Process-oriented Production of Learning Units for sustainable E-Learning Offerings

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Abstract. During the federal funding program 'New Media in Education', a project group was established, which produces learning contents for two E-Learning offerings of an international virtual university: Process Modeling and Knowledge Management. The continuous improvement and development of the required production processes with the objective of creating professional and competitive learning units lead to process and efficiency-driven approaches for E-Learning production. After introducing the main elements from business process orientation and their application to the E-Learning domain, this contribution proposes a generic procedural model for the production of reusable and standard-compliant E-Learning offerings, which has been derived from the practical experiences. On a Micro-layer, this model can be adapted to meet the individual requirements of content developers. In the second part, the documented processes and their advantages are illustrated using two examples from practical project work: the production of video assets and XML-based SCO production.

Keywords. Process Orientation, E-Learning, Production Processes, Reference Model, SCORM Standard, Learning Unit, Virtual University

1. Efficiency and E-Learning Production

The BMBF grant program ‚New Media in Education' supported a multitude of E-Learning projects. This initiative aimed at a wide integration of new media as a means for teaching, learning, working, and communication in higher education. A further objective was the qualitative improvement of educational offerings using media support [2].

However, the projects within this program often created on proprietary and mainly technology-driven developments and attributed low priority to issues of efficiency, sustainability and flexibility of the material produced. But once this initial development of E-Learning offerings ends, concepts for ensuring the appropriate revenues are necessary to compensate the high initial investments and the costs of actually running the structures and processes of production [7]. Moreover, it can be doubted, that the achieved individual project results are able to create the intended wide integration effects. This would have required the elicitation and documentation of organizational best-practices to enable a roll-out to other universities.

Participating in one of these funded initiatives, the work group 'Process-oriented E-Learning' is responsible for the development, production, technical hosting, and tutorial hosting of the two internationally offered E-Learning courses Process Modeling and Knowledge Management. Together with the learning offerings of 16 further university chairs from Germany, Swiss, and Austria, these courses lead students towards an internationally accredited Master Degree at the 'Virtual Global University'. This institution exclusively operates via the World Wide Web. Its foreign affiliations in Pakistan, Nepal, Taiwan, Slovenia, etc. target students from Asia and eastern and middle Europe. The special position of the work group in a project of this scope soon required to focus on the establishment of very efficient processes which simultaneously guarantee a professional and competitive product. The objective was hence on producing the best outputs with a minimum of personnel, time, and costs. Here, the group's strong background in Business Informatics and Process Modeling motivated to assess methods and theories which initially have been developed to design and improve structured, efficient and transparent corporate business processes and their applications to the field of E-Learning Content Production and its manifold tasks and techniques.

The primary focus of this transfer is on concepts and optimization approaches for easy, applicable, sustainable, standardized and standard-conformant processes which are able to create professional high-quality E-learning offerings with a minimum amount of resources.

Throughout the project work, the practical experiences in the development and the hosting of the units have continuously been documented to assemble a generic procedural model for the Production of reusable and standard-compliant E-Learning Offerings (PELO-Model). This process enabled the systematic reflection, structuring and improvement of an increasingly complex amount of production processes and aids as an approach towards a generic organizational handbook for E-Learning production.

Given the small organizational and financial efforts for the production, the positive comments of our fellow international students about the professional appearance and quality of the offerings substantiate the success of these process-oriented approaches. The experiences achieved in practice help to continuously improve and generalize the developed concepts in order to answer questions like:

- How can professional learning contents be produced in an academic context with scarce resources and low budgets?
- How can learning contents be easily reused and platform-independently generated by meeting available standards?
- How can process automation be increased in order to improve the process execution, the process duration and the process costs?
- How can process transparency be increased by standardized process definitions, or process models?
- How can E-Learning production be supported by content-oriented structural concepts?

2 Applied Elements of Process Management

In order to establish a comprehensive process-oriented approach for E-Learning production, a methodical Process Management is utilized to continuously run and improve the existing infrastructure. This concept is a feedback circle which includes the modeling of required E-Learning production processes, their subsequent execution to generate the offering, and finally the improvement of existing processes using process performance measures and process analysis [9]. The main idea is to increase the efficiency with a clear definition and systematic documentation of processes, their variants, and their interfaces using special modeling techniques.

