A Comparison of Visual Instructional Design Languages for Blended Learning

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Abstract: Visual Instructional Design Languages (VIDLs) are powerful tools for building conceptual models of instructional designs. E-learning courses appear to be a very suitable “playground” for VIDLs, as they usually provide a plethora of design options (e.g., tools, materials, delivery channels). Today there are a lot of different approaches to visual modeling of learning designs. In this paper we give a brief introduction to four VIDLs suitable for e-learning purposes: E²ML, the Person-Centered e-learning pattern approach, the EduWeaver modeling framework, and IMS Learning Design. Subsequently, an evaluation framework is proposed and the VIDLs are compared according to proposed criteria based on modeling experience with a complex blended learning course at the authors’ institution.

Introduction

The design and development of university courses has become more complex through the increasing use of new media. Visual instructional design languages (VIDLs) and notations can be used as tools for modeling different aspects of courses involving the use of new media, e.g. e-learning, blended or distant courses, etc. Designing e-learning courses is a complex task and requires expertise in several fields – so design teams are often interdisciplinary: Communication and cooperation between involved pedagogues, psychologists, instructors, subject experts, instructional designers, administrative support staff and technicians, can be facilitated through modeling of the courses. In general, VIDLs can support the design process in the following ways:

- Better communication with less misunderstanding between experts due to consistent terminology.
- More intuitive understanding than a textual description through reduction of complexity.
- Educational requirements for tools to be used in specific e-learning settings can be defined more easily.
- Investigation and diagnosis of different e-learning settings and comparison with respect to main course design principles, e.g. the alignment of face-to-face and distant activities. In this way a VIDL can lead to a more profound understanding of e-learning scenarios.
- Reuse of already successful e-learning course designs or e-learning content (Tattersall et al., 2003).
- Sharing of expertise as well as best practices.
- Training of new designers.
- Teaching strategies as well as used materials can be documented in a standardized and compatible way.
- Bridging the gap between the design and implementation. For example, in the Blended learning Systems Structure model (BLESS) VIDLs are used for assisting instructors and administrators in customizing the web support for their e-learning courses (Derntl, 2004).

However, there are also drawbacks. For example, users need to collect experience and feel comfort in employing VIDLs; otherwise few of the potential benefits are likely to take effect. Therefore in this paper we try to identify and describe criteria for useful and usable VIDLs. We build an evaluation framework around these criteria, which we subsequently apply to analyze four different VIDL approaches: the Educational Environment Modeling Language (E²ML), the Person-Centered e-learning (PCEeL) pattern approach, the EduWeaver modeling framework (Eduweaver) and the IMS Learning Design (IMS/LD) specification. Based on experiences with modeling a whole blended learning course, specific strengths and weaknesses of the different VIDLs with respect to our criteria are elaborated.
Presentation of Selected VIDLs

E²ML – Educational Environment Modeling Language

E²ML is a semi-formal modeling notation for creating and documenting instructional designs (Botturi, 2004a). Learning goals, requirements and design of teaching and learning activities can be modeled. There is a more specific tool for goal classification that was developed together with E²ML: the Quail Model (Botturi, 2004b), which is a visual model for the definition and classification of high-level learning goals. E²ML modeling starts with the definition and mapping of educational goals, then all available resources (actors, resources, tools) get listed and action diagrams as the core part are modeled. Finally overview diagrams are created, for example a timeline as visualization of the “course calendar” (Botturi, 2003). So there are three central document sets: (1) goal definitions, (2) action diagrams and (2) overview diagrams (Botturi & Belfer, 2003).

Person-Centered e-Learning (PCeL) pattern approach

PCeL combines Carl Rogers’ person-centered approach to teaching and learning (Rogers, 1983) with elements of e-learning (Motschnig-Pitrik & Derntl, 2005a). PCeL scenarios and instructional activities which facilitate meaningful learning are modeled and collected in the PCeL pattern repository (Derntl, 2005). Families of related patterns are organized in packages. There are seven packages in the pattern repository: Assessment, Course Types (e.g., patterns for seminars, lectures), Evaluation (e.g., self- and peer-evaluation), Feedback (e.g., reaction sheets), General (e.g., meetings, team workspaces, diary), Interactive Elements (e.g., brainstorming, team building, chat, tutorial) and Project-based Learning. The patterns are modeled using extended UML activity diagram. The most notable extensions include different stereotypes for declaring activities as face-to-face, web-based, or blended (Motschnig-Pitrik & Derntl, 2005b). The complementary structural models use generalization/specialization concepts, as well as dependency relations (e.g., include, derive, successor-of, or use). All patterns are described by a template style including name, intent, motivation, parameters, and further sections.

