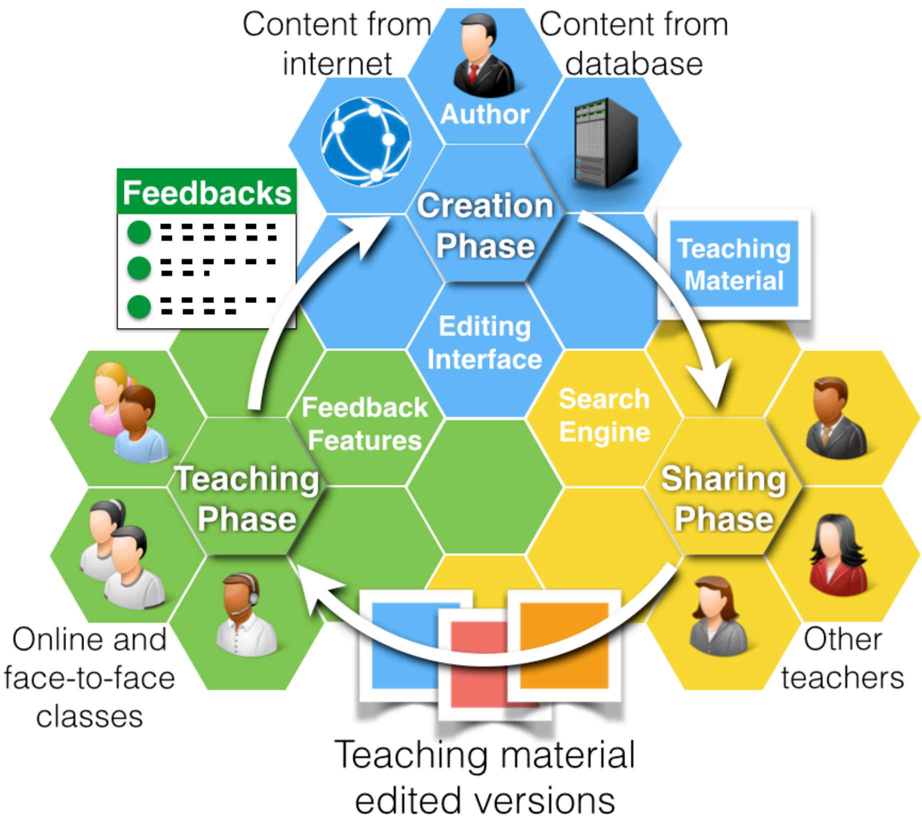

Figure 5-1. New Dynamic Teaching Materials cycle.

Compared to the first version of the DTM concept, the three operating phases of the system still the same, the creation phase, the sharing phase, and the teaching phase. However there are differences in the processes of each phase. The new real time editing interface needs to be compatible with external authoring tools, and services, especially for contents created using other web applications. The DTM system cannot guarantee the real time editing of the external content, however since these content are going inserted in the system database as a slide or part of a slide, the database features for managing the editions and version still available.

During the creation phase, the user can use the real time editing interface to create interactive multimedia teaching materials as slides. Using the interface features the user can write texts, insert simple geometric symbols, arrows, and tables. The user also can upload images from his/her own computer, or link the images from the internet. The users can upload or link videos and SWF files and insert them in the teaching materials slides. The simple interactivity of the teaching material can be configured using only the real time interface, the uploaded or linked content can have more complicated internal interactive features.

The support of external authoring features is important to help the users that have some experience using other authoring applications, and also expand the possibilities of the teaching materials. However it is important that the system manage all the content, internal and external in the same way, therefore the users do not get lost with different features and navigation patterns. Inserting the external content inside a slide in the DTM system also make unnecessary the conversion of the content, allowing the content to be used as it was created in the original application, and reducing compatibility problems.

The support to external authoring applications can help to smooth the initial learning curve of the teaching materials edition part of the process, in the case of users that already have experience with other tools. These users do not need to learn everything from scratch, and it is also easier and more natural because they can continue to use the applications that they are already familiar with. The real time editing interface also needs features to record the user's actions. This feature is important to enable the teaching material creation process to be reproduced afterwards, therefore other users, especially novice user can see step by step how every edition, or version of every teaching material was created, understand more about the system's features, and learn how the settings are made, from other users experiences.

Before creation, or choosing a new teaching materials, or version the teachers needs to fully understand the needs of his/her students in order to do not use unnecessary features, or media types, that instead of helping, on the contrary can became a barrier, and difficult the teaching and learning process [44].

