Master Thesis

Fly

Expressive and Conveying Planar Presentations

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I hereby declare that I have created this work completely on my own and used no other sources or tools than the ones listed, and that I have marked any citations accordingly.

Aachen, March 2011
Thomas Heß

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Abstract

Software that utilizes the slide show metaphor is the prevalent way to create visual presentation support. The format originates from physical overhead slides. Nowadays, however, visual aid is shown with video projectors, which makes the slide format arbitrary. Despite that fact, there is no established alternative format. The slide format has several disadvantages. The content must be divided into equally sized chunks and adjusted to fit into the slide frames. In the strictly linear slide deck format, the content cannot be arranged into an overall hierarchy. These problems do not only affect presentation authors, but also presentation audiences. We continue our work on an alternative format for presentation visuals, called *Fly*. It allows to arrange the content on a zoomable planar canvas and to describe presentation sequences as paths through the created information space. In this thesis, the existing Fly concept was developed. Shortcomings of the previous version have been addressed and new features have been added. Furthermore, the Fly format was evaluated with regard to the perception by presentation audiences. In particular, Fly's effectiveness for knowledge transfer was analyzed. In an experimental comparative study against the baseline *PowerPoint*, informative presentations of both formats were shown to groups of students. Afterwards, the participants were tested for content retention and understanding as well as asked about their attitude towards and satisfaction with the presentations. While no significant effect for learning outcome could be found, there were significant results in favor of Fly for the perception of the presentations. The attendees could understand the presentations' structures more easily and were better informed about current context and presentation progress. Individuals with a high spatial cognitive ability preferred the flexible resolutions of the Fly visuals. Overall, the Fly format assisted the audiences better in understanding and following the presentations.

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Conventions

Throughout this thesis the following conventions are used.

T-test results are reported in the form

$t(\text{degrees of freedom (df)}) = \text{t-value}, p = \text{probability (2-tailed significance)}$

Since the order of groups is not relevant for the tests in this thesis, the t-values are reported as absolute values.

For the independent samples t-tests, the Levene's test for equality of variances was used to test if the assumption of homogeneity of variance in the conditions was violated. In cases where the variability was significant different, the violation was corrected by not using the pooled estimate for the error term for the t-statistic and by making adjustments to the degrees of freedom using the Welch-Satterthwaite method. The respective cases are marked in the reporting.

Source code and implementation symbols are written in typewriter-style text.

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The thesis is written in American English.

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Chapter 1

Introduction

Slide-based visual presentation support, such as Microsoft's PowerPoint, commonly denoted as *slideware*, is prevalent in industry, education, government, and other areas of life. The format originates from physical overhead slides. Nowadays, however, presentation visuals are shown directly from a computer with a video projector, which makes the slide format arbitrary.

Slides are the common form of presentation support.

The slide deck format has been repeatedly criticized for the limitations it imposes on authors and presenters. The content is divided into equally sized chunks and a strictly linear presentation sequence is enforced. The structure of the content has to be mapped onto the linear slide deck format, which makes it especially difficult to represent complex topics that have more than one logical dimension or that are highly interconnected. In order to convey the content's structure and to provide information about context and progress, crutches, such as manually inserted overview slides, have to be used. The result of these limitations and slideware's standardized templates are overly predictable and generic presentations in which content and originality get buried. The limitations and implications of slideware are described in section 2.2—"Slideware".

The slide deck format has disadvantages for authors, presenters, and audiences.

There have been multiple approaches to address the problems of slideware. These systems either extend the slide deck format by features for slide classification and non-

There are alternatives that augment the slide deck format and other approaches that dismiss the slide metaphor.

linear deck traversals or dismiss the slide metaphor and instead allow for an alternative organization of the individual content elements. Many of the alternative systems use a canvas-based format for the arrangement of either the slides or the content elements. In these formats, the presentation sequence is described as a path through the created information space. Path stops show views of the canvas at varying zoom levels. This functionality decouples content and presentation authoring. Chapter 3—"Related Work" describes the related alternative systems.

In Fly, users arrange the content spatially on a planar canvas and create a presentation path across the plane.

Fly is a canvas-based system for presentation visuals that is developed as a continued research project at the Media Computing Group[1] at RWTH Aachen University. Fly works without slides but instead allows to place the content atomically onto the zoomable canvas. Previous work evaluated the presentation authoring with Fly. This study showed that Fly provides superior authoring support in comparison to PowerPoint. See section 3.2.1—"Fly" for a detailed description of the prior work on Fly and the previous evaluations.

The existing Fly concept was developed and extended.

This thesis develops and extends Fly. The usability problems that had been identified in the evaluation of the previous version have been addressed and new features have been added that extend the format's capabilities and that make Fly's feature set more comparable to that of common slideware applications. The new features benefit presentation authors, presenters, and audiences. The chapters 4—"Design" and 5—"Implementation" describe the design and the implementation of the developed Fly concept.

Authors can represent content accurately in Fly and the Fly format has cognitive benefits for the audiences.

The second objective of the thesis was to investigated how presentation audiences perceive the Fly format and if Fly visuals can convey information better than slideware. We argue that Fly can be a better visual presentation support because of the possibilities it provides for presentation authors and because of the cognitive benefits that Fly visuals have for audiences. In Fly documents, the content macrostructure is represented in the canvas layout. Thereby, all information is integrated into its context. The structure of the canvas and thus also of the content is con-

[1] http://hci.rwth-aachen.de

veyed to the audience during a presentation. Fly makes it easy for authors to incorporate overviews, to partition content variably, and to integrate related content. During presentation delivery the Fly format utilizes the human spatial cognitive abilities for perception and learning. All content elements are associated with spatial positions which provides an additional encoding of the information. The spatial layout provides orientation about the context of the current content and the progress of the talk. Not least, Fly's animations make the visuals engaging and attention grabbing. We make the argument for Fly in chapter 6—"Argument for Fly as Better Presentation Support".

The Fly format was evaluated with regard to knowledge transfer and perception by presentation audiences.

To test the audience perception of Fly visuals, an experimental evaluation was executed in which the learning outcome for informative presentations with Fly and PowerPoint support was tested and the audience members were asked about their attitude towards and satisfaction with the presentations. While the study could not show a significant difference for knowledge transfer between the formats, the participants stated that they could understand the structures of the Fly presentations easier and that they had a better orientation about the current context and progress. Viewers with a high spatial cognitive ability preferred the content partitioning of Fly over that of PowerPoint. The presentation documents for the study were created by an external author. Qualitative observations were made about the authoring process in both formats and the differences between the PowerPoint and Fly documents. Chapter 7—"Audience Study" describes the audience study.

1.1 Contributions

The contributions of this thesis are:

- A quantitative evaluation of presentation documents of a format that is similar to Fly. The evaluation examined how presentation authors use a canvas-based document format.
- The extension of the Fly concept with features that

were adapted from slideware and with unique capabilities that take advantage of the canvas format.

- Qualitative observations of the authoring process with Fly in comparison to PowerPoint. The results confirm the findings of the user studies in prior work.
- An experimental evaluation of Fly in an audience study against the baseline PowerPoint. The study tested learning achievement and presentation perception.

1.2 Chapter Overview

The thesis is structured as follows:

Chapter 2 covers the relevant foundations. It describes presentation formats and the roles within presentations, examines the problems of the slide deck format, introduces zoomable user interfaces, and summarizes the cognitive foundations of learning.

Chapter 3 discusses the related work. Six alternative systems for presentation visuals are described in detail. Furthermore, the results of the evaluation of 50 canvas-based presentation documents are presented.

Chapter 4 describes the concept and design of the new Fly version and the reasoning behind it.

Chapter 5 briefly documents the implementation of the software prototype.

Chapter 6 contains the argument for Fly as a better visual support for presentations.

Chapter 7 describes the experimental evaluation of Fly with regard to knowledge transfer and audience perception. It also documents the authoring process of the used PowerPoint and Fly documents.

Chapter 8 summarizes the thesis and gives directions for future work on Fly.

Chapter 2

Foundations

2.1 Presentations

Presentations are a communication format used for many different purposes in education, business, and even everyday life. The visuals to support presentations are nowadays created and delivered with the help of a computer.

In comparison to other communication means for addressing an audience, such as distributing documents, sending emails, conference calls, or broadcasts, presentations have important advantages. In presentations, speakers can use the content of multiple modalities together with the interaction possibilities of face-to-face communication. A presenter can immediately respond to reactions from the audience. The typical means of a presentation—the spoken commentary, the visual support, and a take-away written summary—do, when done well, reinforce each other to create a memorable learning experience. A good presentation will capture the audience's attention, successfully fulfill the presenter's intentions, and not least create lasting memories for the audience.

Presentations are superior to other formats for addressing audiences.

2.1.1 Presentation Formats

The form of a presentation varies with its purpose.

The great variety of scenarios, in which presentations take place, lead to different formats with varying characteristics. The formats can be classified along these criteria:

Intention Does the presenter want to instruct, to persuade, to report, or to discuss? Is the goal to inform neutrally or to elicit an emotional response? There can be multiple purposes for a single presentation.

Audience A presentation should have the addressed audience in mind. Who is in the audience? How small or large is the audience? A bigger audience tends to increase the formality.

Formality How formal or informal is the event? Is it a presentation among familiar colleagues or does the presenter address strangers?

Interaction How much interaction is allowed from the audience? Can they interrupt and ask questions? In a meeting-like scenario, even open discussions might be desired. A less formal event with a small audience will allow more interaction.

2.1.2 Role of the Presenter

The presenter's performance is the most important factor for the quality of a talk.

In a face-to-face presentation the speaker is the most important factor for the success and quality of the talk. The performance is influenced by the presenter's skill and experience; the amount of preparation and rehearsal; the use of movements and gestures; the choice of words; the fluency, pacing, and emphasis of the articulation; and last but not least, by the presenter's form of the day. A speaker sets the presentation's pace with the spoken commentary and by controlling the visual support. With the explanations the speaker even controls in what speed and sequence the audience takes in the visual information [Slykhuis et al., 2005]. A good presenter is able to compensate for shortcomings in the presentation support [Blokzijl and Andeweg, 2005].

2.1.3 Role of the Visual Aid

The visual aid should support a live presentation by illustrating the spoken commentary to allow for easier and immediate understanding of the presented ideas. For simple topics, no visual reinforcement may be needed. But for more complex topics, especially those involving detailed data or models of interrelationships, the visuals are critical to provide a framework for understanding.

The visuals support the speaker's message and help the audience to understand.

Computer-based visual support can utilize and combine different kinds of media: static text and graphics, animations, and audiovisual material. What type of content the visuals should contain depends on the presentation's goal. If the goal is to inform about a complex and technical topic, the visuals can show sophisticated informative graphics, such as graphs and diagrams. In this case, the audience will also benefit if a framework of the ideas is shown on screen. Whereas, for a non-technical and emotional presentation, e.g., when the purpose is to persuade, compelling visuals and little text can be used to boost the speaker's message [Farkas, 2008, 2009]. This is taken to the extreme in presentation styles where the visual support only shows large graphical elements in a rapid sequence, e.g., in the *Lessig method* [Reynolds, 2005].

The content of the visual aid depends on the presentation's purpose.

A good presentation support will help the presenter to communicate the content and stay on track. Especially unskilled presenters can benefit from well-prepared visuals. When delivering a presentation, the presenter has to think about what to say and simultaneously control the visual aid. To attenuate this multitasking conflict, the cognitive load of the controlling task should be minimized by making the navigation through the visuals as easy as possible [Good, 2003].

The visual support can also assist the presenter.

2.1.4 Role of the Audience

Presentation delivery is a two-way communication process in which the audience communicates with the speaker as well. The audience will express its attitude towards

The audience will always interact with the presenter.

speaker and presentation. Audience reactions indicate if additional details, clarifications, or examples are needed, if the content is already known, or if the presenter should progress slower or faster. The audience will communicate if they do not understand, loose attention, or even become bored. These reactions can be conveyed verbally by means of questions and interruptions or silently through signals and behaviors that the presenter can sense, such as eye contact or body language.

2.1.5 Authoring Tasks

Presentation authoring is an iterative, multi-stage process.

Lichtschlag [2008] identified and analyzed the tasks involved in presentation authoring and delivery. Presentation authors first have to research, collect, and, if necessary, create the content that is going to be presented. Next, they have to create the presentation document, which involves selecting, structuring, arranging, and formatting the assembled material. The content is laid out along a narrative and the visual support is coordinated with the planned commentary. This includes to decide which and what content to show on screen and what content to communicate solely orally. Finally, authors have to create presenter notes and possibly handouts for the audience. Presentation authoring is an iterative process in which authors apply both top-down and bottom-up strategies [Lichtschlag, 2008].

2.2 Slideware

The slide deck format originates from physical slides.

Slideware's conceptual model is based on the notion of rectangular slides that are shown in a linear, predefined sequence. It comes from physical presentation media, such as overhead transparencies and 35-mm slides. Originally, the purpose of slideware was to design physical slides.

Besides static content, slideware supports the use of animation, audio,

Today, slideware visuals are displayed with video projectors and can, therefore, also incorporate multimedia content. In particular, slideware adds support for animation and audiovisual content. Animations can be used for slide transitions and animated builds. Embedded audio and video snippets are usually used to illustrate and exemplify.

and video.

There is currently no established alternative format for presentation visuals.

Slideware is prevalent in industry, education, government, and other areas of life [Parker, 2001]. There is currently no established alternative format for computer-based presentation support. Slideware's adaption is so universal that the document format is also used to gather and record information that is not necessarily going to be presented.

In university education, slideware is used in the majority of all lectures [Craig and Amernic, 2006, Kjeldsen, 2006]. The format is so well established that students expect it and insist on being able to download the slide decks after the lectures [Kjeldsen, 2006].

Microsoft's PowerPoint[1] (PPT) is by far the most common slideware software. It is part of the *Microsoft Office*[2] suite that has a worldwide market share of more than 60% [Hümmer, 2010, Vile, 2007]. Because of this propagation and because PowerPoint was the first available slideware application, it got established as a shorthand for slideware [Farkas, 2009].