EduWeaver modeling framework

EduWeaver is based on the meta-modeling platform ADONIS®. EduWeaver allows defining courses and teaching processes with coherent learning units in a sequence, as well as lessons and learning objects. An XML-export interface is included, which allows to export content packages according to the IMS standards and integrate them into learning management systems. There are four modeling levels that are hierarchically linked with each other (Karagiannis & Bajnai):

1. Course: provides an overview of all courses, which will be specified in the other levels.
2. Module: One course consists of different modules, which are thematically coherent units and they can be modeled in several possible teaching paths – sequential, alternative (if previous knowledge is necessary) or parallel (e.g. theory and practice) (Bajnai & Steinberger, 2003).
3. Lesson: Lessons take about 45–90 minutes of learning time. Lessons can take place sequential (e.g. weekly), in loops, or parallel (e.g. online and present) and alternative paths can be defined.
4. Learning object use: what learning objects are used in a single lesson?

Designers can either start bottom-up with learning objects, collect them in a lesson, and in modules building a whole course – or they can start top-down modeling courses first. Learning objects are small, homogenous parts of the subject and they need about 5–15 minutes to be taught. They are linked to the real multimedia material (HTML, document...) and can be used in several courses (Bajnai & Steinberger, 2003). For each of the modeled elements – courses, modules, lessons, and learning objects – the application offers a “notebook,” where further information can be supplied. For learning objects this is for example general data like description or owner and additional data like related learning objects, target group, requirements, key words or HTML documents.

IMS Learning Design (IMS/LD)

The IMS learning design is a XML-based language for specifying learning content and processes. IMS refers to the Instructional Managements Systems Project which develops and promotes technical specifications for learning technology (IMS Global, 2003). Historically the basis of IMS/LD is EML (educational modeling language) (Tattersall & Koper, 2003) which was developed by the Open University of the Netherlands. It is independent of any specific pedagogy and its main focus is learning content, which is one important aspect of blended learning. IMS/LD is a modeling language for elements and structure of learning units and learning processes; it is modeled
Learning Design consists of three parts: Level A, B and C. There are different XML schemas provided for each level and each level extends the previous one. At level A time ordered activities which are performed by teachers and learners (role) are specified within an environment of learning objects and services (IMS Global, 2003). At level B there are also properties (additional information about persons or roles and conditions) and conditions. Notifications, which are added at level C, can trigger new activities, e.g. a teacher has to answer if a question of a student occurs. Usually one starts the analysis of a didactical scenario with a narrative. In the next step semi-formal UML diagrams are drawn. They are more rigorous than a narrative, but less detailed than an XML document. On the basis of the UML activity diagram the XML document instance is created. In the last steps, actual physical content is created on the basis of the XML file and the physical resource files and the design gets linked to each other and packaged in a content file.

Method

For the development of the evaluation framework a top-down as well as a bottom-up approach was employed: In the top-down approach several important aspects were gathered before comparing the visual languages. They were derived from literature study about distinctions of visual languages and tailored to the specific purpose of VIDLs. According to a bottom-up approach we comprehensively modeled one and the same blended learning course in each of the four languages to gain a deeper understanding of differences between the languages. A blended learning course was selected as this mode is currently popular in most presence universities. Starting from the modeling process and the different models developed as a result, differences of the modeling languages as well as criteria for comparing the languages were elaborated.

