Estimating the Effort in the Development of Distance Learning Paths

Milena Casagranda[1], Luigi Colazzo[2] and Andrea Molinari[1]
[1]*Department of Economics and Management, University of Trento, Via Inama, 5, 38122 Trento, Italy*
[2]*Department of Industrial Engineering, University of Trento, Via Sommarive, 2, 38122 Trento, Italy*

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Abstract: The quantification of the effort required to produce e-learning material has been always subject to the proposal of some "magic numbers" not always supported by a method or analytical data. In this paper we propose a method for calculating the effort required to design and develop e-learning paths. Our model is based on a systematic gathering of data regarding the effort of the different actors involved (teachers, tutors, instructional designers etc.) from a series of e-learning projects carried out at the Laboratory of Maieutics over the last five years. In the first two years we collected ex-post data on design and development times, being careful to include a variety of different teaching methodologies. In the following years we identified critical variables which allowed us to abstract and generalize a possible costing model. The model proposed could be used as a reference point for professionals working on the development of content in their estimation of costs linked to the design and development of learning materials, providing a calculation basis which takes a number of methodological approaches and educational objectives into account.

1 INTRODUCTION

Over the years the fortunes of Distance Learning (DL) have see-sawed, for reasons both cultural and technological: among them, a reluctance to replace face-to-face interaction with instructors; inadequate communication lines for the transmission of complex learning objects (LOs); insufficient bandwidth for the reliable streaming of multimedia material and also a lack of standards for tracking and certification of on-line courses. Most of these problems have now been overcome: it therefore seems that the hesitant progress of e-learning – always on the point of spreading extensively and then for some reason never really succeeding - should not have to continue any longer, given the disappearance of most of the technological barriers.

In fact, we believe, there is another - considerably more insidious, not being linked to the inevitable progress of technology - obstacle which threatens to further slow the spread of DL. This obstacle is the economic advantage of instructors in the production of LOs in relation to the traditional method of being paid an hourly or daily rate, linked to their verifiable, physical presence in a classroom. This point seems rather crass and mercenary, but we have observed early signs of such resistance, especially as it is now clear, at the industrial level above all, that e-learning will become indispensable. We refer to those cases where e-learning has unquestionable advantages, for example: a) large numbers of people to be trained in a short time; b) people widely dispersed or hard to access physically; c) training regarding software or ICTs usage.

All the above cases include factors which could be considered to "justify" fair pay for the creators of LOs (instructors, instructional designers, tutors, etc.). A comparison of the production costs of the LOs with how much it would have cost to run a face-to-face course normally justify the choice for an e-learning initiative. On the other side, however, we find the perspective of the creator of the LOs, who should be highly paid due to the number of users involved and due to the strategic value of the training itself. We are thus witnessing an extension of the online course offer, which is going to involve an increasing range of subjects, ever more closely linked to those areas (like soft skills) traditionally not "favorable" to e-learning. Nevertheless, this potential burst of growth in LOs production presents a number of criticalities:

- a more detailed planning is required in order to create interactive, reflective, self-rating situations for the learning of soft skills;

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- LOs are delivered by instructors who are often unfamiliar with ICTs ;
- LOs represent an area of the market which is still very profitable for traditional classroom based education.

Regarding the last item, resistance on the part of instructors, who have always been the authors of the destiny of e-learning initiatives, is presumable – and, as far as we are concerned, already verifiable. By instructors we mean everybody involved in the development of courses and related educational objects. The argument is very simple: considering for example the business of professional training, teaching a given subject requiring 20 classroom hours to 100 people allows an instructor to suppose N repetitions of the course, each multiplied by 20 hours, multiplied by their hourly pay. The economic final reward (FR) for the instructor, by which to calculate the threshold of convenience in creating the LOs, is function (at least) of the following parameters:

$$FR = f(r , h , hr , d , ph , hpc)$$

where

r = No. of course repetitions;
h = No. of hours of each edition;
hr = hourly rate of the teacher for that course
d = rate for design activities
ph = preparation hours needed for LOs creation
hpc = hourly preparation costs

Other elements should be considered, like the location of the course, travel expenses, credibility of the organization etc. Sometimes, moreover, a flat rate is paid for design, or it is not always recompensed, since instructors receive a good hourly rate for classroom hours (particularly as they become more senior).