Other established WYSIWYG (What You See Is What You Get) desktop slideware applications are Apple's *Keynote*,[3] and OpenOffice.org's *Impress*[4] . Slide decks can also be created using LaTeX,[5] e.g., with the LaTeX beamer class,[6] or in HTML, e.g., with the *S5*[7] system. Furthermore, there are web applications for creating slide decks, such as *Google Docs*,[8] *SlideRocket*,[9] and *280 Slides*.[10]

Slideware and the slide format have been criticized for several years.

Slideware has been repeatedly criticized for degrading the quality of presentations [Doumont, 2005, House et al., 2006,

[1] http://office.microsoft.com/powerpoint/
[2] http://office.microsoft.com
[3] http://www.apple.com/iwork/keynote/
[4] http://www.openoffice.org/product/impress.html
[5] http://www.latex-project.org
[6] http://bitbucket.org/rivanvx/beamer/
[7] http://meyerweb.com/eric/tools/s5/
[8] http://docs.google.com
[9] http://www.sliderocket.com
[10] http://280slides.com

Kjeldsen, 2006, Parker, 2001, Tufte, 2003] (see *sooper.org*[11] for a list of more than 250 articles criticizing slideware, in particular PowerPoint, published between 1998 and 2009). The following sections describe how slideware, because of the linear slide deck format and the encouraged authoring practices, "shapes the presenter's message" [Farkas, 2009].

2.2.1 Format Implications

The slide deck format has implications for all aspects of presentations.

The linear slideware format has in itself significant implications for authoring, presenting, and attending presentations. These hinder authors in creating documents along their mental models, limit the flexibility during presentation delivery, and make it difficult for the audience to follow and memorize the presented content.

Unstructured Linearity

The structure of a slide deck is inevitably flat and linear.

The strictly linear structure of a slide deck is unapt to convey the hierarchical structure of a topic [Doumont, 2005, Good, 2003]. All slides in a linear deck are semantically on the same hierarchical level, which does not correspond to the logical relationships of the content they contain. It is only possible to organize the content hierarchically within, but not across slides. The hierarchy within the deck remains flat.

The global content hierarchy is not visible.

An individual slide, with its title, is on the top of the visual hierarchy, but may contain the content of various levels on the logical hierarchy. Therefore, the visual appearance does not reflect these hierarchical distinctions, but masks them [Farkas, 2009].

Content gets fragmented into chunks.

As a result, the content is fragmented into isolated chunks without coherent context and global narrative [Kjeldsen, 2006, Tufte, 2003]. This makes it difficult to understand context and relationships of information [Tufte, 2003]. The audience must discern the hierarchical distinctions without

[11] http://sooper.org/misc/ppt/

visual support. The presenter needs to clarify the masked logical relationships.

Dedicated structure slides must be used to convey the global hierarchy.

To counter this limitation and to visualize the content hierarchy and narrative, the presentation author has to manually create and maintain additional dedicated slides, such as overview, section, and category slides [Farkas, 2009, Good, 2003]. Overview slides visualize the presentation's logical hierarchy at the beginning of the slide deck and, additionally, repeated throughout the deck. Section slides can be placed in front of the individual sections to highlight their beginning. Category slides are used to outline the next upcoming slides and clarify their logical relationships.

However, all of these additional slides do not structure the slide deck, but only visualize the logical hierarchy to counter the format's masking effect. They reside between the content slides on the same hierarchical level.

Slideware does not facilitate the use of structure slides.

Deck authors have to know that adding these distinct slides is good practice and they have to invest the additional effort to create them and keep them up to date when the presentation is reorganized [Good, 2003]. Slideware applications provide no assistance for creating overview, section, or category slides, but promote to "present in relentless sequence" [Kjeldsen, 2006].

Because of the inability to convey a global hierarchy, the slideware format is especially unsuited for communicating complex topics that are highly interconnected, nonlinear, or have more than one logical dimension. Because the linear slide deck format can only represent one dimension, authors cannot express their mental model of the content directly, but must convert it to a linear structure [Good, 2003, Lichtschlag, 2008]. Furthermore, because information can only be shown after each other sequentially in time and never side by side, the deck format is also not well suited for comparative analysis [Tufte, 2003].

Content is associated with single temporal positions.

Another consequence of the strict sequentiality is the fact that content must be copied if it occurs multiple times in a presentation. These copies bloat presentations documents and lead to data synchronization issues.

Meanwhile, sophisticated slideware applications, such as PowerPoint and Keynote, allow to break up the strict linearity with hyperlinks. Authors can link content elements to random slides within the same deck or to other slide decks. As a result, it is possible to structure a presentation as a directed graph and to provide for some flexibility during presentation delivery. Keynote even supports hyperlink-only presentations that completely get rid of the linear slide sequence. Slideware, however, is not geared well for this kind of authoring. Consequently, it has been shown that the hyperlink functionality is rarely used by deck authors [Spicer and Kelliher, 2009b].

Fixed Chunk Size

The slide format imposes a fixed, rather low resolution.

The resolution of slides is fixed to the detail level. This rather low resolution, together with the fixed slide frame dimensions, limit the amount of information that can be presented at a time. The fixed chunk size is not correlated to the natural content chunk size of an individual topic and is not compatible with the changing levels of detail during a presentation. As a result, authors have to edit the content to fit it into slide frames.

Content must be adapted to fit onto slides. There are three strategies to deal with too much content for a slide.

If there is too much content to fit on a slide, they have three possibilities. First, they can abbreviate content to fit it into the available space [Tufte, 2003] and exclude content they originally planned to use—this practice is called *content cutting* [Farkas, 2009, Lichtschlag et al., 2009]. Second, they can adjust the slide layout by reducing the font sizes, tightening the spacing, and deleting and shrinking the graphics to create more space on the slide [Farkas, 2009]. The result is an overcrowded slide that is hard to read and causes a high cognitive load for the viewer. This practice can be called *content squeezing*. Third, they can distribute the content over multiple slides by creating continuation slides (*content overflow*). In the process, authors have to pay attention to indicate properly that the slides belong together rather than stand on their own and that the in-slide content hierarchy of a preceding slide is correctly continued on the subsequent slide [Farkas, 2009]. If the content overspill is not enough to completely fill a continuation slide, authors run into the other form of the fixed chunk size problem: not enough content.

In the case of too little content to fill a slide, authors can either revert to content cutting and drop the content, or fill up the slide with extraneous material that potentially distracts from the relevant content. The reason for these practices is that a partially filled slide will give an unfinished impression.

The reverse of the problem is not enough content to fill a slide.

In any case, the slide format edits the author's ideas [Parker, 2001]. Slideware's formality prevents the author from pursuing the goal of simply entering the information. Slideware adds adaptation costs that reduce the chances that alternative organizations will be explored [Good, 2003].

An example for the fixed chunk size problem is the slide shown in figure 2.1. It was part of a recent presentation by the leadership of the US and NATO forces in Afghanistan and is to show the complexity of the military strategy [Bumiller, 2010]. Because slides are not part of an overall hierarchy, but separate chunks, the whole graph had to be squeezed onto one slide—making it unreadable. The resulting slide lacks any focus, which makes it unsuited for a presentation where the visual aid must focus on the currently relevant aspect to adequately support the audience.

Because the fixed format necessitates careful visual formatting for accommodating the content, whenever the content of a slide decks changes, it takes additional effort to adjust the slides. The limited reuse support of the slide format is further discussed in section 2.2.1—"Inflexible Linearity".

Limited Drafting Support

In order to create a good hierarchy and narrative for a presentation, it is important to be able to explore alternatives during the early authoring stages. The more difficult it is to explore alternatives, the fewer are going to be considered [Good, 2003]. The early stages of presentation authoring

There is inadequate assistance for the early authoring stages.

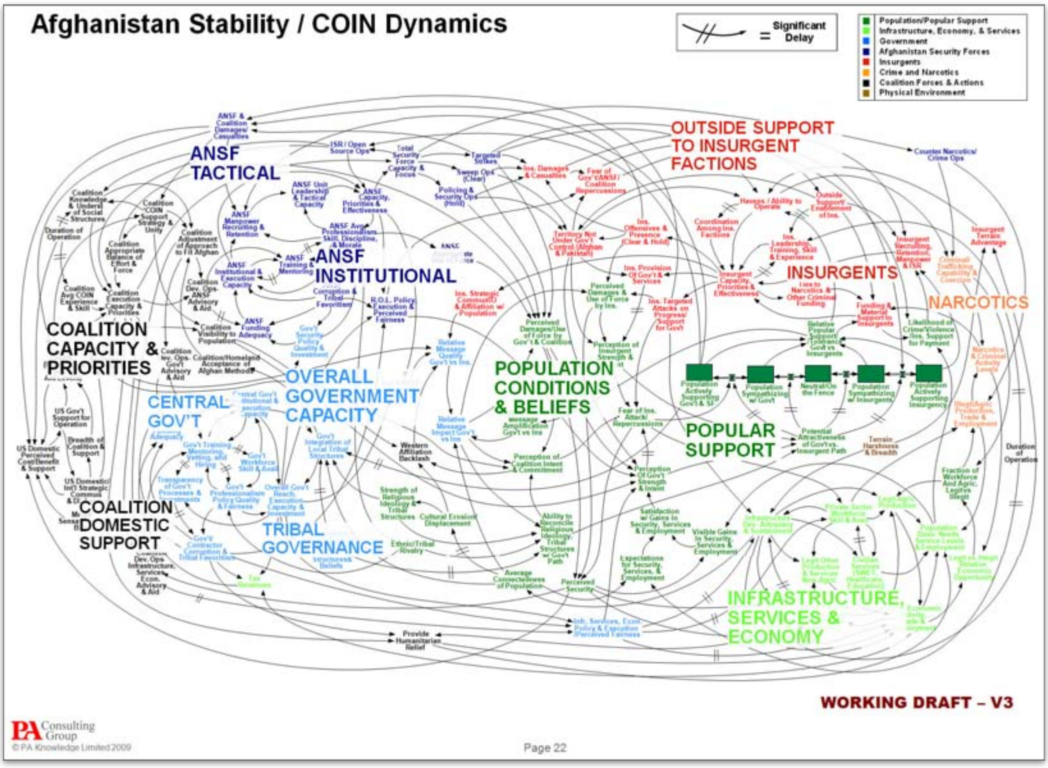

Figure 2.1: US Army/NATO Afghanistan Military Strategy Slide (From [Bumiller, 2010])

are the collection and selection of the content that is going to be used and the organization of the content into a overall structure and narrative. To support these tasks, it should be possible to prepare the content independent of the presentation's final format.

Slideware makes it difficult to explore alternative content organizations.

In slideware, however, authors can place content only onto slides and, therefore, immediately associate it with a specific sequential position. The content is also right away subject to the slide frame's limitations. There is no intermediate place to gather content. The fixed linear structure "disregards the way that talks are typically created, edited, and presented in practice" [Moscovich et al., 2004]. The formality of slideware does not match the user's task and, consequently, increases the cost as the user's mental model must be converted to the system's representation [Good, 2003].

As a consequence, authors have to use other tools, such as outline applications or pen and paper, to draft the overall structure of presentations. Inexperienced authors may not do so and instead develop the structure while authoring the individual slides, which can lead to a deficient content organization and a simplification of complex topics [Tufte, 2003].

Slideware does not facilitate top-down authoring strategies.

Being limited to authoring on the detail level leads to the problem Good [2003] described as *perfection fault* and Lichtschlag et al. [2009] called *detail trap*. Instead of thinking about the presentation's main structure and narrative, authors are misguided into formatting and beautifying the details of slides [Good, 2003, Lichtschlag et al., 2009, Tufte, 2003]. Complex relationships may become simplified and the resulting polished visual design adds additional format constraints [Good, 2003].

Inflexible Linearity

Presentations need to be adaptable during delivery.

During presentation delivery, a presenter may need to adapt the scripted presentation on the fly to outside influences, such as audience reactions or time pressure. The audience may have questions about an earlier slide or a related point, or the speaker may have a moment of inspiration. Consequently, the presenter may need to access specific content from the presentation, to show additional content, or to skip over content.

Slideware's has limited navigation possibilities.

The linear slide deck format severely limits the presenter's possibilities to navigate through the presentation content. It is possible to navigate back and forth in the slide deck sequence and jump to a slide out of order. Presenters can access a random slide by typing in its serial number or, if the setup provides a separate private presenter screen, from a thumbnail overview of all slides (see figure 2.2). Despite these possibilities for random slide access, it is a common bad practice to rapidly flip through slides by "fire-clicking the 'next' button" [Moscovich et al., 2004].

The presenter can only trigger slides, not specific content.

Nevertheless, the presenter has no way to access content without locating the slide that contains it. Current slideware applications do not support to search within the slide

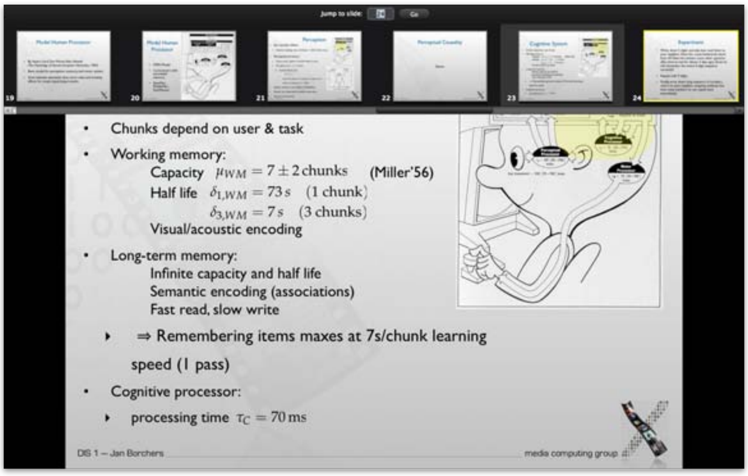

Figure 2.2: Apple's Keynote With Slide Switcher

deck in presentation mode.

These navigation limitations make it hard for the presenter to access specific content and to adapt the presentation by skipping parts of the content. Therefore, presenters will be reluctant to improvise and to adapt the presentation to the situation. Whenever there is a navigation between nonconsecutive slides, the presenter has to improvise a transition that describes how the slides are related [Good, 2003].

Authors must place additional material separately from the content it relates to.