The differences in the sharing phase are linked to the content management features. The new concept makes necessary the creation of features to let the authors control the content access. The teaching materials still can be automatically shared once they are stored in the database, however now the user have more control and can decide when and if the content will be shared or not. This feature is necessary because differently from a normal version management system that merges the different version files to create a final one including all of the changes, in the DTM concept, the system needs to keep all of the versions separated because storing the evolution of the teaching material is important for understanding how and why it changed over time. For this reason, all of the different versions and updates need to be available all of the time. However, if the user is just a student searching for some material to study, the intermediary updates are not necessary. The system needs to show only the complete finished versions. Another problem that may occur is when the teacher who is updating a teaching material needs to stop the update before it is finished, resulting in a teaching material that is not complete and thus should not be accessed until the update has being completed. In this situation, the system needs a feature to control access to some teaching materials or filters for the search engine, to prevent unnecessary results in the search engine.

For the above cases tags and search filters can be used to solve the access problems, however there are also cases when the author needs the content to be available only in a specific period of time for the other users. In this case the access setting is a little more complicated. In this case the tag system can be used as a solution, without making the interface more complicated. However the type of tags that are going to be used for this kind of task and the tags themselves need to be decided by the users, they are the ones who are going to use it, and the tags need to have a meaning to them to be more easy to understand.

The system will also need features to allow the users to create content relationships that goes beyond the editions and version. For example if a teacher create a series of ten teaching materials about a specific subject, should be interesting that the teacher could indicate somehow for the other users, that these ten teaching materials compound a series, like a book collection, they are related, and probably should be better if the user read them in order. Even using the same tags to every teaching material in the series, it will not be enough for the users to understand the relationship of the these teaching materials, because only the tags cannot guarantee that these content are going to be shown together in the search results.

Other important feature needed for sharing is a feature to allow the users to notify other users about a new content, a new edition, or new version when it is released. When the system is used in a school, or university with closed courses, it is easy for the teacher to notify his/her students using general communication features. However if the student have interest in other subjects than the subject of his/her main course, should be interesting if the user could get notifications like the ones that users of online social network services, or sites like Youtube get about the content they have interest in.

Analytic processes like semantic web mining can be used to analysis user logs and access data, in order to get information about the kind of content, or the kind of tasks, and study strategies the user do when using the system [45]. This kind of data can be used to suggest additional teaching materials, or study topics to the students, as well as teaching materials that can be used as templates by the teachers, based on their activities on the system.

The teaching phase now correspond to two parts of the process, how the users access the teaching materials, and how they give their feedback after using the teaching materials. As discussed previously, the system needs a feature to allow the users to manage the teaching materials, not only for the authors, but for the students too. The new concept requires features to allow the users to mark content, or create private folders of content that can include content made by other users. The main purpose of his folders is to enable fast access to these content afterwards, when the users needs to make a review, or in cases that the user could not have time to view the content till the end, and want to continue later.

These folders are also useful for content authors, because they can create folders of content that they like to use as templates. They can have fast access to these content without having to search for them again, and also organize the content in folders by type of teaching materials, subject, or even interactive features used to create the content. The folder can also help teacher when suggesting teaching materials to users, or to indicate the teaching materials that are going to be used in the course. The teacher can create a folder with all the necessary teaching materials, make the folder access public, and send the folder link to the users, for example.

The description of a teaching material is important to help other users to understand how the teaching material was meant to be used, however teachers who have found different ways of using the teaching material can share his/her findings through feedback. The feedback feature can be used not only to evaluate the teaching material, but also to make suggestions for other users, and these suggestion can be made by the author himself/herself, or by other users who tried the teaching material.

Since all the editions and version of the teaching materials are available at once, the feedback need to be linked to the specific edition, or version that the user was using in the moment of the feedback. This feature is important because it allow the users to see the feedbacks of the teaching materials related to the edition, or version, and also see how the feedbacks influenced the future editions, or versions of the teaching material. Helping specially novice teacher to understand how the teaching materials where created in the beginning, and how it changed over time to meet the needs of the different teachers and students who used it.

After the feedbacks the authors can see if the teaching materials have some problem to be fixed, or if there is some other possibility of improvement, taking the author and the teaching material back to the creation phase closing and restarting the system operating cycle. However to guarantee that the e-Learning system is compatible to the e-Learning environment infrastructure, and to help the acceptance of the system's technologies by the learning community, the revised version of the DTM concept have some more aspects that go beyond the system operating cycle.

Accessibility and compatibility are fundamental for a successful implementation of an e-Learning project. The technologies chosen to be used in the project need to be accessible, that means the technologies need to available in the educational environment where the project will be implemented, and compatible with the users' workflow. Bring a completely new technology that will requires the users to learn everything from the beginning again, and also requires the users to completely change the way they, teach, or learn, will create a high initial learning curve for novice users, also will take more time for the user community to accept the technology, or even can cause the learning community to reject the technology, causing the e-Learning project to fail [29].

