A Review of Storyboard Tools, Concepts and Frameworks

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Abstract. This paper describes and analyses storyboard tools, concepts and frameworks. It aims to identify gaps in storyboard works in an attempt to extend support for establishing a common ground between instruction designers and subject-matter experts as a distributed instructional design team. Twenty-four storyboard tools, concepts and frameworks are described according to the two classifications of domain applications, domain-independent and domain-dependent. They are reviewed and analysed with regard to three aspects of e-learning storyboard requirements: collaborative design environment, iterative process methodology and designer-centredness support. The finding shows that much less research has been done on collaborative environments and iterative processes than on supporting designers' work. It is also found that storyboard systems have some limitations in terms of giving the distributed instructional design team opportunity to engage in these cognitive task-related activities.

Keywords: storyboard tools, storyboard systems, distributed instructional design team.

1 Introduction

Instructional design teams in communities of practice recognise the importance of establishing a common ground with the people they work with. In an extended and distributed design project, experts from different domains must coordinate their efforts despite the limitations of time and distance. The application of storyboarding techniques has been a useful approach in distance learning development to support interaction between instructional designers and subject-matter experts in communicating the design of an e-learning course. A substantial amount of time and effort is required however to reach a shared understanding of the coordinated tasks and activities. The purpose of this paper is to review and analyse existing storyboard tools, concepts and frameworks. It begins by describing 16 storyboard systems and groups them into two types of software classification tools and models. The next section focuses on eight storyboarding concepts and frameworks which have the potential to become functional tools in future. This is followed by analysis of the storyboard tools, concepts and frameworks whose design implications have fostered an approach to support instructional designers and subject-matter experts' interaction as a distributed instructional design team.

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2 Storyboard Tools and Concepts

Following Wang, Shen, Xie, Neelamkavil, and Pardasani (2002), these tools are classified into domain- independent and domain-dependent tools. These software classification tools and storyboard models are not confined to any particular domain and cover a wide spectrum.

2.1 Domain-Independent Tools

The domain-independent tools of storyboards are tools that support specific but general-purpose tasks. They are divided into three sub-categories: the sketch-based approach, authoring approach, and SCORM approach.

The sketch design approach is treated as a domain-independent tool as it can provide functionalities to assist designers to sketch user interfaces and web pages. Landay and Myers (2001) developed SILK (Sketching Interfaces Like Krazy), a storyboard that allows designers to sketch user interfaces easily by recognising the designer's ink strokes. Bailey, Konstan, and Carlis (2001) developed DEMAIS (Designing Multimedia Applications with Interactive Storyboards), a sketch-based, interactive multimedia storyboard tool that uses a designer's ink strokes and textual annotations as an input design vocabulary. Newman, Lin, Hong, and Landay (2003) developed DENIM (Design Environment for Navigation and Information Models), an informal website design tool that supports designers in sketching input, allows design at different levels of granularity, and unifies the levels through zooming.

In the context of instructional design, an authoring tool supports non-programmers in assembling media objects and preconstructed scripting code to build instructional learning applications (Chapman, 2008). The authoring approach is treated as a domain-independent tool to support users or designers in authoring any aspects of objects and processes required to reach a specific objective. Harada, Tanaka, Ogawa, and Hara (1996) developed ANECDOTE to support designers to edit the different aspects of the scenario using multiple editing views, and help them to create the final application seamlessly from the prototype scenario. Midieum, Byung-soo, and Jun (2005) developed the AR storyboard (augmented reality-based interactive storyboard authoring tool) to support intuitive interfaces for scene composition and camera pose/motion control. Thronesbery, Molin, and Schreckenghost (2007) developed the ConOps (Concept of Operation) storyboard to help designers to create, communicate, and refine concepts of operation information.

SCORM (Sharable Content Object Reference Model) is a technical specification that governs e-learning content creation and delivery (Bohl, Scheuhase, Sengler, & Winand, 2002). The SCORM approach is treated as a domain- independent tool as it helps designers to create e-learning content that complies with SCORM specifications. Ting et al. (2005) developed the eStoryboard authoring tool which is intended to provide designers with functionalities such as creation of HTML documents, Flash editing, and inserting images and, at the same time, generating outputs in flash format to produce a SCORM-compliant document. Yang, Chiung-Hui, Chun-Yen, and Tsung-Hsien (2004) developed the Visualized Online Simple Sequencing Authoring

Tool (VOSSAT) to help designers to edit existing SCORM-compliant content packages which can be embedded as a module on the Content Repository Management System (CRMS).