If the presenter wants to provide additional material, e.g., in preparation for potential questions or for additional elaborations, it has to be placed on distinct slides at the end of the slide deck because of the format's strict linearity. This makes the content hard to access and places it disjunct of the context it conceptually belongs to.

Improvisations are often not visually supported.

Consequently, it is rather uncommon to provide additional material. Improvisation is often not visually supported [Moscovich et al., 2004], or worse, the presenter may not even be able to react adequately because the required material is missing.

The slideware format's rigid linear nature may even discourage the audience to interact [Bumiller, 2010, Good, 2003, Spicer and Kelliher, 2009b]. When even the presenter refrains from improvisation, the audience will also be held back to interrupt and ask for additional information.

Limited Reuse Support

It is common to create multiple presentations on the same topic, intended for different audiences and different situations. For example, a topic may be presented in an exhaustive colloquium presentation, a 20 minute conference talk, and a five minute summary.

In slideware, all the content is directly tied to the presentation sequence. Content and presentation authoring are not separated. Since a modified presentation will have a different temporal sequence, an author must copy the reused content to a new slide deck that implements the new timeline.

Authors must duplicate content for alternative presentations.

The resulting documents with duplicated material become hard to manage, as the changed content multiplies and diverges. It becomes difficult to keep all versions coherent; edits must be propagated back and forth.

Another reason for limited reuse support is that the slide deck format is inherently unsuited for managing large amounts of content. The means for overview, such as the thumbnail view, do not scale well for many slides. This makes a slide deck unsuited for storing the material of multiple presentations.

2.2.2 Encouraged Practices

Slideware is like all tools and technologies not neutral, but affects its users and constraints the products that are created with it. Technologies influence people's actions, they make tasks easier or harder, and guide in certain directions [Kaptelinin and Nardi, 2006, as cited in [Farkas, 2009]].

Slideware's affordances encourage the creation of typical documents.

Slideware can be used to create effective presentation support, but it promotes certain bad practices that lead authors to create visuals that can be harmful to the communication and comprehension of the content. Creating presentations without these flaws is certainly possible, but takes more effort and necessitates to work against the affordances.

Standardized Templates

The standardized templates embody the typical, criticized design.

The common slideware applications provide sets of standardized templates. Each template defines a series of slide layouts containing specific design elements. These are usually a slide title, one or more levels of bullet points (sometimes in two columns), and placeholders for graphic elements, such as figures or charts [Farkas, 2008]. The templates also set the typographic formatting, color schemes, and background design [Kjeldsen, 2006].

The default templates are criticized for their low resolution that is caused by the used design elements and the applied formatting decisions. The consequences are the aforementioned problems of simplification, abbreviation, and fragmentation of information [Tufte, 2003, Alley and Neeley, 2005].

New documents with content placeholders afford immediate detail level editing.

When an author creates a new document in slideware, one of the built-in templates is automatically used. Instead of thinking about the purposes and goals of the presentation as well as the formats and means best suited for fulfilling them, the software encourages the author to rather fill out the template slide layouts—to write slide titles and fill in the bulleted lists. Slideware applications make it simple to create documents along the template designs, but it is more difficult, to create documents with individuals means and methods.

Many slide decks look alike.

Consequently, many slide decks look similar. Especially presentations created with PowerPoint, as the dominant slideware application, have become “overly predictable and generic” [Alley and Neeley, 2005] as a result of the standardized templates [House et al., 2006]. If most presentations look and feel the same, audience attention decreases and originality and content get buried.

Much Textual Content

One of the major problems of presentation slides is that they contain too much text and thereby "become the message rather than a means to enrich the message [Goldstein, 2003]" [Alley and Neeley, 2005]. Text-loaded slides are unsuited for presentation support because they put the audience into a dilemma. The attendees have to choose between reading the slides or listening to the presenter. Section 2.4.1—"Limited-capacity Assumption" discusses the cognitive problems of text-filled screens together with an oral narration further.

Slides with a lot of text take attention away from the speaker.

One main reason for extensive text is the misuse of slides. Authors tend to put too much text onto slides if they use them as notes for themselves, instead of creating separate presenter notes. Slides should act as aids to the audience and not help the speaker to remember what to say [Doumont, 2005, Norman, 2004, Tufte, 2003].

Slides are misused as presenter notes.

The misuse of slide decks as handout documents also affords to make slides too verbose. Since handout documents may reach people who did not attend the live presentation, every aspect of the narration is included to avoid leaving an incomplete picture. Section 2.2.2—"Slide Deck Misuse" discusses this issue in detail.

Bullet Point Lists

The formatting of most textual content as bullet point lists is one of the main points of slideware criticism. The standard templates make this formatting decision. Consequently, bulleted lists are used in the vast majority of slide decks. The problem with bullet point lists is not only their format, but also that the content that would be better represented graphically is written as bullets, as this is the afforded and, therefore, the most effortless way.

In the built-in templates, bulleted lists are the default text format.

Bullet point lists can only describe sequential and hierarchical relations. But they can neither clarify narrative or causal relations nor explain the relations between items in

Bulleted lists bury the relations between the items.

detail. They thereby omit and suppress important lines of reasoning as to how items are interconnected [Tufte, 2003, Kjeldsen, 2006]. This makes them unsuited for representing complex connections [Bumiller, 2010].

Bulleted lists can oversimplify.

The fact that bullet points usually only contain abbreviated forms of the main ideas without details [Tufte, 2003] is not a problem, as long as a spoken commentary elaborates on the ideas. However, writing slides in form of bulleted lists can lead authors to simplified ways of thinking [Kjeldsen, 2006, Parker, 2001].

Bulleted lists can give wrong impressions.

Because of their format, bullet lists can give a structured, controlled, and finalized impression of information that is in fact not as thoughtfully organized, carefully selected, and mature as it looks [Bumiller, 2010, Doumont, 2005, Parker, 2001].

Extraneous Material

Overuse of decorations and animations leads to cluttered and distracting visuals.

Slide decks are often cluttered with diluting and distracting extraneous material, such as too many colors, typographical formatting, clip art, overdecorated graphs, and decorative animations [Doumont, 2005, Kjeldsen, 2006].

As described before, the fixed chunk size problem of slides (see section 2.2.1—"Fixed Chunk Size") and the detail trap during authoring (see section 2.2.1—"Limited Drafting Support") can cause this. But also because slideware applications make decorations easy to use, they are often applied even when they have no clear relevance to what is being said [Kjeldsen, 2006].

Especially the provided animation effects are often overused or used in distracting ways instead of when appropriate. Animations can enhance the content, but they can also be visually distracting [Zongker and Salesin, 2003].

Slide Deck Misuse

Slide decks are often misused as handouts that can be studied after the talk. This is a bad practice, as slides that synchronously support a live presentation and asynchronously used handouts serve different purposes with conflicting requirements [Doumont, 2005, Norman, 2004]. Printed slide decks do not include the oral commentary's content and do not reflect divergences from the originally planned presentation. Because handout documents may reach people who did not attend the talk, printed slides in their own will leave an incomplete picture. Slideware allows and even suggest to print unmodified slide decks as handouts and thereby encourages this bad practice.

Slide decks are misused as handouts.

Slides make substandard handouts.

The problem becomes even worse when authors try to counter the effect of missing information on the handouts by including every aspect of the oral commentary on the slides. This will still leave them with handouts with abbreviated arguments and, in addition, with slides that do not support the spoken narration properly anymore, but rather distract from it (see section 2.2.2—"Much Textual Content").

Slides intended as handouts are a poor presentation support.

Because of the universal adaptation of slideware, slide decks are even misused as general purpose documents independent of presentations. They are created as substitutes for proper written documents with the purpose to archive information [Farkas, 2009, Gomes, 2007, Norman, 2004]. Even if the resulting documents are verbose, due to the format's nature, they can only contain a summary of the content without details.

Slide decks are even misused as general-purpose documents.

2.2.3 Improvement Suggestions

The format limitations and the bad affordances are countered with best practices advices and usage guidelines. Savvy authors that follow these suggestions can create good and effective visuals.

Common advise is to deviate from the afforded design.

The common advise is to depart from the design of the standard templates, in particular, by reducing the amount of slide text and extraneous material, using more visual content, and using bullets only for true list content [Doumont, 2005, Reynolds, 2007]. Farkas [2009] describes various sophisticated techniques to specifically address the visualization of the content hierarchy and the fixed chunk size problems content cutting and content overflow.

Alley and Neeley [2005] and Atkinson [2008] suggest a slide design that consists only of concise, full sentence slide titles in combination with large graphical content elements. Bullet point lists are excluded. As described in section 2.1.3—"Role of the Visual Aid" this approach can be apt for non-technical presentations, but will be too radical when the goal is too inform about a complex topic.

Doumont [2005] suggests to redesign slideware applications in a way so that they discourage the typical bad practices. He suggests to move away from bullet point lists and to offer non-linear alternatives for slide ordering.

2.3 Zoomable User Interfaces

Zoomable user interfaces (ZUIs), first implemented in Pad [Perlin and Fox, 1993] and Pad++ [Bederson and Hollan, 1994], are graphical user interfaces (GUIs) that support the spatial organization of visual data and the navigation through the resulting information spaces.

In a ZUI, the content is not bound to a formal structure.

In ZUIs, users place all the content onto a conceptual infinite two-dimensional canvas, on which the relationships among the content elements are expressed by means of spatial proximity and clustering. This distinguishes the approach from graph layouts that incorporate the content elements into a formal structure. Users can place content at varying levels of scale or magnification, e.g., to express different hierarchy levels. A ZUI is apt for handling variable amounts of content [Good, 2003].

Users can navigate through the content by changing the current view by means of panning in two dimensions across the pane and zooming to change the visible area's scale. Zooming in focuses on individual elements and reveals more detail. Zooming out shows more context. The operations are usually animated to give a sense of physical movement [Bederson and Hollan, 1994]. The zooming movement creates the sensation of depth, therefore, ZUIs define a 2.5D space.

The user navigates by means of animated panning and zooming movements.

ZUIs allow to interact with more content than a screen can display at a time. The low resolution of computer screens does not allow to display large amounts of information in a high level of detail. It is only possible to either show a large amount of information with little details or a small amount at a high detail level.

Standard GUIs deal with these screen limitations by moving the content via paging, scrolling, and panning or by partitioning the content, e.g., with windows. These solutions have the problem that content becomes hidden. Since the meaning of information usually depends on its context and information must often be related to each other, user interfaces should instead display the content that is currently in focus simultaneously with its context.

To display more content than a screen can accommodate, standard GUIs move and hide content.

An alternative approach are interfaces that show focused and contextual views to keep all content always accessible [Cockburn et al., 2008]. The types of these interfaces differ in the way they integrate the two views. ZUIs separate the views temporarily, which allows to dedicate the entire display space to either a more focused or a more contextual view. The user zooms in and out to change between the views. *Overview and detail* interfaces use a spatial separation to display both views simultaneously, each in a distinct presentation space. Examples are image-editing tools with a separate overview of the whole canvas. *Focus and context* interfaces display the focus within the context in a single continuous view, e.g., a fisheye view. See Cockburn et al. [2008] for a detailed comparison of these interface types.

Overview & detail, zooming, and focus & context interfaces combine focused and contextual views.

By utilizing a metaphor based on physical space and navigation, ZUIs utilize the human spatial abilities for percep-

ZUIs utilize spatial cognitive abilities.

tion and learning. The user moves through the information space and builds a spatial mental model of it. Content elements act as landmarks and provide orientation. Section 2.4.3—"Human Spatial Abilities" discusses the spatial cognition further.

2.4 Cognitive Foundations of Learning

2.4.1 Cognitive Load Theory

The cognitive load theory is the accepted model of the human cognitive resources.

In cognitive science the cognitive load theory [Sweller, 1988, 1994] is the established model to explain how human cognitive resources are focused and used during learning activities. The model is based on a cognitive architecture in which information progresses from sensory impression to sensory memory, further to working memory, and finally to long-term memory. Part of the theory are a series of assumptions about the working memory that are described below.

Dual-channel Assumption

There are separate cognitive channels for verbal and pictorial information.

According to the dual-channel assumption [Paivio, 1990] the human information processing system has two separate channels for processing auditory/verbal and visual/pictorial information. The *auditory/verbal channel* processes auditory input and verbal information representations; the *visual/pictorial channel* processes visual input and pictorial information representations. Since the two channels are separated, humans are able to simultaneously process incoming data in both channels. For example, it is possible to view pictures and animations while listening to an oral narration.

Encoding information in both modalities leaves a stronger impression.

Building upon the dual-channel assumption is the *dual-coding theory* [Mayer and Sims, 1994, Paivio, 1990] according to which humans can integrate the information of the two different sensory modalities into one mental model in which the two encodings are linked to each other. If one encoding becomes activated, the whole model is activated. Individuals, therefore, have better chances of activating information in memory since they have additional attributes or memory pathways through which they can recall the information. Multimodal impressions are, therefore, richer than experiences from information of only one modality.

Limited-capacity Assumption

Whereas the long-term memory's capacity is virtually unlimited, the working memory is limited in its ability to attend to and process incoming sensory data [Baddeley, 1987]. The working memory, therefore, limits the processing capabilities of both cognitive channels.

The working memory's capacity is limited.

When the incoming sensory data exceeds the cognitive processing capacities, *cognitive overload* occurs. As a result, incoming information is missed. One or both cognitive channels can become overloaded at a time. In a learning situation it is important to avoid cognitive overload to make the instructions effective. Especially in a multimedia learning scenario, such as an oral presentation supported by computer-based visuals, cognitive overload is a constant risk since information is coming in simultaneously from multiple sources in different representations [Kjeldsen, 2006]. For example, when there is too much information on the screen, a learner has to focus on the visual input and has not enough free capacity to process the speaker's words [Blokzijl and Andeweg, 2005].

For effective instructions, cognitive overload must be avoided.

Heavy cognitive load occurs, in particular, when information of one modality, from multiple sources, has to be processed at the same time. This leads to the *split-attention effect* [Kalyuga et al., 1999]. For example, when listening to a spoken commentary while reading texts or taking notes, the verbal attention is split.

Simultaneous input of the same modality causes the split-attention effect.

Presenting information in a fragmented way increases the cognitive load since it takes additional mental effort to follow instructions if the relation between the information chunks is not clear. A confusing presentation, therefore, adds incidental processing load [Mayer and Moreno, 2003].