"Innovations which are perceived to be successful generally show high relative advantage and compatibility in combination with low complexity for all participants. While innovations which are perceived to be failures tend to have perceived characteristics which reverse that trend" [10]. If the new technologies are too complex, or do not show advantages that seems worth for the learning community, these technologies will probably be rejected.

To avoid, or at least reduce this kind of problem, the user community have to participate in the process of choosing the technologies, therefore the developers can evaluate the technologies that the users already know, and see if there is a real necessity of bring new technologies to the environment, or if only giving a better orientation about how to use the technologies they already are familiar, is enough to solve the problems. In the case of giving a better orientation about the technology, this orientation can create changes in the user's workflow, however since the users already know the technology the impact may not be high, depending on the case.

When the situation requires bringing a new technology, the e-Learning environment should have something to help the users to learn how to use the necessary technologies. For instance, there could be some kind of “technical assistance team” whose objective is to help the users to learn how to use the technologies rather than using the technologies for them, which is what usually happens in e-Learning environments.

Because students usually already know today’s technologies, it is good for students themselves to teach teachers how to use these technologies. This can be done through the feedback system, or workshops like in the project ELO, where the advanced users shared their knowledge with other users, students and teachers. This kind of strategy can be useful to strengthen the feeling of community between the users, that is really important to help the users to engage with the project, help one another to learn about the technology, and how to use it at the same time[46].

Students can show teachers how they use the technologies, which also makes it easier for them to understand what their teachers are going to do in the classroom, or online. They can discuss with the teachers and create strategies about how to use the technologies in a way that best fits to their needs, also including strategies that incorporate technologies other than the educational institution e-Learning system, like the Facebook [47],[48]. Having people who can help teachers in this task is just as important as having a user-friendly system interface. Teachers who do not know how to use the computer need to begin learning the basics, and they also need to be willing to learn other new technologies and teaching techniques, because it can become a big motivational barrier especially if they try to learn alone. Having someone who is close, and also cooperating in the same matter can help.

The strategies also can be applied as guidelines for the system features. Utilization patterns can be used to help users to understand the system's features, and how these features were meant to be used in specific cases, by observing other users experiences. One important point about the DTM system is that since the system stores all the editions, and version of the teaching materials, the evolution patterns of the teaching materials can also be used to help the users to understand the system features, and how the users are reacting to specific types of contents.

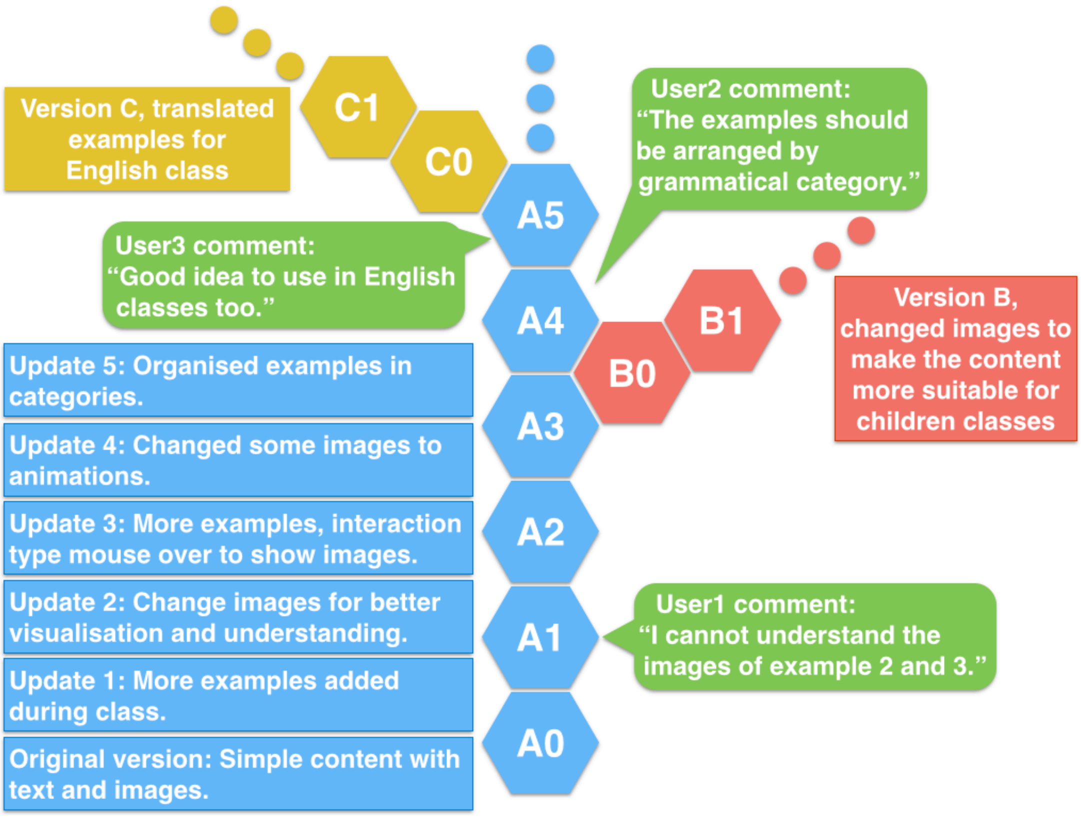

Figure 5-2. Content evolution pattern with users' comments.