Table 1 shows a summary of domain-independent tools and their implementation technologies.

2.2 Domain-Dependent Tools

The domain-dependent tools of storyboards are tools that are hard-wired with theories and models in an instructional design that cannot be altered. These tools use underlying philosophical models and theoretical underpinnings (Gustafson, 2002). They can perform various functions for different kinds of learning solutions. They are divided into two subcategories: the learning theories approach and instructional design model approach.

The learning theory approach is treated as a domain-dependent tool as it supports the intended application of learning theories which inform the designer about the flow of the modules and ensures that all aspects of the intended course have been covered. Hundhausen and Douglas (2000) developed SALSA (Spatial Algorithmic Language for StoryboArding) as a teaching approach in which students use the simple art supplied to construct and present the algorithm to their instructor and peers for feedback and discussion. Lee and Chong (2005) developed OntoID (Automated Eclectic Instructional Design) to support the design phase through the explication of different techniques in the learning theory categories. Deacon, Morrison, and Stadler (2005) developed Director's Cut to support students as designers in the production of multimodal texts which enable the understanding of conventions and processes. Mustaro, Silveira, Omar, and Stump (2007) developed a schematic storyboard for learning object development to support the instructional design (ID) team throughout the model schemes moulded in a linear process according to the five processes in ID: analysis, design, development, implementation and evaluation. Igbrue and Pathak (2008) developed the Multiple Intelligence Informed tool to support both novice and experienced IDs in designing storyboard assessments suitable for multiple intelligences in e-learning.

The instructional design model approach is treated as a domain-dependent tool as it supports the design of a particular instruction. Hodis, Schreiber, Rother, and Sussman (2007) developed eMovie to support designers in making molecular movies in 3D structures. Furini, Geraci, Montangero, and Pellegrini (2010) developed STIMO (STIll and MOving storyboard) to help designers to produce on-the-fly, still and moving storyboards.

Table 2 shows a summary of domain-independent tools and their implementation technologies.

3 Storyboard Frameworks

In addition to the above domain-independent and domain-dependent tools, the following storyboarding concepts and framework have the potential to become functional tools in future. Baek (1998) developed a KMS-based environment to support the

knowledge management activities of multimedia designers. Jakkilinki, Sharda, and Ahmad (2006) developed the MUDPY (multimedia design and planning pyramid) to guide designers through the various phases of a multimedia project in a systematic fashion by allowing them to create a project proposal, specify the functional requirements, decide on the navigational structure and create a storyboard. Dohi, Sakurai, Tsuruta, and Knauf (2006) developed the Dynamic Learning Needs Reflection System (DLNRS) storyboard tool to support the formal process of representing, processing, evaluating and refining didactic knowledge. Choo Wou (2007) developed the ILC-CMAS Model (Intuitive Life Cycle-CMAS Model) to assist the process of content development and the storyboarding management process for multimedia software development. Bulterman (2007) developed a framework to support user-centered control of media within a collection of objects that are structured into a multimedia presentation. Kleinberger, Holzinger, and Müller (2008) developed MEMORY (Multimedia Module Repository) to provide designers with a technological base for implementing e-learning applications that make extensive use of continuous media, especially video. Wan (2007) developed the Content Storyboard Application System Framework to monitor subject-matter experts in performing storyboarding activities. Wahid, Branham, Harrison, and McCrickard (2009) developed the concept of Collaborative Storyboarding to help in aggregating designers' expertise in the storyboarding process, and it offers the opportunity for a group of designers to make progress toward creating a visual narrative for a new interface or technology.

Table 3 shows a summary of conceptual models and frameworks and their implementation technologies.

4 Design Implications: Storyboarding Approach

This section discusses three requirements of an e-learning storyboard which support instructional designers and subject-matter experts' interaction; the relationship of instructional designers and subject-matter experts, which is recognised as collaborative in nature, the importance of iterative process in design, and the importance of designer-centredness support. The storyboarding tools, concepts and frameworks are discussed in that context.

4.1 Collaborative vs. Non-Collaborative Design Environments

The literature contains no description of collaborative effort by tools from the domain-independent category and only one tool, i.e. Director's Cut (Deacon et al., 2005) from the domain-dependent category mentions this collaborative environment. The collaborative design environment has been identified in many conceptual models and framework research: Baek (1998) describes the KMS-based environment, Choo Wou (2007) the ILC-CMAS model, Wan (2007) the Content Storyboard Application System Framework, and Wahid et al. (2009) the concept of collaborative storyboarding.