Description of the course: “Web Engineering”

The Web Engineering course is part of the Business Informatics curriculum of the University of Vienna. It is recommended for 4th semester students. The course consists of 2 hours lectures and 2 hours lab practice per week. In the lectures relevant subject matter and theory is presented, while in the lab practice students work together in teams on a project and have to do several exercises according to predefined milestones. For passing the lectures students can take a written exam or they can engage in a learning contract and take an oral exam.

- **Learning Targets:**
  - Methods and processes for planning, modeling, and developing Web Information Systems.
- **Content:**
  - Planning, Modeling and Implementation of Web Information Systems (e.g. in categories Informational Systems, Interactive Systems, Transactional Systems, Workflow Systems, etc.)
- **Learning Goals:**
  - Students know different kinds, architectures and areas of application of Web-based systems (WBS) in economy and society and can find suitable web solutions for new problems.
  - Students can develop a simple WBS with data link (SQL, XML). Gained skills refer to technical aspects and to insights of the user acceptance, Usability and the ability to work in a team.
  - Students can create XML documents and understand the role of XML and related technologies such as XML Schema (XSD), XPath, DTD, etc.

Examples of the models

All together 25 visual models, 12 tables and a long textual description in IMS/LD were elaborated. Figure 1 shows an overview diagram of the lab practice of the WE course, modeled in PCeL on the left side. The dependencies diagram of the lab practice modeled in E²ML down to the right shows that in the construction phase of the team project an XML tutorial and assignment take place. An action description of the XML assignment modeled in E²ML is shown top right.
Evaluation Criteria

The following criteria, along with the corresponding questions, were selected for the VIDL comparison:

C1: **Focus of content modeled:** Visual Models can address e.g. learning goals, learning activities, learning materials or course schedules. Are there differences and overlaps in what and how things are modeled?

C2: **Pedagogical theory:** Does the modeling language rely on a specific pedagogical theory? Or is it completely independent of any pedagogic foundation and can it be used in every teaching and learning setting?

C3: **Standardization/ Formal degree:** Does the modeling language build on standardized conceptual modeling techniques like UML? Are object-oriented principles like abstraction or encapsulation used?
C4: **Reuse**: Is it possible to integrate models and reuse sub-models for models of another course? Is reuse of learning content supported?

C5: **Usability** (clarity, understandability): Are the models easy to understand for someone, who is not used to them? Is it easy to learn how to model courses with the language? This point should be evaluated separately for the different sub-models of the modeling language.

C6: **Modeling tools and Impact of/on design activities**: Are connections of the models to e.g. learning management systems or to web templates possible?

**Results**

**Comparison of the visual design languages**

In the comparison the IMS learning design specification has partly a special status, because it is not a “visual” modeling language. Aside from the UML diagrams used in the creation process of IMS LD files, no visual models are created. Nevertheless this specification plays an important role and integration with the other modeling languages would be important.

**C1: Focus of content modeled and model types**

Concerning the focus of content modeled and the model types interesting differences between the modeling languages could be found. The differences are partly very large so as a consequence it is also interesting to look for overlapping and for possibilities where the languages could complement one another.

**Similarity: Sequences of educational activities**: In all of the languages a kind of sequences of educational activities in form of activity diagrams can be found. The Flow chart diagram in E²ML is one example modeling the learner’s point of view. Another example is the UML activity diagram of the PCeL pattern approach, where all kind of activities of all actors are modeled. Furthermore the levels two, three and four of EduWeaver framework resemble such sequences, though there the focus lies - especially in level two and three - on the content and only in level four content and learning activities are modeled. In the IMS learning design also UML activity diagrams are used, but they only have the role of a pre-step for the creation of IMS/LD files.

**Model types not overlapping**: The visual modeling of learning goals can only be found in the Quail model, which belongs to E²ML. There are also tables like Goal statement, Resource lists and the Course Breakdown statement, which cannot be found in other modeling languages. Furthermore action diagrams are used, which are a structured verbal description of activities and a dependency diagram that shows dependencies among activities, independent of time. In the PCeL pattern approach there are diagram packages showing which parts a course consists of. This could also be modeled in model level two of the EduWeaver modeling framework, but there a sequence is modeled compared to the dependency relations modeled in the diagram packages. In the PCeL pattern approach there are no further individual model types; the strength of this approach are the pattern repository and the structured descriptions of the patterns. The learning object pool of EduWeaver modeling framework is something that is not modeled in the other modeling languages. Furthermore on level one an overview of courses is modeled. The mixture of learning objects and activities in the model type of the learning objects use is also an individual feature. In the EduWeaver modeling framework and in IMS LD a strong focus lies on modeling content, which is not that central within E²ML and the PCeL pattern approach.