To exemplify how the DTM concept apply utilization and evolution patterns to help the users, the Figure 5-2 show an example of a teaching material evolution, with a simple description of the updates that occurred over time, and feedback comments of the users. The content “A0” starts as a simple content with sentences using the new vocabulary students are learning in a Japanese class; the content also has images to illustrate the meaning of the sentence or its main word. When using the content in the class, the teachers had to add more examples to help with the explanation, and it generated the content’s first update, “A1”.

After some time, the “user1” made a comment saying that some of the images used in the content were not clear, and to solve that problem the teacher changed the images to ones that were more easy to understand, generation the second update. After that the teacher decided to add more examples with text and images, but there were too many examples with images to show them all at the same time, therefore the teacher decided to put only the text and use the mouse-over interaction feature to show only the image of the sentence being read, thus saving space on the screen to contain all the examples at the same time.

After the third update, a different teacher liked the content “A3” and wanted to use it in his classes for children; however he thought that he needed different images to use it with children, therefore the he used the content “A3” as a template to create the content “B0”, a version with the same texts but different images to make the content more suitable for children. The fourth update was made by changing some of the images to animations, for the best understanding of words like action verbs.

After the fourth update, the “user2” made a comment stating that the examples should be arranged by categories; to solve that the teacher simply changed the positions of the examples on the screen to put the examples of the same category together, generating the fifth update. Afterwards “user3”, an English teacher, made a comment saying that the content could be good for English classes as well, and then he created an English version of the content translating the example sentences but keeping the images.

In this evolution pattern sample, we can see how the content changed over time and why the updates happened, when the content was updated in real-time to meet necessities during classes as in update 1, or updates because of user feedback like update 2, or updates because the author himself/herself detected a problem like in update 3. We can also see how the content was adapted to be used in different situations with different target students by other users.

The utilization patterns being used as user guidelines should have the best practices for the users on two sides: the side of the user who created the content, and the side of the user who is observing the content's evolution pattern, in a way in which the content's author can really transmit his/her experience in an intelligible manner, and in which the other users can understand how to access the data stored in the database to actually see the evolution pattern. To help the users to better transmit their experiences and use the evolution patterns to learn and evolve, the concept suggests utilization patterns based on the following points:

- Before creating new content, search the database to see if an other user has already created the necessary content; the user can create a version of another user's content to best fit his/her needs if necessary.
- Every time a user creates or updates a content, he/she should at least use tags that describe the topic of the content, the target students and the content type.
- The author can use tags to show the differences between content editions and versions.
- Pay attention to the feedback of other users; they can highlight problems not yet found, or even show better ways to use or edit the content.
- Every time a user releases a new edition or a version of a content, he/she should write a comment explaining the objective of the update, what kind of

problem he/she wanted to solve with the changes, as in the Figure 5-2 example updates list.

- The user comments are linked to the specific edition that was being accessed by the user; it is useful to observe how the comments influenced the subsequent editions and versions.
- Before creating new content, use the search to see how other users are creating the same kind of content; the comments in the previous updates can reveal about possible problems faced by the users, and the updates themselves can show how the author tried to solved the problem. This can help prevent the same kind of problem from happening again.
- Take the time to see versions of your own content created by other users; they might contain hints on how to solve problems, as well as new features and utilization techniques.
- Whenever possible, give feedback to the authors; it helps them to understand the pros and cons of their work.

These are basic evolution and utilization patterns samples, however to implement strategies based on them the development team needs to discuss with the users to if they can really be applied, and how to apply them if it is the case. Also there are other possibilities for evolution patterns and utilization patterns that are specific to each e-Learning environment, and also strategies that could be created for specific classes, based on the teacher’s and students’ teaching and learning style. It is something that cannot be predefined the users and the development team needs to analyze the current situation and decide together the best solution.

The main idea is that the development team also needs to work as a guide. First It needs to work orienting the learning community, therefore the community can understand what are the problems. Second the development team needs to show what technologies can be used to solve the problems, and the learning community decide which ones are more suitable for its case. Finally the development team creates the necessary system features to make the technology available for the learning community, and help the community in the creation of utilization strategies and guidelines to help the users to organize themselves, and better use the technologies improve the teaching and learning process. The development team and the learning community need to work together in order to the e-Learning project to be successful.