Fragmented information increases the cognitive load.

If instructions use visual content this is especially true for individuals with low spatial abilities (see section 2.4.4—"Individual Cognitive Differences") as they are less able to keep an image in working memory active [Mayer and Sims, 1994] and, consequently, rely more on the provision of a coherent visual representation [Allen, 1998].

Active Processing Assumption

During meaningful learning, there is active processing in both channels.

According to the *active learning theory*, meaningful learning requires considerable activity in both cognitive channels [Mayer, 1997, Mayer and Sims, 1994, Mayer et al., 2001, Moreno and Mayer, 2000].

Active learning consist of selecting relevant information in each channel, mentally organizing the information in each channel into coherent verbal and pictorial representations, building connections between the corresponding representations in each channel, combining visual and pictorial information into a coherent model, and finally integrating it with relevant prior knowledge [Mayer, 1997, Mayer and Sims, 1994, Mayer et al., 2001, Moreno and Mayer, 2000]. Consequently, active learning requires a considerable amount of cognitive processing.

2.4.2 Cognitive Theory of Multimedia Learning

The cognitive model for multimedia learning can be applied to presentations.

Based on the cognitive load theory, Mayer and Moreno [2000] have created a cognitive model for multimedia learning. This model can be applied to presentations with computer-based visual support, as hereby the audience usually receives visual as well as auditory information simultaneously.

Figure 2.3 shows a diagram of the model. The top row represents the auditory/verbal channel and the bottom row shows the visual/pictorial channel. The arrows stand for the active processing steps required for multimedia learning.

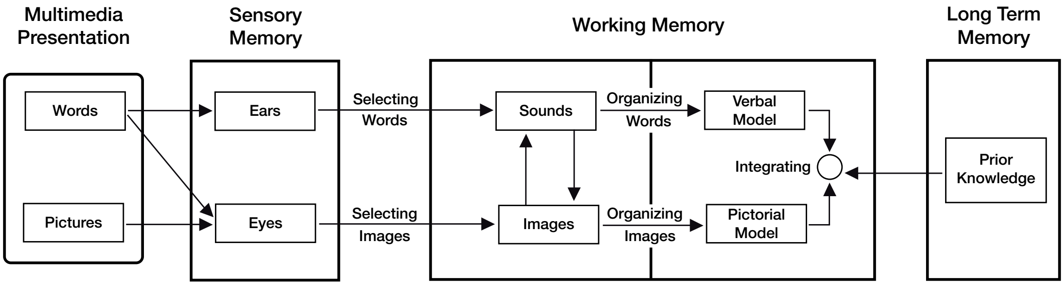

Figure 2.3: Cognitive Model of Multimedia Learning (Adapted From [Moreno and Mayer, 2000])

2.4.3 Human Spatial Abilities

Spatial abilities are cognitive functions that enable people to deal effectively with spatial relations, visual spatial tasks, and orientation of objects in space [Sjölinder, 1998].

In spatial displays with meaningful layouts, e.g., concept maps (see figure 2.4), spatial location and clustering encode the content's macrostructure. Viewers learn the relations among concepts by simply looking at their relative locations. This allows to learn connections quicker and easier than with linear textual representations [Robinson et al., 1999].

Spatial layouts utilize the spatial cognitive abilities.

Because spatial information is mentally encoded separately from verbal information [Robinson et al., 1996, 1999] and visual graphs are not processed sequentially [Doumont, 2005], learning the content macrostructure from a spatial layout does not compete with the cognitive resources required for processing verbal input.

The visual/pictorial channel processes spatial information.

The *conjoint retention hypothesis* [Kulhavy et al., 1985] states that textual information in a map representation is encoded in memory in both verbal and spatial format. Consistent with the dual-coding theory the two encodings are linked into one mental model with the resulting benefits for information recall.

Text in spatial layouts is encoded in two modalities.

The knowledge about a spatial environment is commonly differentiated into three sophistication levels: landmark, route, and survey knowledge [Dillon et al., 1993, Sjölinder,

There are three levels of spatial knowledge.

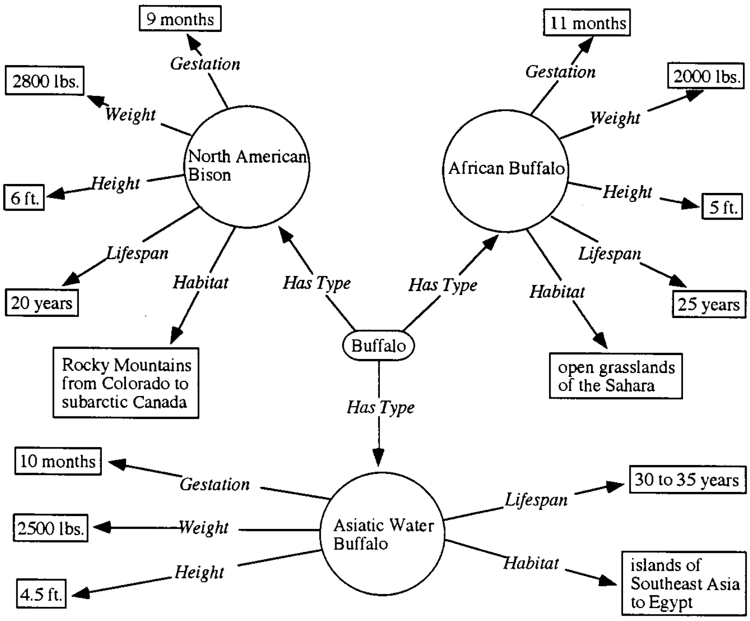

Figure 2.4: Example of a Concept Map (From [Robinson et al., 1999])

1998]. With *landmark knowledge* the current position can be recognized in relation to reference points. *Route knowledge* allows to navigate from one position to another along previously travelled routes. *Survey knowledge* (also called map or configuration knowledge) enables to plan new routes and to describe the relative locations of landmarks within the environment.

Various studies showed the learning benefits of spatial displays.

Several studies have proven the advantages of spatial layouts for learning. O'Donnell et al. [2002] showed that students recalled more central ideas when they learned from a map representation than from a linear text representation. Students with a low verbal ability (see section 2.4.4—"Individual Cognitive Differences") and little prior knowledge benefited the most. There were, however, no significant differences on the recall of detail content. Information represented in well-structured maps that are designed according to gestalt principles were recalled better than information from less well-structured maps. Thüring et al. [1995] have shown that providing spatial overviews of hypertext documents reduces the mental effort of comprehension. Dillon et al. [1996] have shown that spatial hypermedia overviews improve the recall of the content structure compared to hypermedia with linear overviews and without overviews.

2.4.4 Individual Cognitive Differences

Verbalizers and visualizers are differentiated based on their individual cognitive abilities.

Two cognitive processing abilities can be differentiated based on the cognitive load theory: conceptual/verbal processing and spatial/visual processing. Each person possesses different levels of these abilities [Allen, 1998, Carroll, 1993]. Mayer and Massa [2003], congruously, differentiate between *verbalizers*, individuals that are better at processing words, and *visualizers*, individuals that are better at processing pictures. This distinction can be decomposed into three components: *cognitive ability*, *cognitive style*, and *learning preference* [Mayer and Massa, 2003, Moreno and Plass, 2006]. Cognitive ability is determined by how high or low the spatial ability is, which means how good someone is in creating, holding, and manipulating spatial representations. Cognitive style denotes if individuals think verbally or visually. Learning preference describes if people favor visual or verbal instructions. Moreno and Plass [2006], however, found in their experiment no evidence for the three-dimensional structure of the visual/verbal dimension, but could rather only distinct between cognitive abilities and learning preferences. Their inference is that there is either no distinction between cognitive style and cognitive abilities or that the established tests are no valid measures for cognitive style.

The cognitive abilities can be measured with timed trial tests.

To measure the personal levels of these ability aspects, there are standardized test batteries. An established one is the *Educational Testing Service* (ETS) kit of factor-referenced cognitive tests[12] based on [Ekstrom et al., 1979]. See [Mayer and Massa, 2003], [Moreno and Plass, 2006], and [Sjölinder, 1998] for other test suites. The tests are usually timed trial tests (performing a task without any study phase or practice).

[12] http://ets.org/research/policy_research_reports/monographs/kit_of_factor_referenced_cognitive_tests

Alternatively to the trial tests, Mayer and Massa [2003] showed that spatial ability and learning preference can be effectively measured with self-ratings. In their experiment, the results of self-reporting ratings strongly correlated with those from timed spatial ability tests. Their study subjects, however, were psychology college students who most likely knew about verbal and spatial cognitive ability and, therefore, could rate themselves in this regard. This knowledge cannot be assumed for other subjects. Self-assessments might, for that reason, at least for cognitive ability, not be appropriate for all subjects.

The two leaner types learn best from information that is represented in the corresponding modalities.

The correlation between learner types and instruction modalities is two-fold. On the one hand, the representations of a modality are well suited for those who are good at processing information of this modality. I.e., individuals with a high verbal ability learn better from textual than spatial representations and, conversely, individuals with a high spatial ability learn better from spatial than textual representations. O'Donnell et al. [2002] and Patterson et al. [1993] have shown that subjects with low verbal ability benefit more from spatial than textual displays. Visual learners are, in particular, better in forming a coherent mental image of related information chunks. Correspondingly, Wiegmann et al. [1992] showed that students with a high spatial abilities can deal better with stacked maps (cross-referenced concept map segments) than those with low spatial abilities.

Systems can also augment the individual cognitive abilities.

On the other hand, a person's abilities and a system's feature modalities can complement each other [Allen, 1998]. Since it takes individuals with low spatial abilities more cognitive effort to build visual mental representations, they benefit from the spatial arrangements [Allen, 1998], overviews [Wiegmann et al., 1992], and animations [Hays, 1996], which provide coherence.

Consequently, when designing instructions, both learner types must be taken into account. Information should be presented bimodal to support both processing abilities and, when possible, system features should augment the abilities of the users [Allen, 1998].

2.4.5 Strategies for Reducing Cognitive Load

Decreasing the cognitive load of instructions reduces the risk of cognitive overload and frees capacities for active learning. An instructional scenario should, therefore, be designed in a way that minimizes any unnecessary cognitive load [Mayer and Moreno, 2003].

A reduced cognitive load facilitates learning.

Clearly, getting rid of extraneous content reduces the overall cognitive load [Kirschner, 2002, Mayer and Moreno, 2002, 2003, Moreno and Mayer, 2000]. Individuals must process all incoming information—at least initially—with their working memory. Consequently, incidental information will reduce the capacities available for the essential content. Extraneous material can be the content that is only decorative or the content that is not directly relevant to the current main focus.

Extraneous content should be avoided.

By using multiple information modalities, the capacities of both working memory channels can be used [Kirschner, 2002, Mousavi et al., 1995]. Mayer and Sims [1994] and Mayer and Moreno [2002] showed that combining the visual content with a concurrent auditory narrative results in improved knowledge transfer, relative to the use of any single modality on its own or when visual and verbal explanations are presented successively. The experiments by Mayer and Sims [1994] have further shown that especially individuals with a high levels of spatial ability (see section 2.4.4—"Individual Cognitive Differences") benefit from coordinated visual and verbal representations. The explanation for this result is the *ability-as-enhancer* principle according to which high spatial ability learners have more cognitive resources available for building referential connections between the different mental representations. Since for them, building the visual representations is relatively effortless [Mayer and Sims, 1994].

When possible, multiple modalities should be used.

Encoding information spatially can shift processing demands from the verbal to the visual channel and thereby reduce cognitive load [O'Donnell et al., 2002]. Reducing the load on the auditive/verbal cognitive channel is especially useful in a presentation scenario in which the oral narration must be continuously processed.

Using visual representations can unburden the verbal channel.

Diachronic and synchronic redundancy improve the learning effectiveness.

Redundancy is another measure to reduce cognitive load [Kjeldsen, 2006]. Kjeldsen distinguishes between diachronic and synchronic redundancy. Repeating information over time, either in the same or another modality than it was introduced in, creates *diachronic redundancy*. *Synchronic redundancy* means to communicate information in multiple modalities at the same time utilizing the dual-coding effect. For example, by showing the visual content together with explanatory narration. For the dual-coding effect, it is important that the information on both channels is directly related. Only then, the learning effectiveness can be improved according to the active processing assumption [Mayer and Sims, 1994, Moreno and Mayer, 2000]. Unrelated information on the different cognitive channels, in contrast, will result in a high cognitive load.

The workings of human cognition should be considered when designing instructions.

The practical implications for instruction design are to represent information multimodally to balance out the load on both cognitive channels to make use of a larger portion of the cognitive resources and to reduce the risk for overload. This will also allow learners to build connections between visual and verbal representations. Furthermore, information should be revisited to provide diachronic redundancy.

Chapter 3

Related Work

There have been various approaches to address the limitations of the slide deck format. Some modified and extended the slide deck format and others dismissed the slide metaphor.

First, two approaches are described that extend slideware with the possibility to arrange the slides spatial on a zoomable space. Second, two zoomable interface systems are shown that leave the slide format behind and instead allow authors to place the content atomically on the canvas. Last, two systems are described that break up the slide deck linearity by allowing for alternatives in the presentation sequence.

The related systems can be classified into three categories.

3.1 Slide-based Zoomable Interfaces

The following two systems are plugins for PowerPoint that enable users to place the slides of a deck onto a zoomable canvas. They thereby allow to put slides in the context of a global content hierarchy and to reveal this structure to the audience by means of overviews and meaningful animations—utilizing human spatial abilities. But they do not address the problems rooted in the fixed slide format. Naturally, they also do not address the bad affordances of slideware applications.

The first two systems are PowerPoint plugins that allow to arrange slides spatially.

3.1.1 CounterPoint

In CounterPoint, slides are arranged in a ZUI.

CounterPoint[1] [Good and Bederson, 2001, 2002, Good, 2003] is a research prototype of a PowerPoint plugin for Windows, implemented with the Jazz [Bederson et al., 2000] toolkit. CounterPoint adds the functionality to organize the slides spatially on the canvas of a ZUI and to define presentation paths through the 2.5D space. During presentation delivery, CounterPoint animates the transitions between the spatial positions.