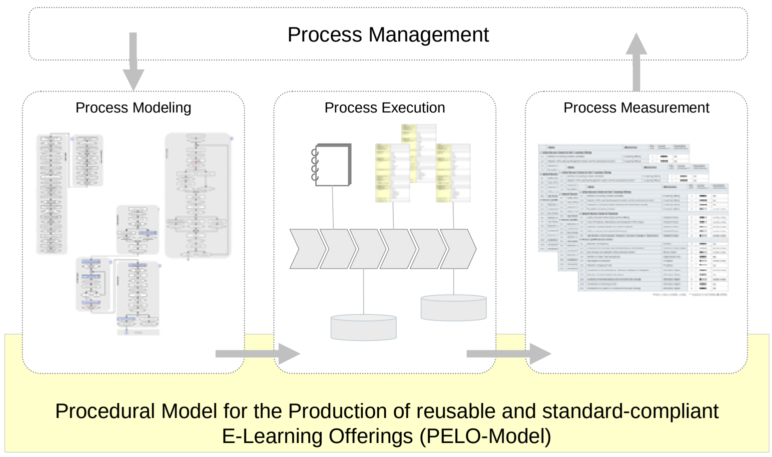

Figure 1: The Elements of Process Management

One example for employing such a Process Management is a recent general process reengineering for all E-Learning Production processes. After modeling, measuring and analyzing the existing processes, new processes have been engineered. Together with the additional introduction of increased process automation using tools like the vbc.contentTRANSFORMER, the time needed to update existing learning objects for the KM and PM offerings could be reduced by about 70 percent [16].

Before the practical production processes of the process-oriented E-Learning offering are introduced, the basic theoretical concepts and terms are introduced in the next section.

2.1 Process Modeling

The central element of process orientation is the definition and specification of all required processes using the formal visualization technique of Process Modeling [9]. A process and a process model is comprised of various elements and properties, which are now briefly introduced.

The main element of a process model is a sequence of production activities. Hence all existing E-Learning production activities need to be arranged as logical or time-related sequences of individual tasks. This can be done by following material or information flows between the respective tasks.

Further, it needs to be determined which material or intangible object is needed as input for the process and what results are delivered as output. This output should focus the successor, i.e. the customer of the process.

The next step is to assign the responsible role (person) to each task or process in order to generate clear accountability for performance or successes and failures.

Further, the resources for executing the production process need to be related to the appropriate activity of the model. The executing persons or the process designers attribute the resources to the various activities of the processes.

A standard approach to visually represent all these process elements is the extended Event-driven Process Chain (EPC). It is primarily based upon Petri-net theory and can be regarded as a version of the cause-event web, which has been extended by logical operators [9]. To restrict the complexity of the models of this contribution, only the core elements of a process are documented, consisting of only three types of objects: event, function, and operator. An event describes the occurrence of a business-like situation which can be the trigger or result of a function. A function describes the business task for the transformation from a starting situation to a final situation. Connecting operators describe the logical relations between events and functions. There are different logical connections to connect events and functions, namely the conjunctive connection ("and"-connection), the disjunctive connection ("either or"-connection), and the adjunctive connection ("and/or"-connection). Lines and arrows are used to visually connect the depicted elements. The simplest EPC is hence a line of alternating events and functions (see for example figure 4).

After the processes have been modeled, these documents aid the process execution phase as illustrated in the second part of this paper.

2.2 Process Measurement

In theory the underlying processes of E-Learning production need to fulfill several general production requirements in order to ensure efficiency [6]. This directly relates to performance measurement. First, the process duration should be minimized to establish a fast value creation. Usually, this strongly affects the costs of executing the process. A third factor to be measured and evaluated is quality, which directly relates to customer satisfaction. Added to that is the long term objective of flexibility and sustainability, which allows to react to different production demands, and to introduce new production elements into the infrastructure.

Next to these general considerations about production requirements and performance factors, the concept of Critical Success Factors has been employed. It assumes that a process's success is largely attributable to only a few factors [11]. Using these both foundations, the most important efficiency criteria for E-Learning production were defined. They include critical success factors for the overall E-Learning offering, general success factors of processes, and special process-specific success factors for the E-Learning production process. Together, these three segments constitute categories of requirements to measure and evaluate the existing E-Learning production processes.

The requirements category of critical success factors for the overall E-Learning offering includes the definition of learning contents and media, the selection of the Learning Management System and the Learning Environment, the realization of a business model, and the reusability of learning contents. The next section contains general success criteria of processes like process duration, costs of production, quality of the output, measurability of the process, and flexibility to change the process structures.