5.4 Possible applications and evaluation tests

Until now, the DTM concept was used in two situations: (1) language teaching in the e-Learning support platform of the ELO project at the University of Brasilia, Brazil, and (2) astronomy teaching at the Nagoya City Science Museum in Nagoya, Japan. For language teaching, the e-Learning platform was used as a support platform for face-to-face classes, the course management was made using Moodle, and the DTM was applied to create an application that was used as a plugin only for creating the teaching material due to several problems with the Moodle content-editing features. In the case of the museum, the teaching materials were created and used in alternative learning situations, such as school tours at the museum, classes in the planetarium, and publications on the museum's website and in magazines and newspapers.

In the two cases listed above, the DTM concept was inserted in projects that were bigger than the DTM itself, and the applications created using the DTM concept needed to be adapted or limited to each environment. These situations helped the development team to develop the teaching material evolution part of the concept because the main objective was to solve problems with content creation, updating, sharing, and the database. The development team also faced difficulties that lead to the creation of the support team strategies that were one of the main reasons of the concept revision. The strategies helped the teachers to learn how to operate the applications. However, even if the objectives of the projects were fulfilled, many things could still be done to improve the projects.

To use all of the potential of the concept, the best approach is to create an e-Learning project that works like a small social network, for example, a social network only for the teachers and students of a given school. In this situation, teachers can discuss and decide together how to organize resources and the teaching materials to prevent students from getting lost when looking for what they need to study.

Since the teachers at a school know one another, they can communicate more easily and also help one another. It also becomes easy to organize a workshop to help novice users. One important thing that really should be decided in a group is which tags should be used for which type of teaching materials. This allows the teaching material description to become more uniform and readable, and it also makes it easier to find related contents.

The utilization of ICT to create a social network, and organizing the users as a community, can also be a great help for the students, applying strategies that encourage collaborative learning. These strategies can increase the learning and the motivation of the students [49].

The creation of this kind of community is also part of the e-Learning project, as the idea is to create a learning environment for both teachers and students where the students need to learn the subjects in the course curriculum and, at the same time, the teachers can learn about new teaching technologies and techniques. The community essentially allows both parties to help each other by sharing their experiences both online and offline.

5.5 Conclusion

The DTM concept was created and tested during the ELO project and Skynavi project. The results of the tests performed in these projects allowed the development team to have a better understanding of teachers' and tutors' needs in online and offline e-Learning environments as well as curators' needs when using e-Learning in science museums. The findings allowed the development team to create a revised version of the DTM concept that not only covers teaching material creation and management processes, but also can help teachers doing continued education to learn new teaching techniques and technologies.

“Quality teaching requires developing a nuanced understanding of the complex relationships between technology, content, and pedagogy, and using this understanding to develop appropriate, context-specific strategies and representations. Productive technology integration in teaching needs to consider all three issues not in isolation, but rather within the complex relationships in the system defined by the three key elements” [50].

The DTM concept extended from a mere approach to making teaching materials evolve in continuously changing learning environments, to a concept that embraces the entire learning environment and how participants should interact with one another in order to improve the environment as a whole. Focusing on strategies to help the learning community understand what they need, and how to use the available technology to solver their problems.

The concept also emphasizes the fact that the technologies being used now, may not be available tomorrow, there will always be something new to learn for the learning community. The e-Learning environment and the system also need to be flexible to these changes. The whole e-Learning system needs to be dynamic, not only the teaching materials, and also be able follow the changes of the educational environment incorporating new technologies and generating new features.

The concept still requires the use of tests to evaluate the utilization of new technologies such as HTML5 in these kinds of projects. Tests are also needed to evaluate new approaches of community learning that are designed to help novice teachers to access and utilize the e-Learning technologies online. The use of utilization patterns, and feedbacks allowing the users to share their knowledge to smooth the initial learning curve of the system, also helping the users to understand why the new technologies are needed, and its benefits, allowing the technologies to be more easily accepted by the learning community.

The participation of the learning community is really important for breaking the barriers to implementing e-Learning projects, as these parties are the ones who know their related needs. Better than simply bringing a possible solution from another place is actually helping them to understand the situation, helping them to learn what they can do, and helping them to evolve, thus creating a new original environment where teachers and students can learn.

CHAPTER 6

Considerations

The proximity between the development team and the end users of the learning system was really important to the development of system features that could make the technology more accessible to the users, and also to guarantee a successful implementation of the new technologies, in a way that the learning community could adapt itself, and incorporate the technologies to its teaching and learning process.