In the simplest situations, the function can be easily calculated as follows:

$$FR= r * h * hr + d – ph * hpc$$

There's no doubt that unless a pay scheme for e-learning courses at least as attractive to instructors as that for traditional courses is provided, there will be a further brake on the spread of e-learning. A number of studies have focused on the determining of parameters, and many authors have already pointed out the complexity resulting from methodologically and educationally based choices in the construction of e-learning courses. (Bacsich eand Asch, 1999); (Bacsich and Asch, 2001); (Lewin, 1995).

To a great degree, over-simplifying the idea risks, we believe, the reoccurrence of the initial problem, the "inexpedience" for experts of transferring their knowledge through DL. We have already drawn attention (Casagranda et al., 2010) to criteria for calculating the production costs of LOs, but extensive subsequent trials have revealed the need to refine and integrate the model, especially in the LOs design stage. In this paper we will propose these extensions and refinements to our e-learning costs model. We have added more importance to the design stage, in order to allow the a-priori estimation of the work done by the different experts involved in project development.

2 THE DESIGN OF EDUCATIONAL PROJECTS

The detailed preparation of an e-learning course or environment needs to be done in advance. The instructional designer should identify the subject matter, define it operatively, decide how to evaluate students' knowledge and skills and introduce occasions for feedback in order to support learning. Therefore, we begin by identifying the different phases of planning stages and then suggest how times and costs might be calculated.

All e-learning projects include at least four basic stages which lead to the delivery of a course. We believe that in the evaluation of the effort involved, we should quantify, optimize and recognize:

- the design of the educational project;
- the design of LOs through an analysis of subject matter, which we introduce as modeling in this article;
- the development of educational material, the utilization of which has already been described by other researchers (Bartley e Golek, 2004);
- the management of interactions with students in order to further learning, mostly following web 2.0 approaches and tools (forums, blogs, wikis, social network interactions etc.), as already mentioned in previous articles (Casagranda et al., 2010)

When discussing the design phase, we include a number of dimensions, already mentioned elsewhere (Raineri, 2005):

- demand assessment: information about clients' expectations is collected, clarified and selected, through hypotheses which designers develop considering technological issues about the creation of LOs ;
- the proposal of hypotheses: the variables and

points of view involved are multiple and it is hoped that decisions / solutions can lead to the presentation to clients of a number of possibilities;

- fine tuning of the project: when a possibility has been chosen the – almost inevitable – next step is the development of the project, a recursive research process in which the direction of the project is defined.

The starting point for the design of both the course structure and content is an analysis of its educational objectives. We have based our work on the model which guided us in our operative planning choices for the project (Battaglia et al, 2008). Through a consideration of three critical variables we can create a 3-dimensional matrix representing the educational models:

- the principal teaching objectives;
- the importance of vertical interaction according to the principle of instructors' authority;
- the importance of horizontal interaction according to the principle of collaboration and dialogue.

The combination of educational objectives has been graded in three segments: knowledge, technological skills, the development of cognitive skills.

The second dimension focuses on the importance of instructors as a source of knowledge and as an expert in the field. The two ends of the continuum are the "Central figure" or "reference point" at one extreme, on whom the learning process depends, and the "Neutral moderator" of students' study, at the other.

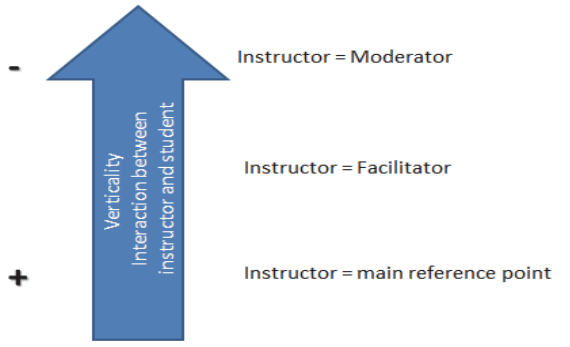

Figure 1: The vertical interaction dimension of an educational model.

In our terminology, "Verticality" represents the degree of interaction between instructor and student, while "Horizontality" refers to the degree of interaction between students. Note that the two dimensions are independent, allowing four different combinations: the weak vertical - weak horizontal combination represents independent learning, while the strong-strong combination represents the development of elaborate educational projects, in which the instructor assumes the role of project manager and strong group leader. The combination of the three dimensions generates an cubic "educational space" in which twelve educational models can be identified. Some of these models are relatively "pure" and can therefore be used as general points of reference.