The last section with individual and process-specific success criteria finally lists items like reduction of complexity, reduction of employed file formats for identical contents, increased transparency about the process's status, or standardized versioning. These criteria have been derived from the existing production processes. For every criterion a description is available to help evaluating the actual process. For example, the reduction of content-related redundancies checks, if the same contents are not stored in different file formats (like MS PowerPoint and MS Word).

Using these criteria, the three main potentials (which can also serve as overall objectives of the production) to improve the general efficiency of E-Learning processes are compliance to E-Learning standards and specifications to enable conform and sustainable Learning Objects, structures, and processes, further improved process automation to increase the efficiency of the processes, and finally standardized processes with process descriptions to improve the ability to evaluate, to measure, and to assure the quality of the output.

2.3 Procedural Model

Based on the introduced process-oriented concepts, an integrative procedural model for the Production of reusable and standard-compliant E-Learning Offerings (PELO-Model) has been created. It can be employed as a production system as it is a structure of all relevant production processes (i.e. for every required asset) and their interfaces for exchanging inputs and outputs. They conjointly produce the final product, i.e. Learning Unit. Such documented sequences of production activities can also serve as a Reference Model for other initiatives. This leads to cost and time savings by enabling reuse and automation and improves quality by specified methods. A further important aspect is an accurate repeatability of process executions [12]. By this, E-Learning production can advance from an art (with many tacit and unrepeatable steps executed by experts) to an engineering discipline.

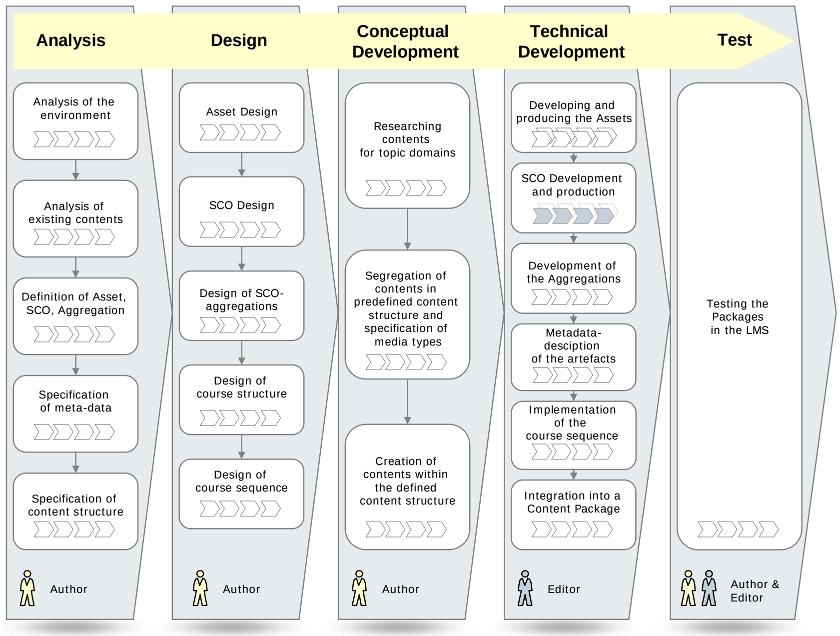

Figure 2: Production of reusable and standard-compliant E-Learning Offerings (PELO-Model)

The procedural model has been influenced by the SCORM Best Practice Guide for Content Developers [10] and extends and specifies it to increase its practical value. Currently, it meets the requirements of the SCORM Version 1.2 specifications. It is not bound to a specific product to support the production of Learning Objects, but is describing a general procedure, which can be applied independently of the employed software.

The PELO-model consists of two layers. On the Macro-Layer, the model has five stages for the content-related and technical development of standardized and standard-compliant Learning Objects. These stages are Analysis, Design, Conceptual Development, Technical Development, and Test (cf. [3, 4]). Each stage is consisting of various steps, which on a Micro-Layer can be further specified by operational and individually adaptable process models and descriptions.

For each of the five stages of the Macro-Layer roles are assigned. The Author role is responsible for the stages Analysis, Design, and Conceptual Development of Learning Objects, whereas the Editor role is dealing with the Technical Development of the content. For the final Test of the produced contents, both roles share responsibility. The Editor is focusing on testing the technical execution and checks if all HTML-pages show their referenced objects. The Author primarily controls the course sequence, focusing on didactical issues.