Layout Authoring

Authors first import the finished slides, second they arrange the slides, and third they define the presentation paths.

In CounterPoint, the authoring process is strictly sequential. Authors first have to create a conventional PowerPoint slide deck and after that they can load the slides into CounterPoint. It is not possible to switch back and forth between PowerPoint and CounterPoint. Since CounterPoint does not support animated builds within the slides, all existing builds are removed during import. In CounterPoint, authors first structure the slides hierarchically and spatially and then they define the presentation paths.

The editor has three dedicated modes.

CounterPoint has three authoring modes: the *layout organizer mode* for defining the conceptual hierarchy of the slides and arranging the slides spatially on the canvas, the *path edit mode* for defining the presentation paths, and the *slide sorter mode* for extended rearrangement of the path stops.

Users arranged the slides into a conceptual hierarchy.

In the layout organizer mode the editor has two panes. The left pane contains a tree view in which the user can arrange the slides hierarchically. For each parent in the hierarchy, a layout template can be applied that arranges the children along a geometric shape. CounterPoint places the title of the parent slide as a text field centered between the child slides.

The spatial layout is derived from the conceptual hierarchy.

The right pane contains the ZUI in which the user can refine the layout that has been automatically derived from

[1] http://www.cs.umd.edu/hcil/counterpoint/

the conceptual hierarchy to emphasize specific aspects or to customize the aesthetics. The user can position and scale the slides freely and add simple text fields and images to illustrate and label parts of the canvas. See figure 3.1 for a screenshot of CounterPoint in layout organizer mode.

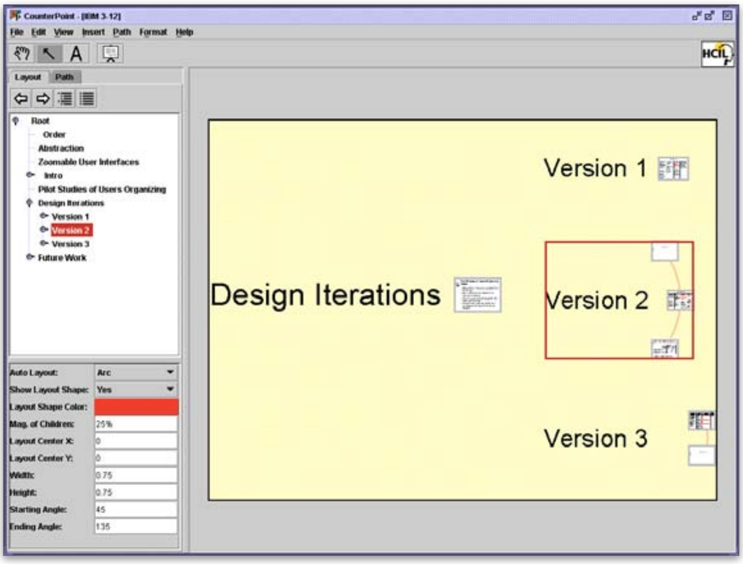

Figure 3.1: CounterPoint in Layout Organizer Mode (From [Good, 2003])

Presentation Authoring

CounterPoint allows to create multiple, unbranched presentation paths through the zoomable space. Path authoring is done in the path edit mode. The paths are not displayed inside the canvas, but in a separate thumbnail list view in the left pane of the editor. In it, the user can rearrange and delete path stops. The right pane shows the canvas, as in the layout organizer mode. See figure 3.2 for a screenshot of CounterPoint in path edit mode.

The scripted presentation paths cannot have branches.

Path stops can be either single slides or views of canvas regions. Dragging slides from the canvas into the list view adds them to the path. Each slide can be added to a path as often as required and a path must not contain all slides

Paths can contain slides and canvas views.

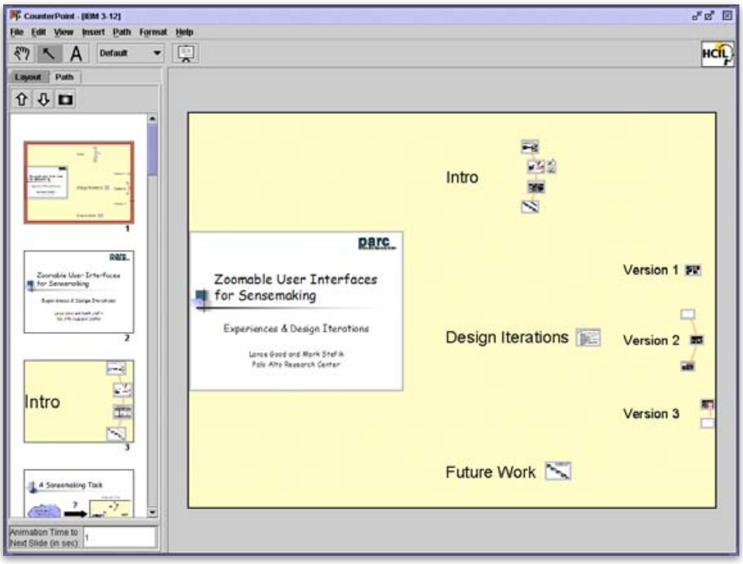

Figure 3.2: CounterPoint in Path Edit Mode (From [Good, 2003])

The function to capture canvas views utilizes a camera metaphor.

of the canvas. The canvas views are created by capturing the editor's current viewport using a button that shows a camera icon.

A path can be generated automatically from the conceptual hierarchy.

CounterPoint allows to derive the presentation path automatically from the conceptual and spatial content structure. When the path is generated, the hierarchy is traversed depth-first and the spatial layout is read, according to western culture conventions, from top to bottom and from left to right. Canvas overviews are automatically added for the different hierarchy levels. Afterwards, the generated path can be refined manually. Furthermore, CounterPoint provides a *Synchronize Path With Layout* function that can update the path when the spatial layout has been modified.

The slide sorter mode shows the path stops as a thumbnail grid, similar to PowerPoint's slide sorter mode. This allows for easier rearrangement of path stops when the path edit mode's thumbnail view becomes to small. See figure 3.3 for a screenshot of CounterPoint in slide sorter mode.

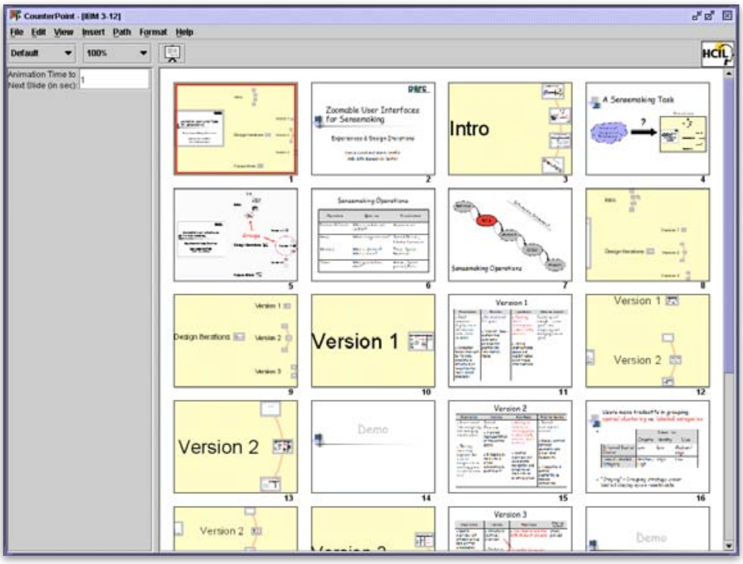

Figure 3.3: CounterPoint in Slide Sorter Mode (From [Good, 2003])

Presentation Delivery

When delivering a CounterPoint presentation, presenters can step sequentially along the scripted path and navigate freely through the 2.5D space. The viewport transitions are animated, creating a visual flow. The animations, however, are "flat", as they incorporate no intermediate zoom-out-movement. The zoom level is linearly adjusted to the level of the target viewport. Zooming out during the transitions would help to communicate the spatial relations of the viewports since more context would become visible. Furthermore, the CounterPoint animations have no easing effects. For these two reasons, the animations do not feel natural, which makes them less effective for conveying the canvas layout to the audience.

The animated viewport transitions lack zooming components and easing effects.

To visualize the presentation progress, the border of slides that already have been presented are colored differently from those that have not yet been presented (see figure 3.4).

The presentation state of content elements is visible.

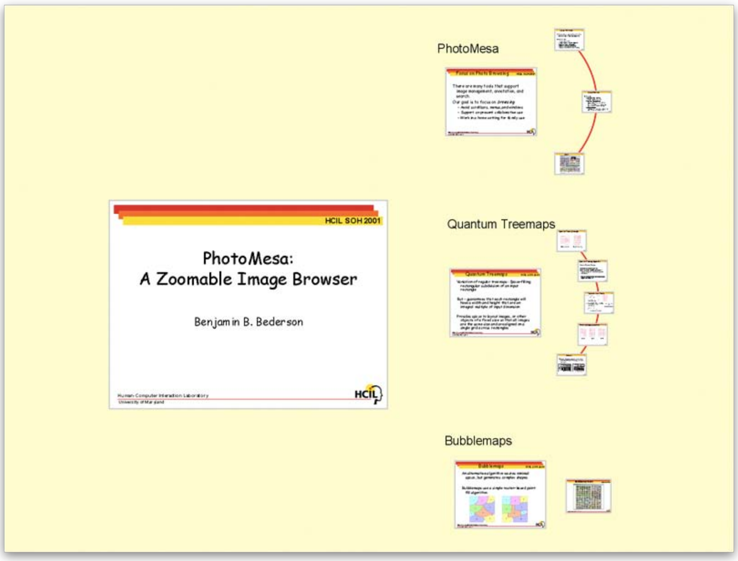

Figure 3.4: CounterPoint in Presentation Mode (From [Good, 2003])

Improvised navigation is performed along the hierarchy levels.

In the improvised navigation mode the presenter cannot zoom and pan freely, as in the ZUI of the authoring modes, but instead it is only possible to navigate up and down along the content hierarchy. By pressing the Up Arrow key, the view zooms out to the next higher hierarchy level, so that all the child content becomes visible. The complete canvas is the upmost hierarchy level. To drill down the user has to select a child with the mouse. This can either be a single slide or a canvas view on a deeper level. The view then zooms in to fit the selected child. Therefore, to navigate to a specific slide or view, it is always necessary to navigate to an overview first. This simpler interaction mode is easier to handle during presentation delivery and ensures that the context of the content is always communicated. However, it limits the presenter's freedom, as not all the content sequences that can be scripted during authoring are possible with improvised navigation.

The point from where the presentation is resumed depends on the current viewport.

After a phase of improvised navigation, the system does not simply continue the path from where it was left off, but instead tries to pick an appropriate point from which to resume. If the current slide or canvas view occurs in the path, the presentation will continue after the occurrence closest to the point from where the presenter has left the path—assuming that the presenter derived from the scripted path to show an alternative route. If the current view does not occur in the path, the path will be picked up where it was left off—assuming the improvisation's purpose was to show additional material.

Authoring Experiences

The CounterPoint developers gathered feedback from presenters within the *Palo Alto Research Center* and seven external presenters that used CounterPoint to author and deliver more than 100 presentations [Good, 2003]. The users appreciated the ability to show overviews and variable levels of detail. They could reveal the presentation structures to the audiences. Thereby they were able to communicate presentation's progress better and could keep their audiences oriented, especially when they derived from the pre-scripted presentation paths.

Authors and presenters gave positive feedback.

CounterPoint was also used for a series of talks on an extensive subject, where each talk only covered a subset of the content. The presenter used a CounterPoint document that contained the content of all presentations and no scripted paths. During presentation delivery, the presenter used only improvised navigation—reacting flexibly to the audiences. This example shows how the separation between content and presentation authoring allows for content reuse.

Multiple, differing presentations have been supported using one comprehensive document.

Audience Study

CounterPoint has been evaluated in a controlled user study with regard to the perception by the audience [Good, 2003]. The two features that CounterPoint adds to slideware—the spatial arrangement and the meaningful animations between the spatial positions—were evaluated with regard to the audience's preferences and perceptions as well as recall of content facts and structure.

CounterPoint was evaluated in a between groups study against PowerPoint.

The between subjects study was conducted with 96 university computer science students (however, the records of 28 participants have been discarded). The students were separated into three groups that each received a 10 minute presentation with the same recorded oral commentary, the same content slides, and the same number of overview slides.

CounterPoint was evaluated with and without animations.

The first group received a standard PowerPoint presentation with the textual overview slides that are common for slideware. The presentation for the second group contained spatial overviews, i.e., it was a CounterPoint presentation without animated transitions. The third group received a complete CounterPoint presentation with spatial overviews and animated transitions.

A subsequent three-part questionnaire asked the participants about their satisfaction with various aspects of the presentation, to write or draw an outline of the presentation, and last, to answer open questions about the presentation's content. In addition, after a two-day break, the participants received a follow-up-questionnaire that again requested to create an outline and to answer a new set of open content questions.

There was no significant effect on knowledge transfer. The satisfaction with CounterPoints's presentation organization was higher.

The study could not detect a significant effect of the different formats on retention of neither factual nor macrostructural information. There was only an insignificant better recall of structure for the two spatial formats, which correlates with the revealed higher satisfaction with regard to the content organization for these formats. The failure to detect a significant difference in learning achievement may have been caused by the between subjects format, with a large variance in the subjects with regard to prior knowledge and cognitive abilities, and the limited complexity and scope of the presentations, which made the format of the visual aid probably not relevant for the effectiveness of the knowledge transfer.

3.1.2 Microsoft's pptPlex

Microsoft's *pptPlex*[2] is a commercial PowerPoint plugin for Windows. It adds the ability to place parts of a slide deck onto different areas of a background slide that acts as a canvas. It does not use a ZUI during the authoring process, but instead incorporates the new functions into the existing user interface of PowerPoint. There is no separation between content and presentation authoring, as in CounterPoint.

pptPlex uses no ZUI, but adds dedicated slides within the PowerPoint UI.

Layout Authoring

Similar to CounterPoint, the spatial arrangement of slides is the second step in the authoring process after the slides themselves have been created. pptPlex does not support animated builds; existing animated builds are removed from the slides.