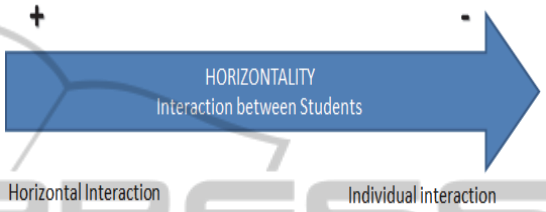

Figure 2: The horizontal interaction dimension of an educational model.

We can place the tutor in this educational space, alongside the instructor. This allows us to see how closely correlated and dependent on each other these roles are: when an instructor is the central role for a course, the tutor – to a large extent an observer – supports him; conversely, when the instructor's role is that of moderator, the teaching role of the tutor is potentially greater, particularly for any Distant Learning versions of a course. In our studies, four educational models have been identified:

1. models aimed at the acquisition of knowledge: characterized by strong vertical interaction between instructor and student, weak horizontal interaction between students;
2. models focusing on method: characterized by strong vertical interaction, weak horizontal interaction and a focus on technological skills;
3. models aimed at increasing ability: characterized by strong vertical interaction, strong horizontal interaction and a focus on technological skills;
4. models aimed at increasing expertise: characterized by weak vertical interaction, strong horizontal interaction and with a focus on the development of cognitive skills.

Note that the variable of technology is not one of the dimensions of the model: the characteristics of the technological tools used to deliver on-line courses cannot be considered primary criteria for the classification of educational models.

We could have different models for the same educational proposal, depending on the methodology that is considered more effective for the learning

process. The detection of the predominant model is useful to determine the educational objectives, while it is relevant for our cost model in order to determine the type and the extension of the support activities in the educational processes, as presented in tables 1 and 2 at the end of this paper.

The central role at this stage and across the other proposals is the e-learning project managers, who support and coordinate those involved in the development of the educational project. The overall organization and implementation of the e-learning system is their responsibility.

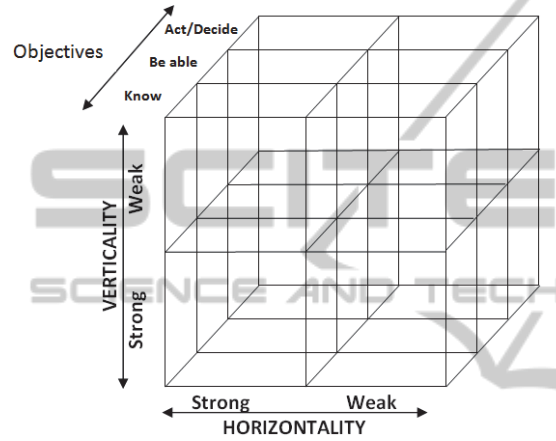

Figure 3: The "educational space" through the identification of educational formats.

They supervise the planning, development and administration of the project and are responsible for its educational content. The project manager undertakes to:

- schedule and coordinate the e-learning program
- identify users' profiles of the e-learning system
- analyze the educational requirements / demand of users
- define the objectives of the e-learning system
- define the type of service to set up
- define the criteria and indicators for the monitoring and evaluation of the service

We examine the roles of the collaborators later on, in particular those of the content manager and instructional designer.

3 LEARNING OBJECTS DESIGN THROUGH CONTENT ANALYSIS

When LOs are being planned, after the appropriate educational model has been identified, we can start to apply our costing model. The most significant variables, which we introduce for the first time in this model, are (Raineri, 2002):

- content "definability": can the content be processed in a standard way, or does it require discussion and comparison and need to be created for a specific group of participants?
- content "interactivity": can the content be conveyed through text, images and graphics, or does it require interactivity? Simulations, for example?

The definition of the content (how much structured subject matter there is, on a scale: low – medium – high) lies on the vertical axis. The lower the value, the less time the instructor will need to plan specific content and design time can be devoted to the methodological structure and to the search for stimuli that can be offered along a study path (e.g. facilitation of the study community, where the educational task and support while the work is ongoing will be more recognized) (Cohen and Nachmias, 2008).