The organization of the research flow was really successfully. The order in which the research steps were executed was really important to help the development team to fulfill the objectives of each research study. Following the process of first analyze the environment problems and how the problems were affecting the learning community could guarantee that the development team was focusing on problems that were really important for the learning community, and not a problem just from the point of view of the developers.

Each part of the research was responsible for the creation of one part of the DTM concept, and in this case the order of the first two research studies were also really important, because each part of each study was used as a base for the next one. In other words, the study 1 was the base for the study 2.

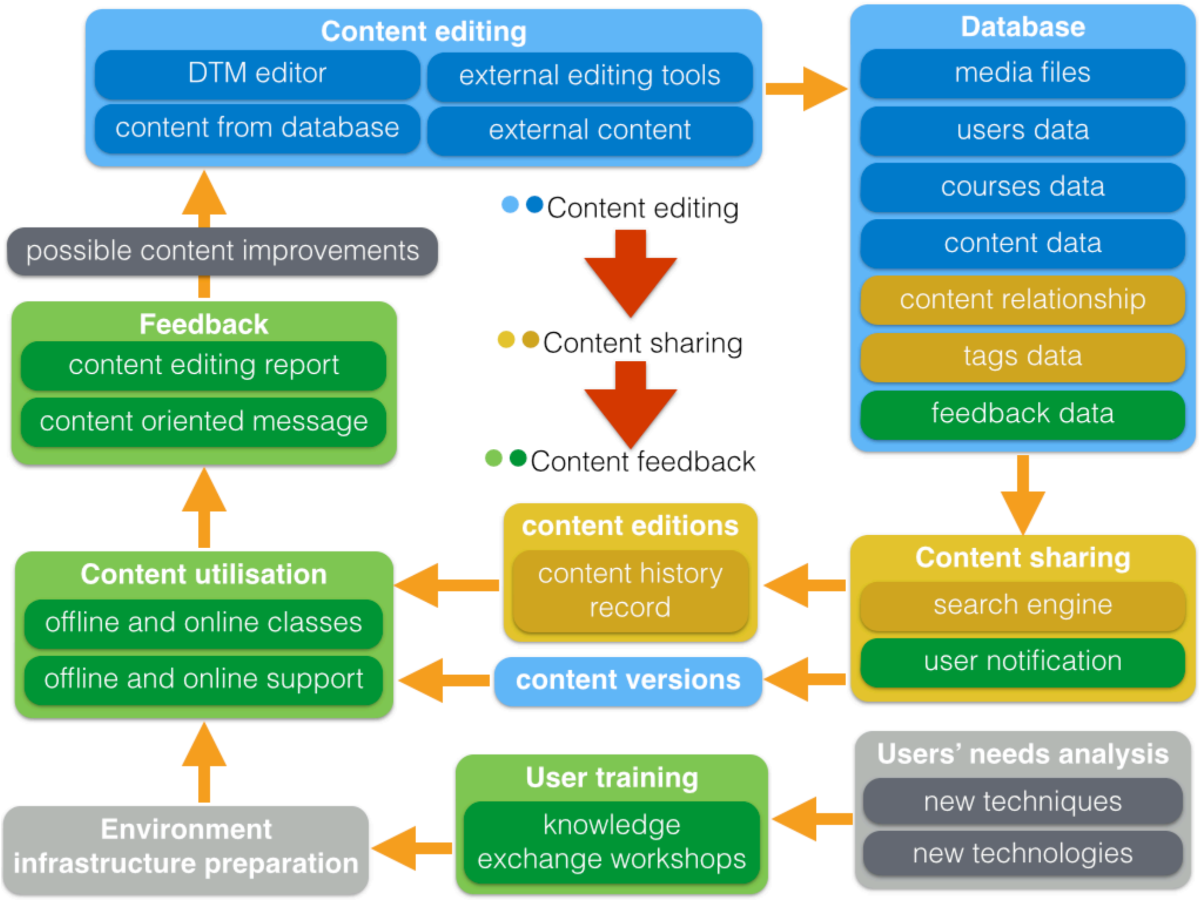

Figure 6-1. System development process overview.

The main system features of each research part are respectively, content editing, content sharing, and content feedback. First the content need to be created, or edited, therefore it can be shared with the other users, and then the author receives the feedback. These three steps are related to the research process parts, the system development process, and also with the three system operation phases, creation phase, sharing phase, and teaching phase.

The willingness of the learning community specially in the first part of the research was an unexpected factor that contribute to fulfill the objectives of the research, and also revealed new possibilities to the development team during the time of the research. During the first study the objective of the research was focused only on the teaching materials evolution features of the system, however when the development team faced problems with lack of infrastructure and human resources, the voluntary participation of the learning community showed that possibility of the implementation of strategies to help the users organize themselves to handle these problems.