This two layer concept enables both, the specification of a reference framework on the Macro-layer and the adaptation of the procedural model to meet the individual requirements of the different production processes employed as content developers can add individual definitions of their production processes to the Micro-Layer. The various steps of the Model for the Production of reusable and standard-compliant E-Learning Offerings are now being introduced and illustrated with practical examples.

3 The Specification of Micro and Macro-Processes

The main reason for differentiating a Micro and a Macro-layer of production processes is the specification of the SCORM Content Aggregation Model (CAM). It defines how learning resources are aggregated to form a structured and integrated learning unit, like a course.

The CAM consists of the ‘Content Model’, which is a terminological definition of the learning objects, the ‘Content Package’, which standardizes the combined learning objects in order to exchange them between different Learning Management Systems, and finally the ‘Metadata’, which describes the included components. The Content Model further specifies the three possible components Asset, Sharable Content Object (SCO) and Aggregation. A SCO should be a self-explanatory part of a learning unit, which contains all necessary resources independently of the learning context [10]. It is the smallest logical learning unit and should at least include one asset. Assets are electronic representations of texts, pictures, audio-, or video-based contents. Their main property is a high degree of reusability.

Based on these definitions, in the practical scenario it was decided to treat an HTML-page as a SCO and its resources like audio or video elements, texts and figures as assets. The advantage of this decision is the increased flexibility the contents, the easier object structure, and the unnecessary Intra-SCO-sequencing (embedded information, which determines the order of the SCO’s execution).

The differentiation into different content objects also determines the production processes. The production of the assets is executed within individual processes, which depend on the asset type and the feasible technical, organizational, and financial scope. On the other hand, the SCO production and the specification of aggregations have to meet the requirements of the SCORM specification.

A further benefit is the opportunity to retain the existing processes of asset production and only to modify the final assembly of the individual SCO. However, the defined Micro-processes should also meet the specified process criteria (see section 2.2 about process requirements). This means that already at the stage of developing the Micro-processes, there should be a focus on sustainability, efficiency, and cost reduction.

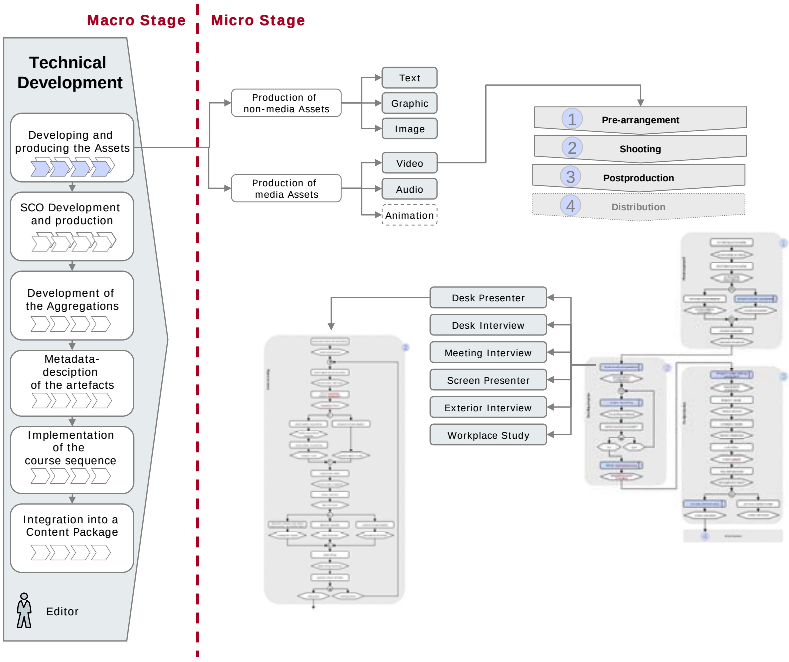

Figure 3: Relation between the Micro-and Macro-layer of the PELO-Model

In the Micro-layer of the practical application, the Macro-step 'Asset production' includes two different strands: the production of non-media assets and the production of media assets (see figure 3). For the project, the term non-media asset refers to the three static asset types which do not possess a time dimension, i.e. text, image, and graphic. The other category currently consists of time-based media, like video and audio-based assets. For these five different asset types, subprocesses have been specified. The course elements exercise, practitioner's opinion, and case study are examples for text-based learning units, which necessitate production processes for graphical-, image-, and text-components. Audio-based learning units are used for most of the training content. They require process specifications for text, graphic, image-, and audio components.