The indicators reported in this paper are multipliers that result from an ex-post analysis conducted over five years of design and creation of learning objects. We collected the detailed data from the roles involved in the process regarding design times and creation times. Afterwards, we identified some recurring variables in the process, and their average influence on the time used to produce the learning objects.

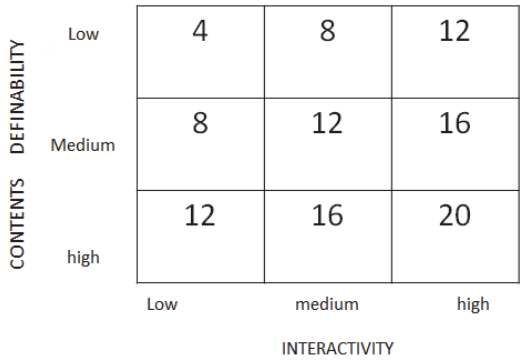

Figure 4: Model for the calculation of multipliers in the planning of material.

We have placed the level of interactivity on the horizontal axis. According to our formulation, here follows some examples of LOs with low levels of interactivity:

- narrative LOs, which introduce suggested courses and/or single modules;

- expository LOs, which refer to text based information and concepts, images.

The following are examples of medium levels of interactivity:

- Demonstrations: animations which illustrate a series of operations
- Interactive LOs: participants are required to interact with the material – providing answers, commands, links, etc.
- Tests: drag and drop, classification tests that start with given possibilities, problem solving tests, etc.
- Guided exercises: step by step instructions on what to do
- Case studies

The following involve high levels of interaction:

- Simulations: presentations of simulated situations in which the student must achieve an objective (e.g. using particular software)
- Role based LOs: contexts in which participants are asked to take decisions, etc.

Each cell in this model is assigned a different value which is multiplied by the expected length of the material being developed. We have excluded "serious games" from the calculation / estimate that can be made at this stage of our experiments / trials. The serious games category is a broad one, nevertheless it always entails, at all stages of development, a quantity of work which definitely cannot be reduced to the elements represented in our model. Currently, there are experiments / trials on-going in this field, but they are still at too early a stage to provide accurate data.

At least two figures are involved at this stage of design, their contributions can be identified using the same parameters (from the point of view of co-planning), using the matrix above:

- the instructor, who:
  - participates in the definition of course structure
  - identifies the possible testing and evaluation methods to be included in the program
  - supports and collaborates with the instructional designer in the creation of LOs
- the instructional designer, who:
  - gives advice on educational methods and strategies for the delivery of content and resources for e-learning
  - decides which software to use for the generation of content
  - manages the multimedia resources
  - identifies the strategies and tools for evaluation and practice most appropriate to the purposes of the course.

4 THE DEVELOPMENT OF EDUCATIONAL MATERIAL

Regarding another component in our model for determining the cost of production, i.e., the development of educational material, in other studies (Casagranda et al., 2010) we suggested a method for estimating the amount of time spent by instructors on the creation of LOs. We will shortly present this part, considering the following questions: a) will all the material be new, or is there any material available for reuse? b) to what extent might the material be reusable in the future?

The possibility of reusing existent material for the development of LOs has a great impact in the perception that end users have about the originality of the creator's work, and sometimes is even subject to negotiation between the educational institution and the instructor. In our model, this aspect lies on the vertical axis, on a scale: absent – low – medium – high. The higher the value, the less time the instructor needs for the preparation of the LO.

The replicability of material – how possible it is to reuse the same LOs for other courses or users (Huddleston and Pike, 2005) – lies on the horizontal axis. The scale we use is the same as the last one: the higher the replicability the bigger the multiplier, as the same material can be used for many versions and subjects and costs can thus be recouped. In contrast, if there is little or no possibility of replicating the material and an LO is useful only in one, or a limited number of, context/s, instructors will be paid proportionately less since they will soon have either to generate new material or update old.

We hypothesize that the values of the variables of the multiplier on this axis will be lower than those on the vertical. All the cells in the model are assigned a different value which serves as a multiplier for the expected useful life of the material being developed. Moreover, the concept of "reuse" can be based on an estimate of the number of versions expected and on the number of possible users, or even on estimates of re-combinability in other contexts.