This fact was important to reveal the possibility of using an e-Learning project not only to implement some kind of technology in a given educational environment, but use the project to help the community to adapt itself to the new technologies, and also to find ways to evolve following the continuous changes of the learning environment.

There were also some problems during the realization of the research, for example in the first study the, the development team was focused in finding an approach to use information technology to allow the teaching materials to evolve. However the development team faced problems during the development of the system, because of lack of infrastructure. As a result the development of some features were delayed, and could not be tested during the main test of the system, forcing the realization of a second evaluation test with a smaller group, just for features like the realtime edition interface.

In the second study the decision of the museum curator to keep the star simulation source code in a closed source application, forced changes in the design of the system. The Skynavi system was supposed to be an web application with all the features running online, however it needed to be changed to become two application, on offline, and other online. This new situation made the overall operation of the system slower, however also opened the possibility of the online application for receiving simulation data from different sources, a feature that was not included in the original design.

There were also some limitations in the research, for example the second study evaluation tests were performed with the participation of only one museum curator. The curator that participated is the chief of the astronomy division of the Nagoya City

Science Museum, and his participation was fundamental for the development of the system features and interface. There are plans to open the utilization of the system for the other curator from next year.

In the first two parts of the research there were some system features that were delayed, but they were completed afterwards and tested. However some of the features implemented during the third study were designed based on the experiences of the community interactions and utilization strategies created during the first two studies to solve the unexpected problems of lack of resources. Features related to community communication and feedback, and knowledge exchange strategies. During the first study these features were not yet part of the DTM concept yet, but were used as extra tools to help solving environment problems, that were beyond the scope of the research at that time.

During the third study, after analyzing the results of the first and second studies, these features that revealed themselves essentials to the development and implementation of the e-Learning projects, were incorporated in to the DTM concept, however there were no available time to perform evaluation tests for evaluate these features again, after being incorporated to the DTM concept.

The main system interface utilized in the Project ELO and in the Project Skynavi were developed using the Apache Flex framework. In the time of the research, there was no need for the systems to be compatible with mobile devices, however will probable be in a near future.The flexible technologies used to develop the systems allow this kind of problem to be easily solved, the Flex interface can be easily replaced by one created in HTML5. The HTML5 has the same functionalities that were used in the Flex interface, and can even use the same PHP connections to link the interface to the database. The similarity of the ActionScript language of Flex to the JavaScript language of the HTML5 is so big, that the new HTML5 interface can even use great part of the same source code as it is.

CHAPTER 7

Conclusion and possible future works

The Project ELO started with the simple objective of finding an approach to allow the teaching materials to evolve, following the continuously changing educational environment, through the use of information and communication technologies. However for this solution to be efficiently applied, the concept needed to expand and cover other different parts of the development and implementation of an e-Learning project.

The results of the research studies evaluation tests, shown that the system developed based on the DTM concept in fact allowed the users to adapt the teaching materials, creating new editions, and version of the teaching materials that were more appropriated for the needs of the situations were they were used. The system also allowed the users to see the history of the teaching materials to access previous editions, and version. This feature is useful to allow the users to see how the teaching materials changed over time, and which teaching material is more appropriated to be used in certain situations.

To efficiently implement the necessary technology to allow the teaching materials evolve, there was also necessary to create a series of other features for the e-Learning system, and also utilization strategies to support the users of the e-Learning system. Basically, these features and strategies are necessary to hep the users to smoothly adapt themselves to new education technologies, and understand how to create and edit teaching materials, to be used in various different situations.

There are still areas in the concept that need more tests to confirm its level of efficiency, specially regarding the community learning features, and how to implement new communication technologies to connect the system to external social network system like Facebook and Twitter, to help the users to communicate with each other, share content, and exchange knowledge about the technologies. There is also the necessity of future tests in other learning environments. During this research the DTM was tested in foreign language classes, and to create astronomy teaching materials about astronomy in a science museum. The application of the concept in other areas of study may make necessary to adjust the concept to new specific needs to the subject in study.