Authors can organize the slides of a deck into sections by inserting *section divider slides*. The divider slides have text fields for labeling the sections. Sections cannot be nested. See figure 3.5 for a screenshot of a section divider slide in pptPlex.

The slide deck is divided into sections.

The *background slide* at the beginning of the slide deck acts as a canvas for the slides. Users can decorate it with texts and graphics to visually connect, illustrate, and annotate the slides. See figure 3.6 for examples.

The slides are not arranged manually onto the background slide, but instead authors have to define rectangular *content boxes*. In each content box the slides of a section are automatically arranged into a grid. The slides are automatically scaled to fit into the box.

Each deck section is assigned to a dedicated canvas area.

The result are four hierarchy/zoom levels of content: all content (the full canvas), a section of slides (a content box), a single slide, and individual content elements on a slide.

[2] http://www.officelabs.com/projects/pptPlex/

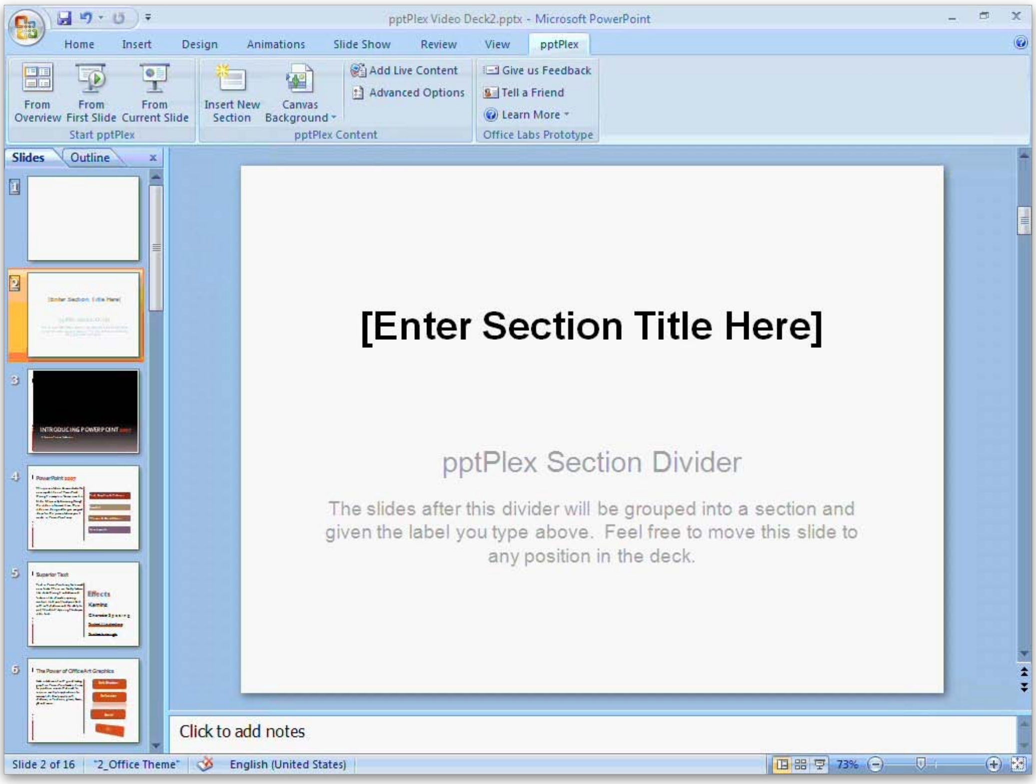

Figure 3.5: Microsoft's pptPlex: Section Divider Slide (From www.officelabs.com[a])

[a]http://www.officelabs.com/projects/pptPlex/

The presentation sequence cannot be manipulated. The canvas views are generated automatically.

Unlike CounterPoint, users do not script the presentation as a path through the canvas, but instead the slide deck sequence is retained. An author can neither add custom canvas views nor partial views of slides to the scripted presentation. The presentation is automatically enhanced with views of the complete canvas at the start and the end of the presentation sequence and with section overviews at the start and end of each section. All slides can only occur once in the sequence. Consequently, pptPlex does not facilitate content reuse.

Presentation Delivery

During presentation delivery, the presenter can step through the augmented slide deck using the same controls

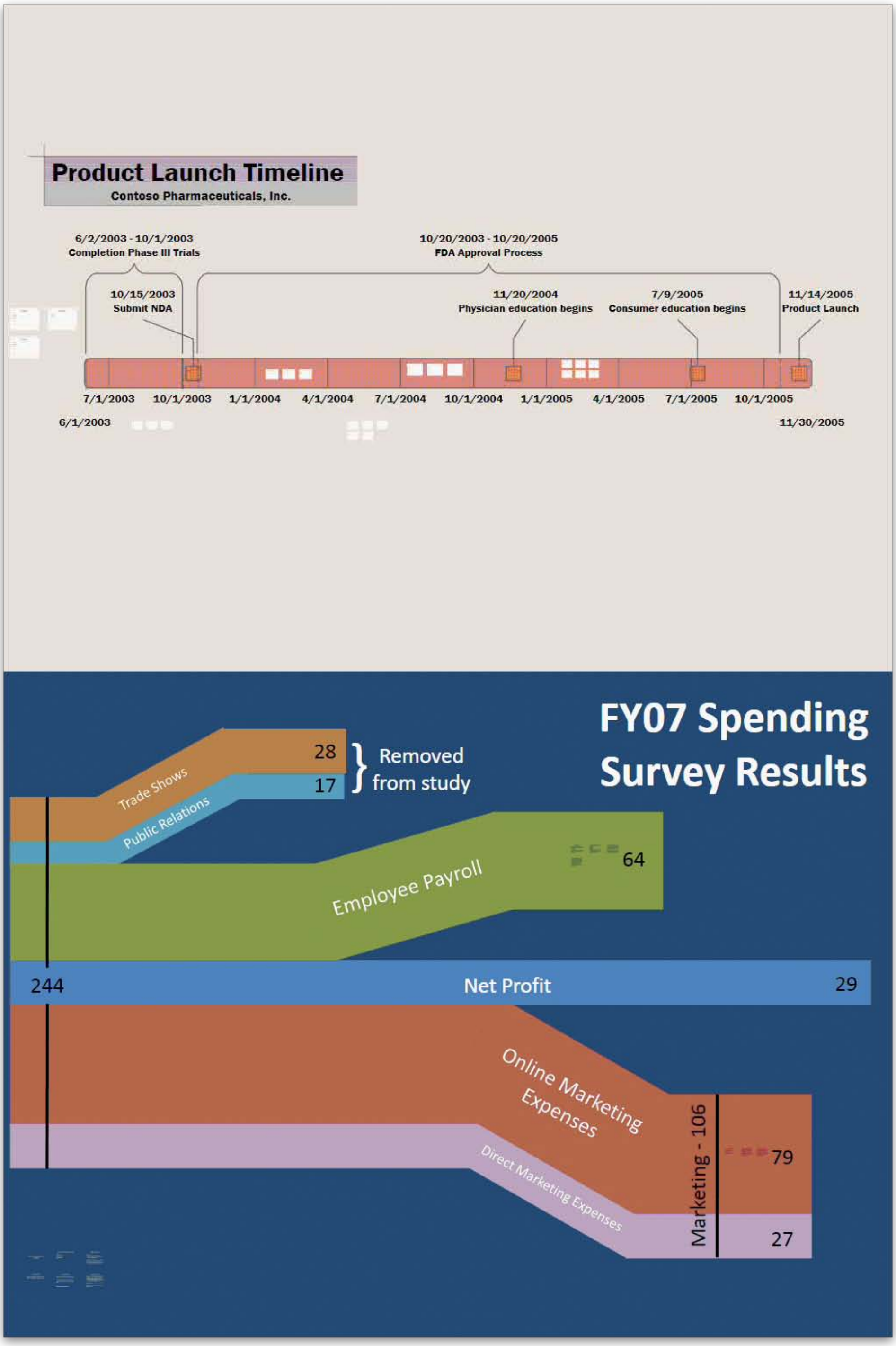

Figure 3.6: Microsoft's pptPlex Canvas Examples (From www.officelabs.com[a])

[a]http://www.officelabs.com/projects/pptPlex/

as in PowerPoint. Similar to CounterPoint, the viewport transition animations incorporate no intermediate zoom-out-movements. In addition to transitioning to the next or previous slide or overview, it is also possible to navigate directly to the next or previous section.

Improvised navigation is possible along and independent of the hierarchy levels.

Furthermore, it is possible to navigate freely across the canvas during improvisation. The presenter can pan around and zoom in and out progressively from the whole canvas to single elements on the slides. Step-wise zooming along the four hierarchy levels as well as zooming directly into a slide or slide section is also possible. By allowing to zoom into the slides, pptPlex breaks up the fixed resolution of the slide format.

It is possible to zoom into slides.

The behavior after improvisation is similar to CounterPoint.

Similar to CounterPoint, after an improvised navigation, the point from which the presentation is resumed depends on whether the current viewport occurs in the presentation sequence. If it does, the presentation continues after the occurrence. If it does not, it continues from where it was left off with an intermediate canvas or section overview.

3.2 Slide-free Zoomable Interfaces

The slide-free, ZUI-based approaches that are described in this section go one step further than the systems of the previous section by dismissing the slide metaphor. Users place the content atomically onto the canvas at arbitrary scales. This allows for viewports of any resolution.

Content elements are spatially arranged without slide frames.

In the following two systems, users define presentations, like in CounterPoint, as paths through the zoomable space. During presentation delivery, the path stops are related with animated viewport transitions that convey the canvas layout to the audience.

3.2.1 Fly

This thesis builds upon the work on Fly[3] by Holman et al. [2006] and Lichtschlag et al. [2008, 2009]. Holman's Fly version still used imported slides that were arranged into a mind map-based graph layout (see figure 3.7). The presentation path was automatically derived from the graph structure. In the next version, Lichtschlag got rid of slides and switched to an atomic placement of content onto the planar canvas of a ZUI (see figure 3.8). The system was implemented as a software prototype. This section describes Lichtschlag's Fly.

Fly is a continued research project. This thesis mainly builds upon Lichtschlag's Fly.

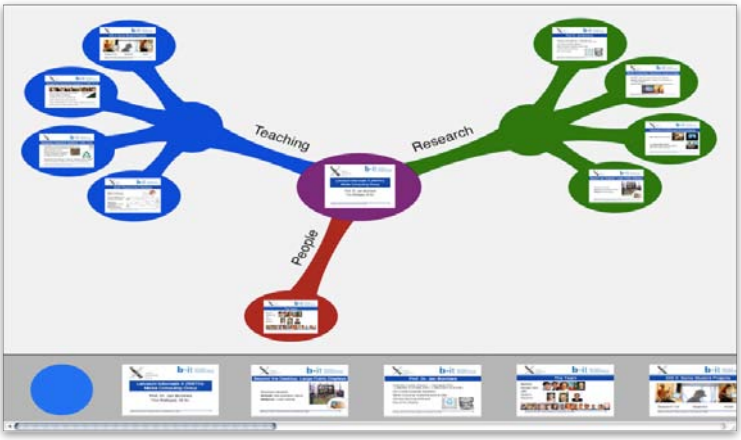

Figure 3.7: Holman's Fly in Authoring Mode (Top Pane: Graph View; Bottom Pane: Imported Slides) (From [Holman et al., 2006])

Content Authoring

In Fly, users can position the content elements freely on a conceptual infinite canvas. Unlike the systems in the previous section, the canvas layout is neither standardized nor automated, but instead allows for individual arrangements that correspond to the topics' inner structures. This freedom of placement facilitates incremental layout develop-

Users can incrementally developed the canvas layout.

[3] http://hci.rwth-aachen.de/fly

Figure 3.8: Lichtschlag's Fly: Authoring Mode (Left Pane: Zoom Level Slider; Center Pane: Canvas View; Right Pane: Presentation Paths Tree View) (From [Lichtschlag et al., 2009])

ment and refinement and allows to place elements at temporary or intermediate positions. Fly allows for and affords top-down authoring strategies [Lichtschlag et al., 2009].

There are dedicated zoom level ranges for topic and detail elements.

Fly limits the range of possible zoom levels to reduce the complexity of the ZUI. This limitation allowed to place a background pattern onto the canvas that gives a constant indication of the current zoom level. See figure 3.9 for views of the canvas when completely zoomed out and when completely zoomed in. Moreover, in Fly, the content elements can reside on two zoom level ranges: the *topic* level range and the *detail* level range (see the zoom level slider in figure 3.8 for the scale classification).

The display of topic and detail elements depends on the current zoom level.

Elements on detail zoom levels reside on the "bottom" of the zoomable space and are, therefore, visible from all zoom levels, as long as they are not scaled down too much. In addition, the detail elements are blurred when the canvas is viewed from zoom levels greater than the detail range.

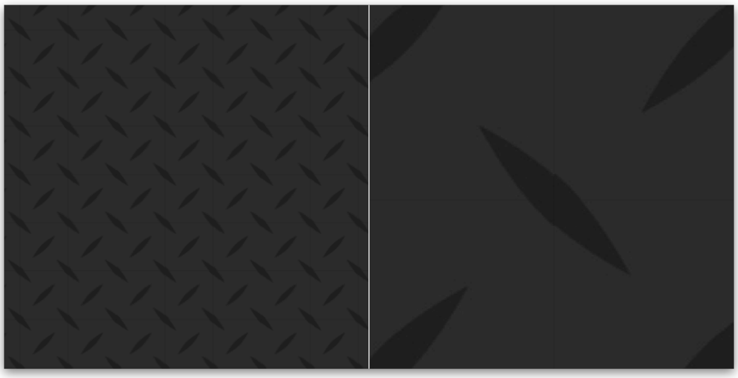

Figure 3.9: Canvas Background Pattern in Lichtschlag's Fly (Left: Completely Zoomed Out; Right: Completely Zoomed In)

Elements on topic zoom levels behave differently. During a zoom-in-movement from topic to detail zoom levels, a viewer "flies past" the topic elements. The elements, however, do not become invisible, but are instead displayed semi-transparently behind the detail elements. See figure 3.10 for the different displays of topic and detail level texts from topic and detail zoom levels.