The following factors are to be considered when determining the "reuse of material" variable:

- Absent: it is the first time that instructors have developed a course like this, so they have neither classroom nor online material available with which to begin the preparation and must start

from zero, or near zero;

- Medium: instructors can adapt material which they have previously used in the classroom for use online, or have a limited amount of relatively unstructured online material available;
- High: instructors have some structured material available, suitable for their chosen type of distance education, and only small changes or updates are required.

The variable regarding the replicability has been constructed referring to the average participation to courses held for University and public administrations in our territory. It is complicated to "universalize" this parameter of replicability, that in our case sets a "high replicability" when courses involve up to 100 participants.

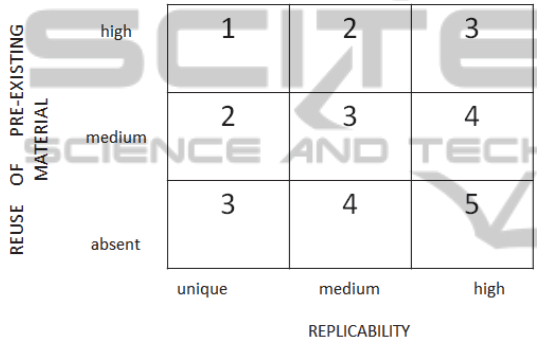

Figure 5: Model for calculation of multipliers in the creation of material.

This parameter could hence be a limit in different contexts respect to those used in our analysis, and should be recalculated and adapted. At the same time, having collected data from several courses editions, in environments very close to what the market nowadays provides, we are confident to have a good basis for future analysis.

At this stage we are also faced with the following questions:

- What are the best technologies for the running of the course? For content management? (We are here referring to LMS and LCMS.)
- What technical support is needed for the production of the material?

Sometimes the instructor him/herself will be able to produce the educational material, sometimes a specific person will carry out this function. The person producing material will have the time recognized using the model in Fig. 5. It is important to add, however, that it would be helpful to add an extra multiplier to our model, both to quantify the work involved in reviewing the content / work, in checking that the material meets established LO standards, and for the professional editing of the material itself, as set out below.

At this stage we add another value, when two roles dominate the work: the content manager and the LO editor / LO production expert, who guarantee the quality of the LO at all stages of its production, and especially:

- when the stages of production and their durations are being decided;
- for the writing of LO storyboards;
- for managing professional standards in the multimedia content (videos, narrators, graphics, etc.)
- for editing of the LO

From our evidences, we derived these multiplying factors, that must be confirmed in further analysis:

Content manager	Responsible for the review of video content: video time multiplied by 3
LO editor	Responsible for editing: video time multiplied by 33

Figure 6: Model for calculating the multiplier for creating material.

The incidence of this element on the production time of LOs is clearly relevant, and in our experience this is particularly true for those institutions that do not have a LO editor at their disposal, thus forcing them to turn to external expertise.

Accessibility of learning objects is a serious issue, and the attention devoted to people with disabilities is never too much. Thus, we observed in our tests to which extend the impact of enriching / modifying material to be usable by this category of users was. When accessible materials are being created, we have identified a further increase in time to be recognized for this activity:

Accessible materials generated by the LO editor
- Addition of Text: Creation of material + Video time - Addition of Subtitles: Creation of material + Video time multiplied by 1.5

Figure 7: Model for calculating multipliers in the case of accessible material.

5 SUPPORTING THE LEARNING PROCESS

Finally, as already discussed in other papers, (Casagranda et al., 2010), we consider the choice of teaching model to be very important for the estimation of the maximum number of hours that

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tutors and instructors will spend on the delivery of a course. The calculation of these hours is based on the application of a percentage on the total number of course hours for face-to-face and DL, shown below:

Table 1: Adjusting factor for distance learning courses based on teaching model for teaching.

% in class room	% in Distance Learning	Expertise	Ability	Method	Knowledge
100	0	///	///	///	///
70	30	5%	4%	3%	2%
50	50	6%	5%	4%	3%
30	70	7%	6%	5%	4%
0	100	8%	7%	6%	5%

This table presents the Percentage of the maximum number of instructor's hours recognized based on combinations of classroom and/or DL hours (supporting students' learning and communication during the course). The following figure, instead, represents the percentage of the maximum number of tutor's hours recognized based on combinations of classroom and/or DL hours (supporting students' learning and communication during the course)

Table 2: Adjusting factor for distance learning courses based on teaching model for tutoring.