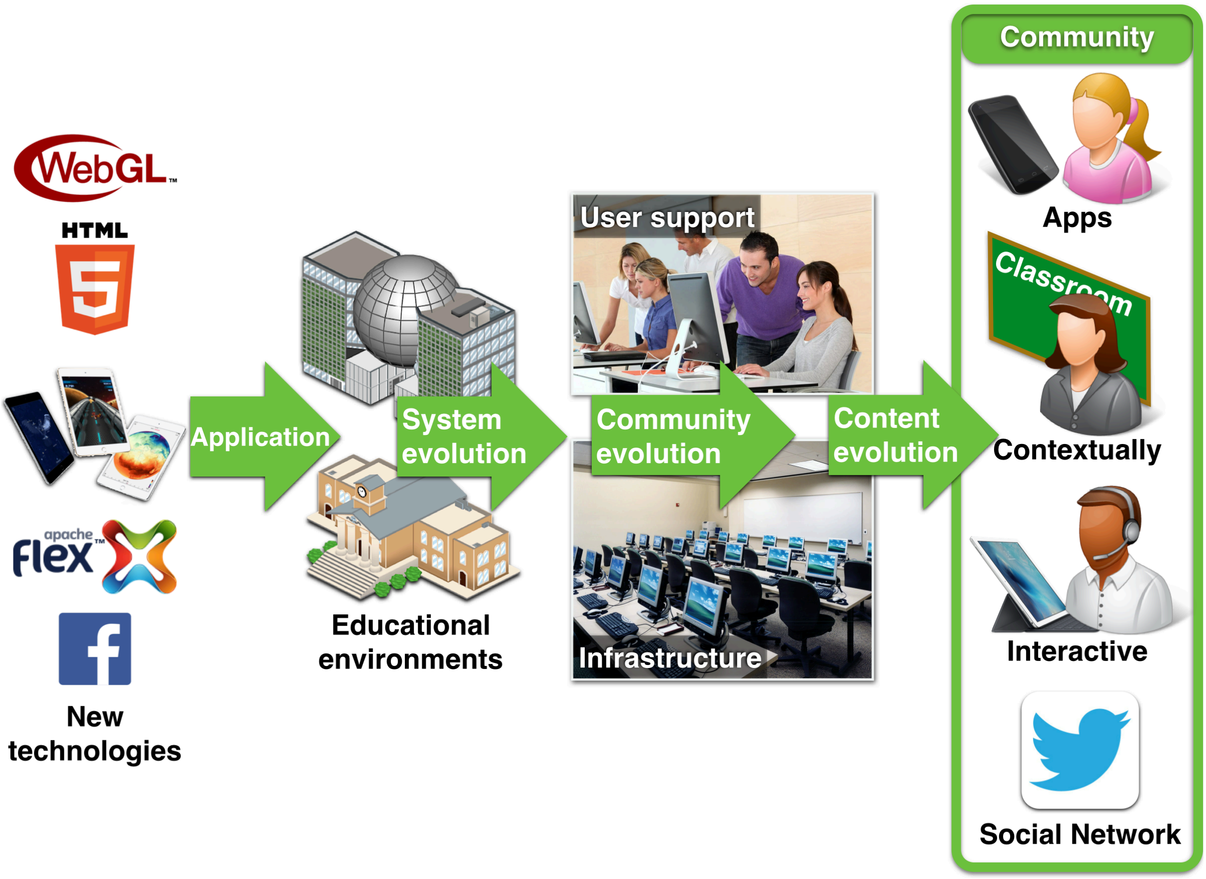

Figure 7-1. e-Learning environment evolution overview.

The final version of the DTM concept can be used not only to develop and implement an e-Learning system that allows the teaching materials to update, but also can be used to, allow the e-Learning system itself to evolve, and also help the learning community that is using the system to better understand its needs, encourage the community users to support each other exchanging knowledge about the system and its technologies, and also evolve following the continuously changing educational environment.

The advent of the technologies open new possibilities for the educational environment. After analyzed, the new technologies can be used to adapt the e-Learning system, in order to make it more appropriated to the new needs of the community that appeared over time, resulting in the evolution of the e-Learning system. However for the e-Learning environment to continue working the learning community need to be able to continue using the system after it is improved.

Every time a change happens in the system or other part of the environment, something needs to be done to compensate this change, and help the users to adapt to it. The development needs to analyze the affects of the improvements in the system and if possible, implement support strategies at the same time, or even before to help the users to understand, accept and finally adopt the changes, allowing them to evolve along the system.

After the users are able to use a new improved system, it is reflected in the content the community can create with the new system, resulting updates and the creation of new improved contents. Therefore the content can evolve to meet the new needs of the users and the environment.

The three evolution processes are interconnected, they may not necessary happen in the order previously described, like in the case of the project ELO where the community evolved before the system and the content, however since the processes are interconnected, when one of them happens, it may cause the others to happen afterwards, or the environment will loose equilibrium, and start having problems, like the situation of the University of Brasilia, before the project ELO, when the students were having problem with the outdated teaching materials, and also could not efficiently use the previous e-Learning system.

To make an e-Learning project survive the continuous changing educational environment, is necessary to use technologies that can be improved to meet future new needs, and also have support strategies to help the users to adapt themselves to these improvements, or new technologies. A dynamic e-Learning environment depends on the balance between the users and the technology.

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