**Time horizon**: Besides different modeling elements there are distinctions according to the time horizon. Neither in the regular UML activity diagrams used in IMS/LD nor in the PCeL pattern approach the time horizon is defined visually. In comparison, in E²ML activities are modeled for each week. In the EduWeaver modeling framework the time horizon is given implicitly by the modeling levels, because it is defined how much time lessons or learning objects take.

**C2: Pedagogical theory**

Visual instructional design languages are likely to be pedagogically neutral. The meta-model would otherwise have to be quite restrictive to allow only for modeling courses according to a specific pedagogical theory. The Person-centered e-learning pattern approach is the only modeling language discussed that has an explicit focus on a specific
pedagogical approach - the person-centered approach, although the language itself that is using UML diagrams is neutral. Nevertheless it is claimed that design decisions are oriented towards this approach. Therefore a clear value system underlies the PCeL patterns (Derntl, 2005). One advantage of following a pedagogical theory is that if new courses are built upon several existing patterns, it is more likely for the new designed course to be homogenous according didactics. In the other visual instructional design languages discussed, the modeler is free to model educational settings following different pedagogical approaches. Nevertheless implicit pedagogical assumptions of the modeling languages can have an influence on the course design. In the EduWeaver modeling framework for example lessons should take about 45-90 minutes and consist of 7+/−2 learning objects. Besides this there is no specific pedagogical approach mentioned in the EduWeaver modeling framework. Moreover there is no single pedagogy inherent in the E²ML and in the IMS LD specification (Tattersall et al., 2003). Several pedagogical models like Problem based Learning, Competency Based Learning or Programmed Instruction can be modeled and be interpreted by an IMS LD aware player (IMS Global, 2003). However thinking about pedagogy is fundamental for using the specification as it is for all modeling languages. E.g. according to the IMS LD specification learning objectives and prerequisites have to be defined, learning activities and tools to be identified.

C3: Standardization and Formal Degree

IMS/LD was created to be a standard by itself. Standard UML diagrams are used in the development process of an IMS/LD file. The PCeL pattern approach also builds on the standardized conceptual modeling technique UML for visualization and description. In the PCeL pattern approach there are some new elements used in addition to the standard UML notation, like the stereotypes “web-based” or “present”. E²ML does not resemble already existing modeling standards. In the E²ML activity flow diagrams there are e.g. other modeling elements for parallelism, options and conditions compared to the standard UML notation. Furthermore, no start and end nodes are used. In the EduWeaver modeling framework no elements of the UML notation, but some elements of the Adonis business process modeling language are used, e.g. the triangle symbolizing the starting point.

Formal degree: IMS/LD seems to be the most formal approach. Besides the UML diagram, which is created in the development process of an IMS/LD file, the XML structures are of course highly formal. Moreover the IMS/LD specification was created to serve as a standard; therefore a high formal degree is inevitable. The different models of E²ML vary in its formal degree. Action diagrams, Resource lists and the Course breakdown statement are more or less structured textual descriptions in tabular form. The dependencies diagram, the Quail model and the activity flow are graphical representations. Formalization is tried to be achieved by good descriptions, nevertheless several questions during modeling how something should be modeled correctly remain open. The PCeL pattern approach claims to choose a “golden mean” according to formalization- semiformal visual design models as well as structures textual descriptions are used (Derntl, 2005). The formal degree of the EduWeaver modeling framework is rather high, because the language was defined with the meta-modeling method ADVISOR.

C4: Reuse

Reuse of models is highly supported by the PCeL pattern approach. In the pattern repository, pedagogic valuable patterns are collected specifically for reusing and combining them by instructors as well as for further development. For E²ML reusing patterns would be suitable too, but is not yet developed. This possibility of integrating models and reuse of sub-models for models of another course is not the main target of the EduWeaver modeling framework, here the reuse of learning content is supported very well. The IMS learning design has also a strong focus on reusing learning objects and content.