% in class room	% in Distance Learning	Expertise	Ability	Method	Knowledge
100	0	///	///	///	///
70	30	4%	3%	3%	2%
50	50	5%	4%	4%	3%
30	70	6%	5%	5%	4%
0	100	7%	6%	6%	5%

The percentage is doubled if it is expected that an instructor's presence in the medium term will be required, either to allow students more time to complete certain activities (e.g. in blended courses: within 3 months of the last classroom based lesson), or to guarantee that the course web pages are updated (e.g. the instructor agrees to update FAQs, regulations, etc.).

6 APPLICATION OF THE MODEL

In this article we describe the application of the model to a self-study course run in 2011 and 2012. Our results were extremely encouraging: a deviation of about 10% between the "ex-ante" calculation, based on the a priori application of the suggested parameters, and the "ex-post" statement of accounts (allowing an a posteriori evaluation of the hypothesis).

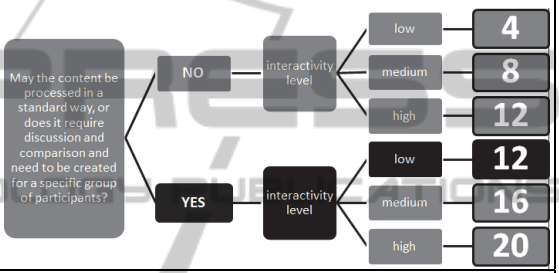
Choice of Educational Model

- Information component: model directed towards knowledge
- Application component: model directed towards method

Figure 8: Educational model.

Calculation of planning time

- Information component: narrative and expository LOs
  - Instructor/expert: 6 hours (effective duration) * 12 (multiplier: high definability of the content/ low levels of interaction) = 72 hours
  - instructional designer: 6 hours (effective duration) * 12 (multiplier: high definability of the content / low levels of interaction) = 72 hours



- Application component: simulations
  - instructor/expert: 2 hours (effective duration) * 20 (multiplier: high definability of the content/ high interactivity) = 40 hours
  - instructional designer: 2 hours (effective duration) * 20 (multiplier: high definability of the content/ high interactivity) = 40 hours
  - total planning hours: 224

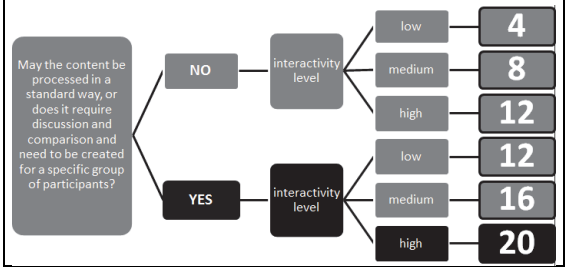


Figure 9: Calculation of planning time.

See below a short summary of the course characteristics:

- Course title: "Digital signatures and Certified electronic mail";
- Participants: almost 22,000 private businesses;
- Course objectives: divided into two areas;
- Information component: a presentation of the main characteristics of digital signatures and certified electronic mail, the related legal aspects, the main uses of these tools, the necessity of

adopting them, limits to their use, opportunities for their use;

- Application component: showing how digital signatures and certified electronic mail work and making available practical demonstrations of their use.
- Effective duration of the educational material– information component: 6 hours, application component: 2 hours.

Calculation of production time

- Information component
  - instructor: 6 hours (effective duration) * 5 multiplier (material replicability high and reuse of existing material absent) = 30 hours
  - content manager: 6 hours (effective duration) * 3 (multiplier) = 18 hours
  - LO editing: 6 hours (effective duration) * 33 (multiplier) = 198 hours;
  - accessibility 6 hours (effective duration) * 1.5 (multiplier) = 9 hours
- Application component
  - instructor: 2 hours (effective duration) * 5 multiplier (material replicability high and reuse of existing material absent) = 10 hours
  - content manager: 2 hours (effective duration) * 3 (multiplier) = 6 hours
  - LO editing: 2 hours (effective duration) * 33 (multiplier) = 66 hours;
  - accessibility 2 hours (effective duration) * 1.5 (multiplier) = 3 hours
  - Total LO production hours: 100