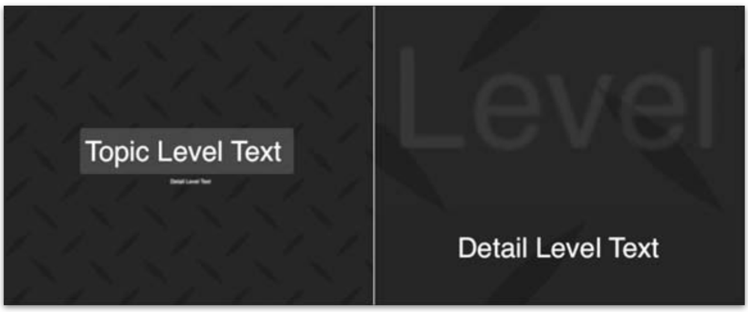

Figure 3.10: Display of Topic and Detail Elements in Lichtschlag's Fly (Left: Topic Zoom Level; Right: Detail Zoom Level)

Elements placed on topic zoom levels act as labels for areas of the canvas. When the ZUI is zoomed out, the topic elements are in the foreground, giving an overview of the various topics on the canvas. When the ZUI is zoomed in,

Topic elements function as labels and thereby structure the canvas.

the elements on detail zoom levels are in the foreground, while the topic elements are still visually present in the background. This gives an indication about which topic the current viewport belongs to.

Only the basic content manipulation functionalities were implemented.

The Fly prototype supports text and image content elements. Whereas images can be scaled freely, it is not possible to change the font size of texts. The font sizes are fixed for the two element types. The font of topic texts is set to a size that is well legible from topic zoom levels, whereas the font size of detail texts is clearly legible from detail levels. Due to the prototypical nature of the software, some basic editing functions, such as cut, copy, and paste as well as undo and redo, are missing.

Presentation Authoring

A path stop is defined by spatial position and zoom level.

Fly allows to create multiple unbranched presentation paths. Similar to CounterPoint, path stops are created by capturing the application's current canvas viewport, utilizing the camera metaphor. A stop is defined by its spatial position and zoom level, independent of the content on the canvas. Therefore, if the layout is changed after a stop was created, the stop will "break" and no longer contain the originally intended content.

The presentation paths are displayed in a separate tree view and the currently selected path is also displayed directly on the canvas (see figure 3.8). The path stops are represented as dots of varying sizes—corresponding to the stops' zoom levels. The dots are placed at the centers of the stops' viewports and are connected with a curved line. The stop sequence is not visible in the canvas display.

A stop's viewport cannot be changed later on.

In the tree view, users can label the paths and path stops and rearrange and delete stops. However, it is not possible to duplicate stops, therefore, if a viewport should occur multiple times in a path, duplicate stops must be created. Furthermore, users cannot change the viewports of existing stops.

Path stops can be previewed. This causes the canvas view to change to match the stop's viewport. Since the proportions of the canvas view may not correspond to those of the screen that will be used during presentation delivery, the preview might not be accurate.

Stop viewports cannot be accurately previewed.

Presentation Delivery

In presentation mode, the presenter can step forward and backward along the selected scripted path. Fly relates the path stop viewports with animated viewport transitions. However, as in CounterPoint and pptPlex, the animations do not incorporate an intermediate zoom-out-movement. This is mostly because of the prototypic nature of the implementation. Holman's Fly did zoom out during viewport transitions.

Of course, it is also possible to navigate freely through the canvas. Because Fly does not provide a separate presenter display, the presenter's navigation is directly visible to the audience. This is not an optimal solution in the case that the presenter does not know where exactly the desired content is located and has to search for it first. After a free navigation, the path is continued from where it was left off, independent of the current spatial position.

Besides of the aforementioned distinct display of topic level elements, Fly provides further means for the audience's orientation. To communicate presentation progress, the presenter can opt to show the presentation path on the canvas, as it is shown in the authoring mode. To provide information about the spatial and, therefore, conceptual position of the current viewport, the presenter can display off-screen topic indicators at the screen edges that point towards the relative positions of neighboring topic elements (see figure 3.11).

During delivery, the presentation path and off-screen topic indicators can be displayed.

Figure 3.11: Off-screen Topic Indicators in Lichtschlag's Fly

User Studies

Authoring with Fly was evaluated against PowerPoint.

Paper and software prototypes of Fly were evaluated with regard to presentation authoring in two experimental, comparative user studies against the slide deck format. The studies showed that Fly provides a better authoring support than slideware.

Fly provided superior authoring support that resulted in better visuals.

The canvas documents that were created in the studies had better structures than the corresponding slide decks. The users created individual meaningful layouts that resembled the structures of the presentation topics. Within the layouts, the content elements were arranged along multiple dimensions. The testers reported that it was easier for them to express their ideas and to capture the topic structures. Furthermore, the created Fly presentations contained more overviews than the corresponding slide decks and nearly all authors utilized zooming in their presentation paths to vary the resolutions of the stop viewports.

The authors used top-down strategies.

During the authoring process, the testers initially worked in a top-down pattern. They first sorted the content roughly and then refined the topic areas. This means that they changed the workflow they knew from slideware. The Fly format allowed them to explore alternative content organizations. In the paper prototype study, the authoring times were measured. It did not take the users significantly longer to author the Fly presentations than the slide presentations with the same content.

Last but not least, for the expression of ideas, the testers significantly preferred the Fly format in both studies. Whereas the users in the paper prototype study were undecided about general preference, most users in the software prototype study said that they would prefer Fly for real presentations.

The participants preferred Fly over PowerPoint.

3.2.2 Prezi

Prezi[4] (former ZuiPrezi) is a commercial *Flash*[5] -based web application (also available are an *AIR*[6] -based desktop application and an *iPad*[7] viewer application). Similar to Fly, the concept is based on a ZUI with atomic content placement. A presentation is, correspondingly, defined as a path across the planar canvas with path stops that show views of the canvas.

Prezi is the furthest developed related system.

Prezi uses the *Freemium* business model [de la Iglesia and Gayo, 2009] in which the basic account is free and users are charged for the premium account with additional features. The documents that are created with a free account are publicly accessible on the Prezi website—either read-only or even available for reuse by others. This pool of public documents was used to examine how authors use a canvas-based presentation format (see section 3.2.2—"Evaluation of Public Prezi Documents").

In addition to the placement of individual content elements, Prezi allows to import PDF (Portable Document Format) files. The pages contained in a PDF document are added as single elements. Therewith existing slide-based

[4]http://www.prezi.com
[5]http://www.adobe.com/products/flash/
[6]http://www.adobe.com/products/air/
[7]http://www.apple.com/ipad/

presentation documents can be imported. Because the PDF pages remain intact, the slide-metaphor is not broken up. The result is a presentation similar to the ones created with CounterPoint and pptPlex.

Prezi has printing support, whereby the viewport of each presentation path stop is printed as one page. The result is, de facto, a physical slide deck without the information that is encoded in the spatial canvas layout. It has the problems known from slideware printouts, in particular, the risk for misuse as handout (see section 2.2.2—"Slide Deck Misuse").

Content Authoring

All authoring takes place within the ZUI interface. It has four modes for different tasks.

The Prezi editor has four modes: *write mode*, *insert mode*, *frame mode*, and *path mode*. Authors can switch between them by selecting the corresponding subtree in the global application menu. The menu subtree provides all the actions that are available in the selected mode. See figure 3.12 for a screenshot.

Various content types can be used. The content elements are not classified as in Lichtschlag's Fly.

The write mode allows to add text elements and to edit existing elements on the canvas. The insert mode allows to add graphics, sounds, videos, and simple line and arrow shapes to the canvas. Unit recently, Prezi had, in contrast to Fly, unlimited zooming capabilities, i.e., a user could always zoom in and out further. A recent update introduced limits to the zoom levels. The available zoom range is, however, still much wider than in Fly. All the content resides on the "bottom" of the zoomable space, i.e., it is not possible to fly past content elements as it is for the topic elements in Lichtschlag's Fly. The sensation of depth comes only from the different scales of the content elements.

An unusual context menu provides the element modification functions.

The actions for element modification in write mode are provided through a circular context menu (called *Transformation Zebra*). It allows to move, scale, and rotate elements, and has further options for deleting, duplicating, and z-axis ordering. See figures 3.13 and 3.14 for the menu's different states.

Figure 3.12: Prezi in Edit Mode (a: Hierarchical Mode Menu; b: Main Menu; c: Zoom Controls)

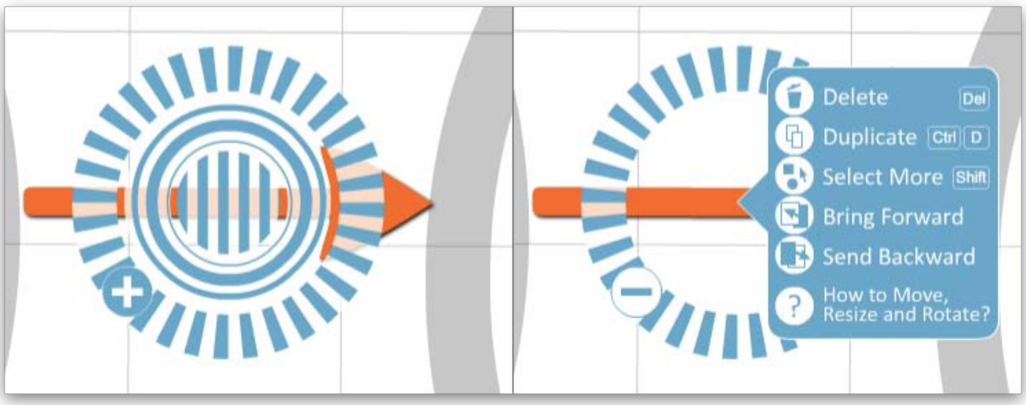

Figure 3.13: Prezi's Transformation Zebra (Left: Mode for Moving, Scaling, and Rotating; Right: Menu for Additional Actions)

Figure 3.14: Prezi's Transformation Zebra Actions (From Left to Right: Moving, Scaling, Rotating)

Content can be rotated, which has implications during presentation delivery.

Rotation is an element modification that distinguishes Prezi from Fly. However, it was a conscious decision not to support rotation in Fly, as it is potentially harmful to the planar presentation concept. When successive path stops contain elements of different rotation angles, the viewport transition animation will incorporate a rotation movement which is not meaningful. It does not help to communicate the spatial layout, but rather diverts from it. It has been documented that spatial knowledge acquired from maps is not robust against orientation manipulations [Schacter and Nadel, 1991]. In Prezi, rotation serves primarily eye candy purposes (see section 3.2.2—"Evaluation of Public Prezi Documents") and, therefore, potentially distracts from the relevant content. Rotation is a powerful tool that can easily be misused since the implications are difficult to foresee.

Having rotated elements on the canvas also makes unassisted improvised navigations during presentation delivery more difficult, as the presenter does need to control rotation in addition to panning and zooming.

The Prezi editor requires initial training because of unusual UI elements.

Prezi utilizes some unusual UI controls that make it initially hard to use. Especially the heavy use of modes reduces the usability. The user is required to constantly switch between the modes since specific actions are only available in particular modes. For example, it is not possible to select and edit elements (using the Transformation Zebra) in other modes than the write mode. This means that the user has to constantly switch between the insert and write modes when adding and arranging content. However, a recent update softened the modes and solved this particular problem. Users can now move elements without using the Transformation Zebra in all modes.

Furthermore, some features are hard to discover, for example, the function to select and modify multiple elements simultaneously, which is essential for layout rearrangements. This feature is hidden in the Transformation Zebra's additional options menu (see figure 3.13).

Moreover, while the Flash-based implementation of Prezi has the advantage of platform independence, Prezi has the usual limited operating system (OS) integration of non-native applications. For example, on *Mac OS X* the common shortcuts for undo and redo as well as zooming do not work. Nevertheless, after using Prezi for a while and learning the custom keyboard shortcuts, it is possible to use it effectively. The AIR-based desktop application has a closer integration. For instance, users can add images, videos, and PDF documents using drag and drop.

The two other editing modes are used to author the presentation path across the canvas. In frame mode, users can add special frame elements to the canvas; in path mode the stops of the presentation path are defined.

Presentation Authoring

Prezi supports only one unbranched presentation path per document. The path is only visible when the application is in path mode. It is displayed as a polygon line through the path stop dots. The stop dots mark the center of the corresponding stop viewports and are consecutively numbered according to their sequence in the path. See figure 3.15 for a screenshot of Prezi in path mode.

Path editing takes place within the canvas view.

In contrast to Fly, Prezi path stops are not defined by coordinates and zoom levels, but instead associated with either a content or a frame element. Position, zoom level, and rotation angle of a stop's viewport are automatically matched to fit the associated element.

Path stops are associated with canvas elements.

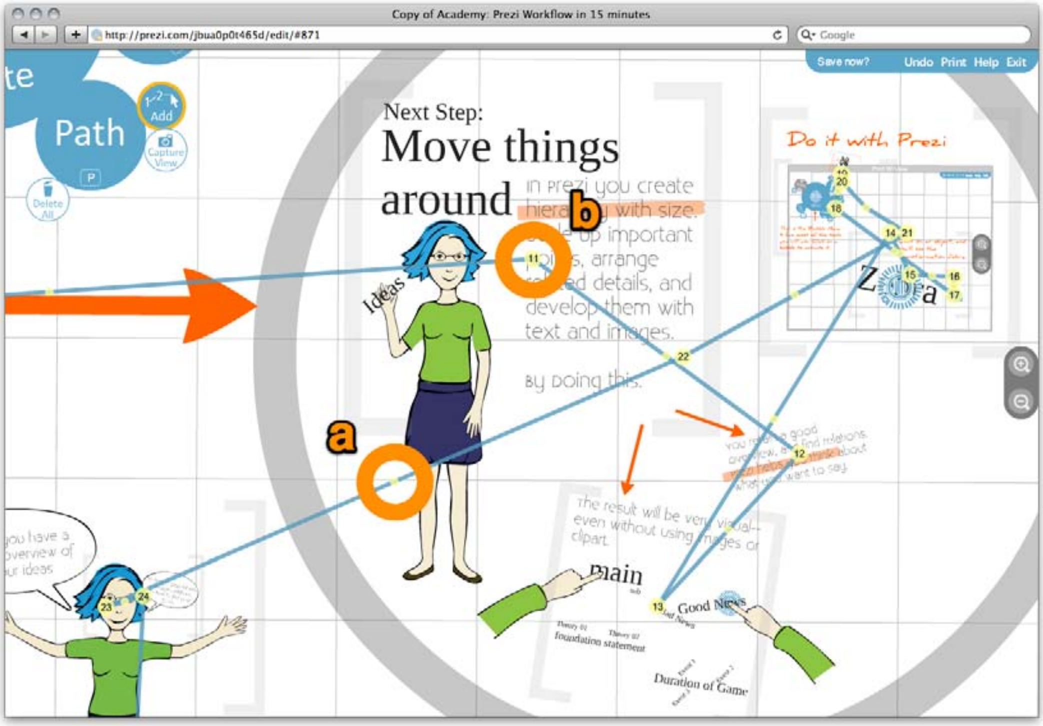

Figure 3.15: Prezi in Path Mode (a: Path Stop Placeholder; b: Path Stop)

The stops cannot be previewed accurately.