Finally, video-based learning units can be generated by executing the specified video-production process. To produce different videos, six different ‚Shooting-Scenarios' have been defined and modeled.

In the next section, this production of video assets will be introduced in more detail to discuss the criteria for standardization and specification of the processes. The employed shooting scenario is of the type 'Desk Presenter'. The produced assets are then incorporated into the PELO-model's SCO-production process in order to generate a reusable part of a learning unit.

3.1 The Video Asset Production Process

For the effective production of high-quality video material for internet applications, a digital production studio called 'vbc.studiolab' has been established. It is based on inexpensive DV-technology [13, 8]. The blue screen studio is equipped with lighting technology, a Camcorder, an audio recorder, editing equipment, and a Streaming-Server. The visual representation of the video elements is designed to comply with the quality requirements and visual impression of telecasts. Utilizing the component-based principle, it is manufactured as a 'Short Clip' of about three to five minutes length each (see cf. [14]).

The video asset production process has been specified for six standardized shooting scenarios (see figure 3). This ensures diversity while simultaneously enabling repeatable, inexpensive, fast and hence efficient processes with high quality outputs:

- The Shooting Scenario 'Desk Presenter' corresponds with the situation of a commenter, who takes the role of a lecturing coach for the learner,
- The slightly more complex scenarios 'Desk Interview' and 'Exterior Interview' integrate external experts,
- The complex scenario 'Meeting Interview' re-enacts a practical corporate situation (for example a consulting meeting), and finally
- The scenarios 'Workplace Study' and 'Screen Presenter' focus the study of work tasks and the presentation of software applications.

For every scenario, specified descriptions of the set and documented PELO Micro-layer processes are provided to support the production.
Although the six standardized shooting scenarios have different requirements for the media production, they could be integrated into a general process model for video production, which can be extended by specialized processes on a lower level of abstraction.

The following figure 4 shows this general process model of video asset production. It is separated into the main components pre-arrangement, shooting, postproduction, and distribution. For the respective process elements like for example 'prepare video editing equipment' a more detailed process specification of the individual shooting scenario can be employed.

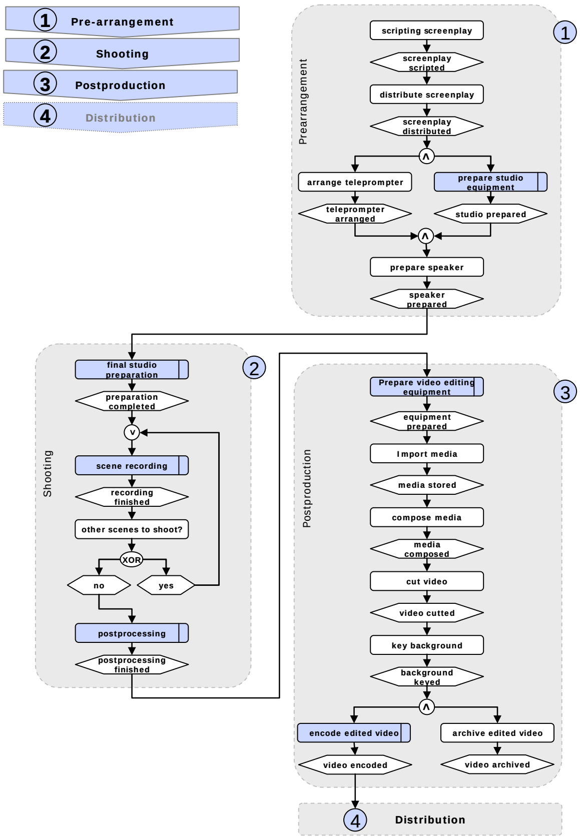

Figure 4: Overview about the Video Asset Production Process on the Micro-layer

The main objective of the process particle ‘pre-arrangement’ is the content-related preparation of the acting persons and the technical preparation of the studio.

The starting point of the video asset production process is the storyboard. It contains the formulated texts and dramaturgical comments for the presenter and the planned shooting scenario written by competent subject matter experts which are also responsible for the content.

The next step is implementing these texts in the teleprompter software application. The technical preparation of the studio is supported by check lists and is executed by the (role) studio assistant. The preparation of the speakers includes camera training and speaking tests using the teleprompter. Just before the actual shooting starts, those activities of shooting preparation are executed, which require the presence of the participants, e.g. the set up of the optimal lighting.

The final recording of individual scenes and takes is determined by various small activities conducted in collaborative team work of all participating people.