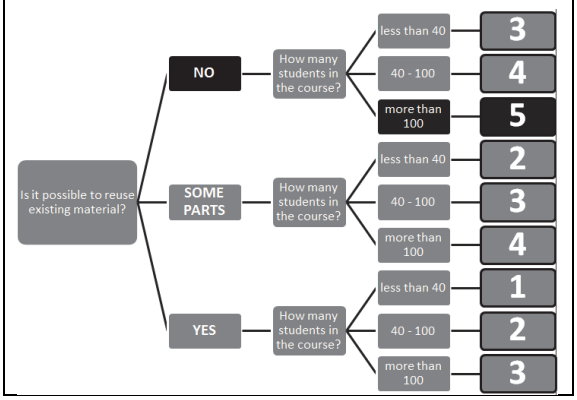


Figure 10: Calculation of production time.

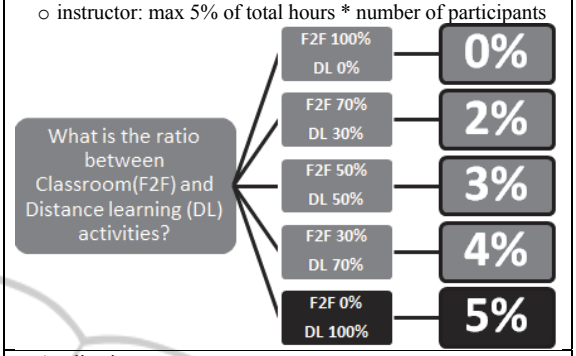
In summary, the original course has been planned as a 6 hours + 2 hours course. With the application of our model to this specific instance, the global effort has been calculated as follows:

- Planning Time: 72h+72h+40h+40h = 224h
- production Time: 30h + 18h + 198h + 9h + 10h + 6h + 66h +3h = 340h
- Support time: n/a

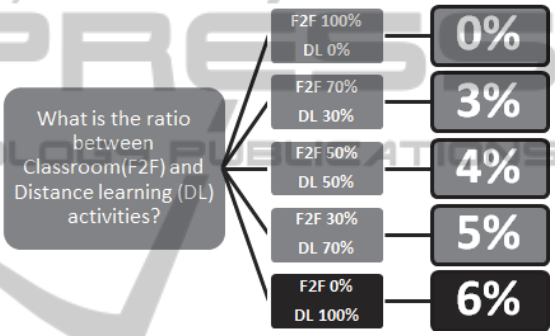
Total Effort: 564h respect to an effective duration of the educational material of 8 hours.

Calculation of time spent in supporting the educational process

- Information component:
  - instructor: max 5% of total hours * number of participants



- Application component:
  - instructor: max 6% of total hours * number of participants



In the case study, given the number of users, no educational support was factored in.

Figure 11: Calculation time spent supporting the educational process.

7 CONCLUSIONS

This article shortly describes a model for the estimation of the time spent by the various people involved in the planning and production of DL material. We attempt to address the problem of calculating total numbers of hours worked by all the actors, providing a general framework for this complex calculation (in the sense of quantity of variables and situations to be considered).

This is largely a result of the lack of an adequate model for standardizing the measurement of the effort required to create online material, leading to instructors receiving completely inadequate recompense for their work. We believe that the lack of this calculation could be one of the possible factors which could slow the spread of DL. Our model calculates, using multipliers and reference tables which have been trialed in the field in some

revealing projects, the number of hours worked by the creators of DL courses to be recognized against the number of hours scheduled for the online course. Most of the trials / experiments with this model were carried out under the auspices of the DL program of the Autonomous Province of Trento and the University of Trento, where we applied the model on a set of 37 editions of different courses run in 2011/2012.

Our results were extremely encouraging: a deviation of about 10% between the "ex-ante" calculation, based on the a priori application of the suggested parameters, and the "ex-post" statement of accounts (allowing an a posteriori evaluation of the hypothesis), based on the systematic gathering of data from the roles involved (teachers, tutors, instructional designers, etc.). Further experiments are needed to confirm or adjust the multipliers stated in the model, especially regarding new media and new educational models and approaches. The evaluation of the multiplier for multimedia learning objects is a crucial component: we are already working on a method that progressively decreases progressively the effort respect to the length of multimedia learning objects to be produced.

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