C5: Usability and understandability

The level of usability and understandability depends amongst others on the existence and quality of modeling tools available supporting the modeling language and on the level of formalization. High formalized models like the IMS Learning design specification seem to be better suitable for designers having an IT background and being familiar with XML. Nevertheless there are sophisticated tools available, where parameters can be filled in and the IMS LD file is created automatically. Drawing E²ML models is quite intuitive and most of the models are easy to understand with a short description. Using EduWeaver modeling according to the EduWeaver modeling framework is easy after understanding the meaning of the different levels. Reading and understanding the models is no problem, especially because there are familiar symbols like books and stick-figures. The PCeL Patterns are a little bit more difficult to understand if one is not familiar with UML. In return they are easy to model if one knows UML.
C6: Modeling tools and Functionality/ Impact of on design activities

There are substantial differences to which degree modeling support is available.
- There is an implementation of the EduWeaver modeling method available on [www.EduWeaver.net](http://www.EduWeaver.net) constructed within the ADVISOR meta-modeling platform. Existing resources like lecture notes, slides, documents, HTML-pages and so on are collected in a “content pool” and can be linked with the instructional model. For completed models HTML-pages can automatically be created, showing the structure of the course and possibly serving as simple web based trainings (Karagiannis & Bajnai, 2001). Furthermore a connection to the organizational model of the educational institution is possible (Karagiannis & Bajnai, 2004).
- For modelling E²ML there is a Rational Rose Add-In available.
- There is a Learning Design Editor from Reload (Reusable E-learning Object Authoring & Delivery), which is based on the IMS Learning Design specification. It allows the creation of reusable Pedagogical Templates. The user defines Learning Objectives, Activities, Roles, Learning Environments and so on and an IMS/LD file can automatically be created.
- For the PCeL pattern approach an Add-In for Adonis was created. Furthermore web templates of selected patterns are implemented on the Cooperative Environment Web Services (CEWebS) learning platform. In the developed “Pattern Manager” patterns can be chosen and a configuration be taken for creating a suitable instance of the learning platform for a specific course.

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<th>Table 1: Summary of VIDL comparison.</th>
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<td><strong>E²ML</strong></td>
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<td>Focus of content modeled</td>
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<td>Model types</td>
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<td>Overlapping: Sequences of educational activities</td>
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<td>Model types not overlapping</td>
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<td>Time horizon</td>
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<td>Standardization &amp; Use of UML</td>
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<td>Relationship to IMS/LD</td>
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<td>High/partly very high</td>
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**Conclusion**

In this paper a comparison as well as short introduction of four visual instructional design languages suitable for e-learning purposes was given: E²ML, the Person-Centered e-learning pattern approach, the EduWeaver modelling framework and the IMS specification of learning design. A concrete blended learning course from the University of Vienna was modelled in each of the four languages for gaining knowledge about differences of the visual instructional languages. An evaluation framework was deducted that included the following six criteria: focus of content modelled, underlying pedagogical theory, standardization/formal degree, possibility of reuse, usability, available modeling tools and impact of/on design activities. A similarity of all VIDLs was that they all included sequences of educational activities mostly in form of UML activity diagrams. There were also many visual model types not overlapping. According to the underlying pedagogical theory it was found that most of the VIDLs were pedagogically neutral. The degree of standardization and formalization are well as usability differed between the VIDLs. For all VIDLs modeling tools were available, although differing in quality.

Because only one single blended learning course was modeled there could not be any generalized assumptions about different application domains for the different VIDLs, e.g. classic courses, pure e-learning, pure distant learning. Analyzing such scenarios may bring up additional evaluation criteria or different results. Providing good modeling tools also has a strong connection to another fundamental step which should be taken in the next future: The development of pattern repositories which are more open and international orientated than the existing solutions on the level of institutes or universities. This could lead to better knowledge sharing on e-learning processes, on-going improvements of didactic scenarios as well as strengthened research in this field.

**References**