Table 1. Summary of domain-independent tools and their implementation technologies

Name of System/Tool	Key Features	Implementation Technologies
SILK (Landay & Myers, 2001)	To support sketching for user interfaces.	Common Lisp. The Garnet toolkit.
DEMAIS (Bailey, Konstan, & Carlis, 2001)	To support the early stages of multimedia design.	Java language, Java Media Framework (JMF) and Java Speech Markup Language
DENIM (Newman, Lin, Hong, & Landay, 2003)	To support early-phase information and navigation design of websites.	Java 2. The SATIN toolkit
ANECDOTE (Harada, Tanaka, Ogawa, & Hara, 1996)	To support the early-design phase and the whole development process of multimedia applications.	-unspecified -
AR Storyboard (Midieum, Byung-soo, & Jun, 2005)	To support non-experienced designers using interfaces in real environments at the pre-production stage of film-making.	- unspecified -
ConOps (Thronesbery, Molin, & Schreckenghost, 2007)	To provide effective task that can support the difficulties of designer to understand end user tasks and software engineering principles.	- unspecified -
eStoryboard (Ting et al., 2005)	To create SCORM learning contents, generate multiple lesson plans, and predict learner performance from the generated lesson plans.	Artificial Intelligence Planning and Bayesian Reasoning.
VOSSAT (Yang, Chiung-Hui, Chun-Yen, & Tsung-Hsien, 2004)	To assist designers in editing the existing SCORM-compliant content packages for learning processes.	- unspecified -

Table 2. Summary of domain-dependent tools and their implementation technologies

Name of System/Tool	Key Features	Implementation Technologies
SALSA (Hundhausen & Douglas, 2000)	To support designers in constructing rough and unpolished low-fidelity visualisations.	spatial algorithmic language
OntoID (Lee & Chong, 2005)	To provide strong pedagogical guidance through the provision of educational models and techniques founded on learning philosophy.	XML technology
Director's Cut (Deacon, Morrison, & Stadler, 2005)	To support students in creating their own video sequences from a set of clips in order to promote creativity.	- unspecified -

Table 2. (*continued*)

Schematic Storyboard tool (Mustaro, Silveira, Omar, & Stump, 2007)	To support the instructional design team throughout the model scheme development and production of learning objects in storyboard.	- unspecified -
Multiple Intelligence Informed tool (Igbrue & Pathak, 2008)	To guide IDs in creating the multiple intelligences informed e-learning content	- unspecified -
e-Movie (Hodis, Schreiber, Rother, & Sussman, 2007)	To support designers with guidance and direction in the form of structures and conformation changes in filming.	open-source molecular graphics program
STIMO (Furini, Geraci, Montangero, & Pellegrini, 2010)	To support the production of on-the-fly video storyboards.	Farthest Point-First (FPF) clustering algorithm

Table 3. Summary of conceptual models and frameworks and their implementation technologies

Name of System/Tool	Key Features	Implementation Technologies
KMS-based environment (Baek, 1998)	To support multimedia designers in sharing their knowledge on the web.	Java script and Cold Fusion
MUDPY (Jakkilinki, Sharda, & Ahmad, 2006)	To streamline the process of creating a multimedia system by providing a clear pathway for planning, design and development.	Protẽgẽ 2000
DLNRS storyboard tool (Dohi, Sakurai, Tsuruta, & Knauf, 2006)	To support the didactic knowledge that can be represented by storyboards and used for supporting dynamic learning activities of students.	- unspecified -
ILC-CMAS Model (Choo Wou, 2007)	To support experts of Smart Schools, organisations and universities involved in the development of multimedia software and courseware.	- unspecified -
User-centred multimedia control. (Bulterman, 2007)	To support user-centred control of multimedia that assist in locating or recommending media objects.	- unspecified -

Table 3. (*continued*)

MEMORY (Kleinberger, Holzinger, & Müller, 2008)	To support continuous media with adaptive multi-media processes in order to achieve efficiency in search, selection, rating and usage.	Python programming language, C++, Java, CORBA
Content Storyboard Application System Framework. (Wan Adli Ridzwan, 2007)	To support SME in constructing e-learning content storyboards based on Gagne's Nine Learning Events.	PHP, MySQL
Collaborative storyboarding (Wahid, Branham, Harrison, & McCrickard, 2009)	To facilitate shared understanding among designers.	- unspecified -

4.2 Linear vs. Iterative Process Methodology

The literature identifies only one tool from the domain independent category which implemented iterative process whereas none is identified from the domain-dependent category. The ConOps tool which is developed by Thronesbery et al., (2007) describes a concept of operations that requires iteration to support creative design activity. Researchers such as Dohi et al. (2006), Choo Wou (2007), and Bulterman (2007) implement an iterative process method in their conceptual models and frameworks.