The detailed process of recording is dependent on the selected shooting scenario. The following figure 5 shows the specification of the process 'scene recording' for the shooting scenario 'Desk Presenter'. The process consists of the documentation of the shooting in the storyboard, the scene slat, the starting of the audio and the video recording devices, and the actual filming of the speaker after the scene has been started.

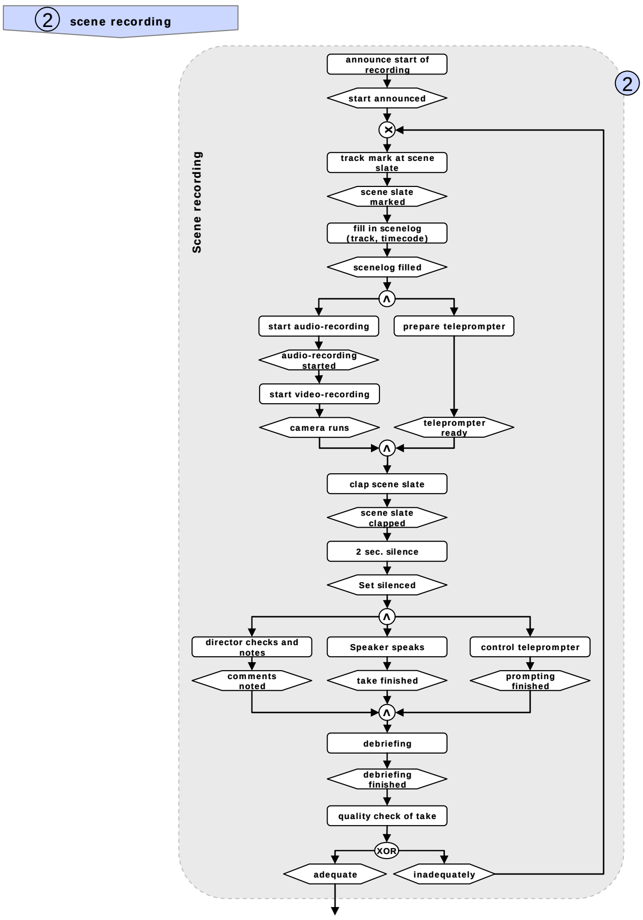

Figure 5: Detailed process component 'Scene recording'

In the step postproduction, the video and audio material is imported, synchronized, cut, and enriched by effects. If the recordings contain blue screen material, the background is replaced by images or video-sequences.

The final raw version is exported as DV-Video on tape. Further, five different band-widths are generated for the Encoding Process. For the distribution, the encoded data is transferred to a streaming server and a quality check is carried out.

3.2 Evaluation of the Process oriented Efficiency Criteria

Because of the standardization and specification of the shooting scenarios and the respective micro-layer process models, the preparatory efforts could drastically be reduced. They are much lower than in conventional open models of producing video material (cf. [15]). The storyboard and large parts of the video production plan have been specified for each shooting scenario and do not need to be developed again for every new scene. All variable parameter could be integrated into the storyboard form, which enables a faster, leaner and more transparent production process as in the conventional approaches. Supporting the preparation of the set with check lists prevents delays in the set's technical and organizational installation and configuration. Markings on the floor help with the installation of the camera, the prompter, and the lighting for each of the standardized shooting scenarios and simultaneously improve the effectiveness and efficiency of the preparations. The process required to prepare the shooting can easily be carried out long before the actual recording of the scenes by only one person.

At the day of scene recording, special emphasis has to be directed to ensuring efficiency, because multiple persons are required at the same time, which implies a high consumption of costly personnel capacity. To minimize this effort, all possible elements have been shifted to the preparation processes.

In the 'vbc.studiolab', the shooting scenario 'Desk Presenter' has originally been recorded by four participating persons (Camera/Audio, Teleprompter, Speaker, Director). However, in the minimal configuration, two experienced persons can be sufficient (Speaker and a directing, prompting and recording Assistant). Experience also resulted in higher productivity. Starting with 15 minutes of material produced in four hours of work, the lab and experienced staff can now generate about 45 minutes of material in the same time.

The actual shooting time is the sum of the recording time and the setup time for each new recording multiplied by the amount of takes necessary to record the planned scene in the appropriate quality. This time is affected by the experience of the crew (the assistant) and the speaker and further by the shooting scenario. It has to be noted, that the last element is the main influence for the resulting shooting time. This implies that procedural specifications allow for improved repeatability and sustainability of the processes, but not necessarily affect the efficiency of the original filming process.

Summarizing, it could be observed, that a definition of the shooting processes could not reduce the overall time of process execution due to many sophisticated manual operations with a low potential for automation. However, checklists support the control of the set installation and the shooting protocol captures all necessary data for the subsequent post-production processes. It is hence affecting the important quality aspect of production efficiency. It further increases sustainability as the process specifications allow for a better and faster training of the foundations of media production to new employees.

In the post-production, the media import could be accelerated by introducing and optimizing shooting and media protocols. The specification of a fixed set of shooting scenarios and the documented post-production process models decrease the complexity of video editing. For example, by establishing a set of standard background motives (showing university facilities like lecturing rooms, offices, and labs) for the shooting scenario ‘Desk Presenter’, this task could be improved in terms of time and quality.

The effective optimization of processes by introducing software applications can be illustrated by an improved Encoding Process. The encoding of different band widths could be developed as a batch processing process, which considers encoding and compression parameters using presets. This helps to eliminate repetitive manual processes like the parameterization of the exports. Moreover, the extensive automatic processing and rendering could be transferred to evening and night hours.

Using the video asset production processes as an example, this section introduced and illustrated the detailed processes on the Micro-layer of the PELO step ‘Asset Production’. The generated assets of the step ‘Developing and Producing the Assets’ are constituting the input of the subsequent step ‘SCO Development and Production’. Here, the assets are merged and integrated into a SCO. This process element is now introduced using the example of the non-media assets for text based learning units.

3.3 The non-media Asset and SCO Production Process

The combination of text based learning units (HTML-pages) and the according audio files form the SCO (Sharable Content Object). The challenge of this process was to reduce the extensive production efforts and duration for the 950 HTML pages of the produced courses on Knowledge Management and Process Modeling. Simultaneously, this process needs to comply with the requirements of the SCORM specifications. Another very important aspect is that once the contents have been produced and are online, there needs to be an efficient process for changing (parts of) the available material in order to adapt to new insights, restructurings and extensions (e.g. a new version of a programming language). In many proprietary E-Learning offerings this aspect is often forgotten or is as expensive as reproducing the complete material again. In the absence of new financial funding, this can lead to outdated and inflexible elements in the courses.

For the production of text based learning units using non-media assets, there is no clear differentiation between asset and SCO production. In principle, the development of learning contents and the allocation of media types is carried out in the PELO step of ‘Conceptual Development’ (cf. figure 2). This content development process is currently supported using the tool MS PowerPoint. Within MS PowerPoint, the Graphic Pane is used for drawing figures, the Comment Field is filled with explaining texts and the Slide Structure Navigator contains the sequence of the contents. A presentation is representing a course unit and within the MS PowerPoint based elements, graphical and textual tags are used to signal the intended implementation of special contents like video components, case studies, exercises etc. The production of the according assets is executed in the known step ‘Asset Development’.

Therefore, the learning contents are stored using the MS PowerPoint file format. As MS Office does currently not provide XML-export of the presentation, OpenOffice.org 1.1.0 is utilized to import the MS PowerPoint document and export the contents in a special file format, which is based on the public XML-standard. This resulting JAR (JavaArchive) Format is a package-file, which includes a manifest that contains a list of the content archive [5]. Using an XSLT-transformation, a reduced and filtered XML-file is generated to ease the subsequent automated processing (see figure 6).