4.3 Designer-Centredness vs. Learner-Centredness Support

In the literature, many researchers have concentrated on the designer-centred approach. All the sketch-based tools (Landay & Myers, 2001; Bailey et al., 2001; Newman et al., 2003) were designed to support designers. An authoring tool that supports designers' work was demonstrated by Harada et al. (1996), and both Midieum et al. (2005) and Thronesbery et al. (2007) designed tools for authoring storyboards to support learners.

All the SCORM-compliant based tools (Ting et al. 2005; Yang et al., 2004) support designers in developing learning content which is compliant with SCORM requirements. The same support can be found in the e-learning theory-based tools (Hundhausen & Douglas, 2000; Lee & Chong, 2005; Deacon et al., 2005). Mustaro et al. (2007) produced a schematic storyboard for learning object development and Igbrue and Pathak (2008) developed a multiple intelligence tool.

Instructional model-based tools (Hodis et al., 2007; Furini et al., 2010) are designed purposely for learners, however. Researchers such as Jakkilinki et al. (2006), Choo Wou (2007), Wan (2007) and Wahid et al. (2009) demonstrated storyboarding concepts and frameworks which are intended to support designers' work.

Figure 1 shows the classification of the available storyboard tools and frameworks in several categories for quick reference.

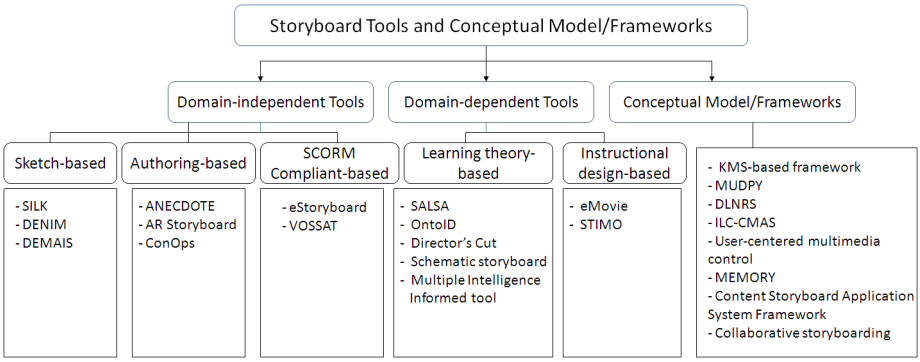

Fig. 1. Storyboard tools, conceptual models and framework

5 Conclusion

This paper discusses and analyses the available storyboard tools which are categorised in two types: domain-independent and domain-dependent tools. Existing conceptual models and frameworks have also been identified and presented. From the analysis of all the tools, concepts and frameworks, it can be concluded that less research has been done on collaborative environments and iterative processes, but much has focused on supporting designers at work. It is also evident that the existing storyboard systems have some limitations in terms of giving the distributed instructional design team opportunity to engage in these cognitive task-related activities.

This study sheds light on the storyboarding systems about the importance to handle the designers in performing their storyboarding task, as well as the cognitive effort that is needed by the designers in performing storyboarding activities. An empirical study has been carried out in order to understand the cognitive difficulties of designers during storyboarding (Yusoff & Salim, 2012). This study explores problem aspects of the cognitive task and the skills required of subject-matter experts by applying a cognitive task analysis approach from the expert perspective, and have consequently identified subject matter experts' difficulties in making decisions on three elements during e-learning course development: the storyboard templates, prescriptive interactive components, and review process.

On the other hand, a storyboard system that can work in a distributed and collaborative environment would be needed in order to support people's interaction, user communication and the iterative process. More necessary, however, for a distributed instructional design team is the functionality to adapt to changes and work towards shared mental model. Future works which incorporate collaborative tasks for the instructional design team should be able to function as a communication tool as well as perform design instruction rather than focusing on the process and tool development.

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