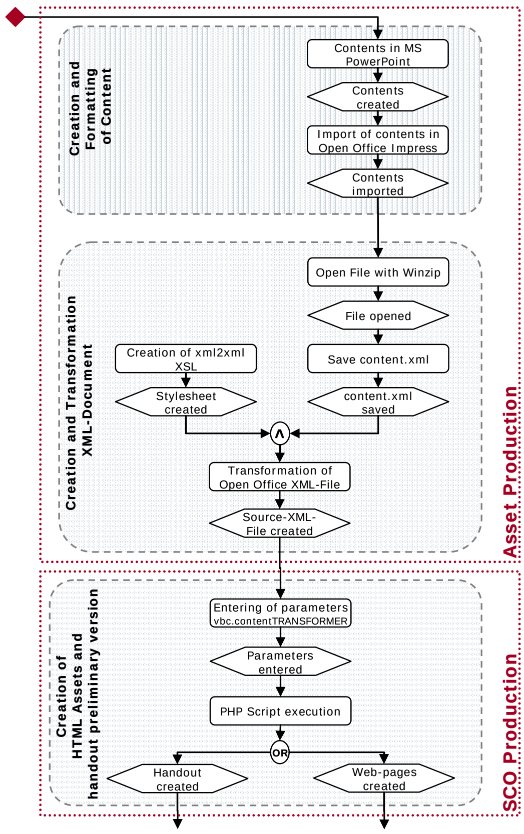

Figure 6: Non-Media-Asset and SCO Production Process

To automate this process, the Java-based XSLT-processor Xalan is utilized [1]. Xalan helps to transform XML-documents into HTML, text, or other XML-documents. In the project, Xalan is used to generate the reduced XML-file from the OpenOffice.org 1.1.0 output format.

Here, it has to be noted, that this process component should formally be a part of the asset production, because the contents generated with MS PowerPoint are transferred into the XML-format and are hence a resource (asset) for the subsequent integration into a SCO in the SCO production process. However, to increase the transparence of the individual production activities, this separation is avoided in this contribution.

In the next process step, the XML-based contents are being automatically converted into the final HTML-documents, using the individually created prototype ‘vbc.contentTransformer’. This tool has been implemented in the scripting language PHP, because it is a language which can be embedded in the HTML source code (embedded code). This is then interpreted and executed on the server side. PHP furthermore owns many convenient commands for treating special variables and working with HTML contents.

After this step, the multiple SCOs of the course are available as HTML-pages. The according layout of the HTML-pages can easily be changed as the transformer tool incorporates the layout definitions and the special Javascript functions to implement the learning path.

3.4 Evaluation of the process-oriented Efficiency Criteria

Next to the evaluation of the video asset production process, the non-media asset and SCO production process is continuously being evaluated using the efficiency criteria introduced in section 2.2. As far as general success factors are concerned, the introduction of the XML-format and the development of the vbc.contentTRANSFORMER helped to decrease the costs of producing, maintaining and developing the output. Furthermore, the required process duration could be reduced. This can be illustrated with the following time-based comparison, which only considers the step of SCO production. The new process is taking 72 minutes less to execute as the original production process[1]. This rather small improvement of 12 percent assumes that the contents are completely new and produced for the first time. However, the comparison should also take into account the time needed to change the actual content material (as an indicator of flexibility). Now, by comparing the old and new production processes of the actual HTML-pages, the new process is clearly advantageous. In the original process, the Editor role needs 106 minutes for the generation of the script and the HTML-pages. With the new process (including improved IT support), the time needed is reduced to 34 minutes. This equals a time saving of about 70 percent.

[1] The complete process for the production of the whole course is 600 minutes in the original structure versus 528 minutes with the new process.

Another improvement is an increased flexibility of the Production Processes to react to changes in the requirements. Modifications of the layout only need to be incorporated into the vbc.contentTRANSFORMER once. Subsequently, they can be applied automatically to all produced HTML-pages.

Next to these general, the specific process success factors can be analyzed. By determining a single authoring tool (MS PowerPoint) and by introducing XML technology, the complexity of the process execution and the content-related redundancies (caused by employing multiple tools for authoring contents) could be reduced.

The definition of Content Components (asset, SCO) and their production based on pre-defined processes could meet the required SCORM-compliant production of the E-learning offerings. Within the project, the aggregation of individual resources (assets) and HTML-pages (SCOs) to a Content Package is supported by IT using the RELOAD Content Packaging Editor.

The complete process has been documented [17] and can be easily reproduced with the help of checklists and task descriptions and for every task a responsible person is being assigned to support a fast allocation of tasks.

4 Outlook and Conclusion

This paper introduced the main elements of business process orientation and its application to the field of E-Learning Production. The fundamental method is to model all relevant processes using standard modeling notations and to employ a fixed set of efficiency criteria in a process management approach to evaluate and improve the existing processes. From the resulting system of production processes a procedural model for the Production of reusable and standard-compliant E-Learning Offerings (PELO-Model) is derived. This model is describing a generic procedure consisting of five Macro stages, which can be applied independently of the employed software. This allows content developers to utilize it for the individual definition of their production processes. Thus, it constitutes a reference model which aims to enable an easy development of standardized and standard-compliant efficient E-Learning processes. Technical examples for production processes were illustrated in the second part with a special focus on the interfaces between the Macro-layer and the Micro-layer of the PELO model.

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