A viewport can, however, not be previewed during authoring. Moreover, neither the element association nor the zoom and rotation properties of a path stop are visible. Consequently, it is hard to envision how the presentation will look like in authoring mode. One must switch back and forth between authoring and presentation mode to fine-tune the presentation path. But even then, the application may not accurately show how the visuals will look like on the presentation screen because Prezi uses the whole size of the browser window it runs in. The aspect ratio of the window, however, does not correspond to the aspect ratio of the display that will be used during the presentation.

Frame elements are used to group the content elements.

Frame elements are used to show multiple content elements in a single path stop. An author has to place a frame element around the elements and then associate it with a path stop. Frames can be added from the global menu in frame mode or by capturing the currently visible viewport in path mode. This *capture view* action creates a frame element around the current viewport and automatically appends a stop to the presentation path associated with it. The action is similar to the actions for creating path stops in CounterPoint and Fly with the important difference that the viewport is manifested as a canvas element, which can be modified later on.

The visible frame elements have the benefit of visualizing what content is grouped together, but they also clutter the canvas (see section 3.2.2—"Evaluation of Public Prezi Documents" for an example). Reasonably, Prezi recently introduced a hidden frame type that is only visible in authoring mode. Now authors can use visible frames if they want to structure the canvas more explicitly than only by spacing and clustering and otherwise use invisible frames without compromising their canvas design.

There are visible and hidden frame elements.

Another potential drawback of the frame elements is that they resemble the slide format and, therefore, can lead authors to not take full advantage of the free placement possibilities, but instead let them fall back into the habits learned from slideware. In particular, into trying to fit the content into frame constraints and thus compromising the global spatial structure. On the other hand, unlike slides, the frames are flexible. When the content does not fit into a frame, the user can simply resize the frame. The evaluation of public Prezi documents showed that only few authors treated frame elements like slide frames (see section 3.2.2—"Evaluation of Public Prezi Documents").

The rectangular frame elements can resemble slide frames.

An existing path stop can be re-associated to another element by dragging the stop's dot onto it. In a similar fashion, users can remove stops by dragging the stop dots away from the associated elements onto an empty space on the canvas. New stops are always added to the end of the path. Once added to the path, stops cannot be reordered. To create stops in between existing stops, there are stop placeholders on the path line that can be dragged onto elements (see figure 3.15). Consequently, creating path stops by capturing the current viewport is only possible for stops that should be appended to the path's end. Furthermore, as in Lichtschlag's Fly, a stop can neither occur multiple times in a path nor be easily duplicated, instead a new stop has to be created.

Path stops can be re-associated with different elements.

The stop sequence cannot be changed.

The camera metaphor does not work for all cases.

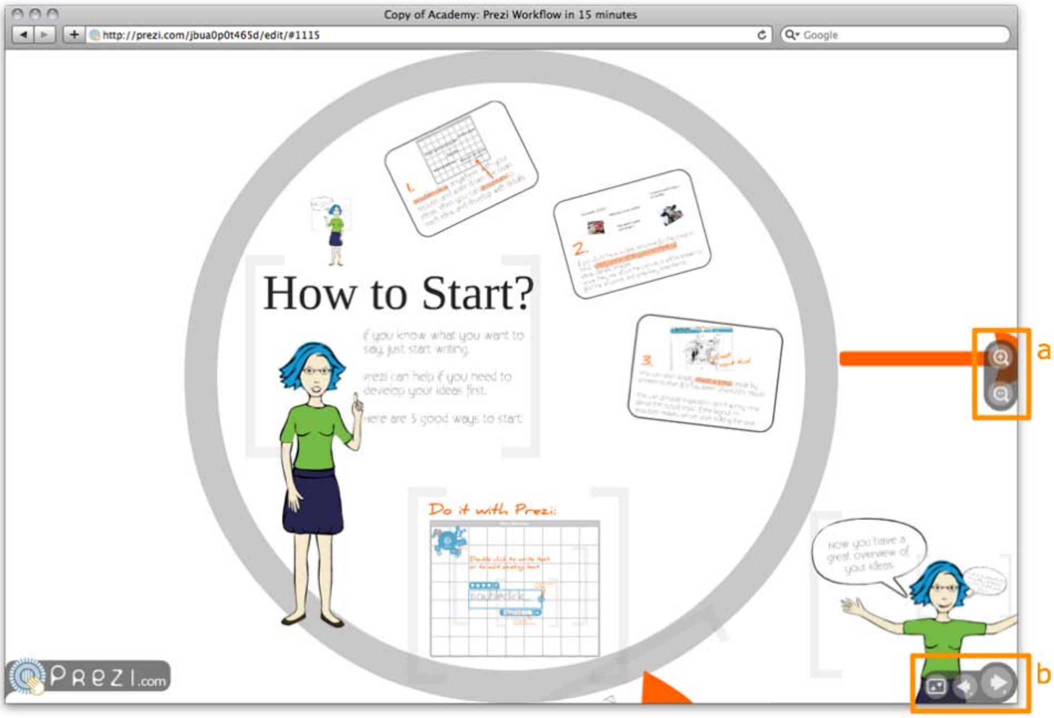

Figure 3.16: Prezi in Presentation Mode (a: Zoom Controls; b: Path Navigation)

Presentation Delivery

In presentation mode, the presenter can progress along the scripted path and navigate freely. It is possible to pan, zoom, and rotate manually, or to click on single content or frame elements to let the viewport adjust itself automatically. Like in Fly, after an improvised navigation, the presentation path is continued from where it was left of, regardless of the current spatial position. See figure 3.16 for a screenshot of Prezi in presentation mode.

Prezi does not provide a separate presenter display and offers no support for presenter notes. Unlike Fly, it is not possible to display the path during presentation delivery.

Evaluation of Public Prezi Documents

Publicly available Prezi documents have been analyzed.

To learn more about how authors use a canvas-based presentation format, a sample of the publicly available Prezi documents on the explore section[8] of the Prezi website was evaluated. The section lists all public Prezi documents. For this evaluation, the first 73 of the 308 presentations listed on July 1, 2010 were considered. After excluding the documents that were either clearly not created as live presentation support, not finished, or served as instructions for Prezi, 50 presentations remained. With this sample size quantitative statements about the use of Prezi could be made.

There are meaningful and decorative layouts.

All of the documents had individual layouts; there were no reoccurring canvas designs. A distinction can be made between meaningful layouts that express the content's conceptual structure and decorative layouts in which the content is primarily arranged along a certain graphic shape. Out of the examined documents, 36 had meaningful layouts and 14 had decorative layouts.

In the decorative layouts a reoccurring strategy was the use of a large background graphic and the placement of the content elements at lower scales into the graphic's gaps. See figure 3.17 for three examples of decorative canvas layouts.

Three types of meaningful layouts have been identified.

For the documents with meaningful layouts, three types could be identified. In 29 documents the content was organized into *topic areas* and the presentation paths explored these areas sequentially. Starting from an overview to preview the upcoming content, such a path drilled into one topic and then, after covering it completely, zoomed back out—either showing a repeated overview of the past topic for recapitulation or directly moving on to an overview of the next topic—and then drilled into the next topic. This kind of structure was often built recursively with topics that contained subtopics, which were traversed in the same way. See figure 3.18 for three examples.

[8] http://www.prezi.com/explore

Figure 3.17: Prezi Canvases with Decorative Layouts (Top: *AIESEC*[a] ; Middle: *Mathematweets*[b] ; Bottom: *Discover IE University!*[c])

[a]http://prezi.com/si0gkpgk6lq-/aiesec/
[b]http://prezi.com/nsu8izuq8jxs/mathematweets/
[c]http://prezi.com/wxv6uhgee4sr/discover-ie-university/

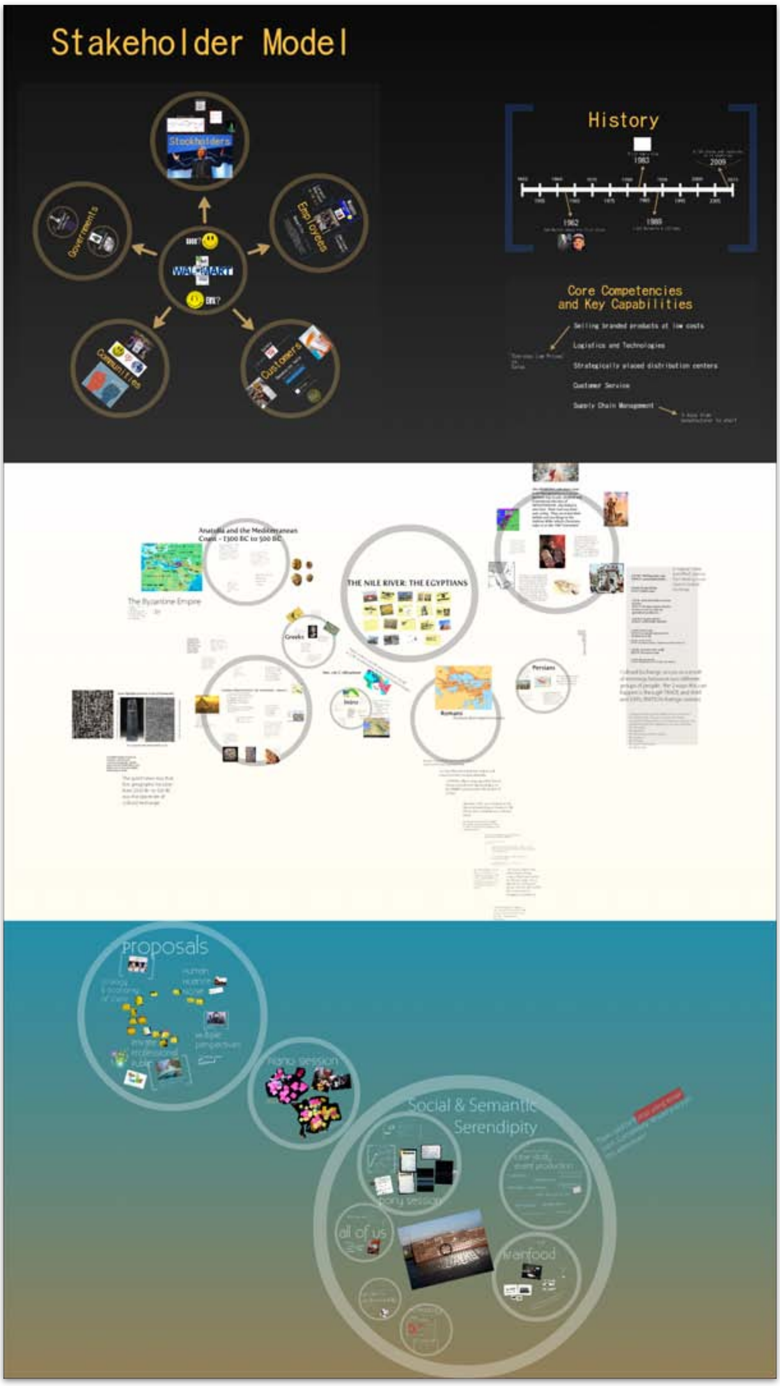

Figure 3.18: Prezi Canvases with Topic Area Structures (Top: *Walmart*[a] ; Middle: *Ancient Civilizations*[b] ; Bottom: *The Future of Email*[c])

[a]http://prezi.com/rvryqupq8fok/walmart-prometisdesigncom/
[b]http://prezi.com/tca87b9tccjn/ancient-civilizations/
[c]http://prezi.com/a4rnnb7mclme/the-future-of-email/

Some presentations with topic area structures had shortcomings.

Not all documents with topic area organizations were thoroughly structured. There were two common shortcomings. The first one—occurring in five presentations—was that layouts were not adequately refined with regard to the presentation path sequence. While the content was organized into topic clusters, the clusters itself were not structured well enough to be traversed smoothly. As a consequence, the paths jumped back and forth between the content elements within the topic areas. The other weakness—also occurring in five presentations—was that the presentation paths did not properly convey the layouts because none or too little overviews were used. Three presentations had both weak points.

Dramaturgic structures used none or little overviews.

Four documents had structures that created *a dramaturgy*. All the content elements shared a small range of zoom levels and the paths traversed them sequentially while constantly remaining on the detail zoom levels with none or little overviews. Purpose of these presentations was to tell a story as opposed to inform about a topic. See figure 3.19 for an example.

Authors illustrated the development of an idea using increasing zoom levels.

The last three documents had structures that *incrementally developed an idea*. Their presentation paths started by showing content on a detail scale. Then they continuously worked their way up to greater zoom levels—ending with a view of the whole canvas. Accordingly, the content was scaled larger the later it occurred in the presentation sequence. Overviews were mainly used to recapitulate. See figure 3.20 for two of the canvases.

The majority of presentations had one to three hierarchy levels.

Because of the, at the time of the evaluation, still unlimited zooming capabilities of Prezi's ZUI, there was no restriction on how deep the content hierarchies could be nested. However, 36 of the examined documents did not create hierarchies deeper than three levels (all content, topics, and subtopics). Out of the others, 12 had hierarchies of four to six hierarchy levels and two of the presentations that developed an idea had more than six levels as a result of their canvas structure.

The use of overviews was common.

The majority of presentations (33) utilized overviews in their presentation paths: 17 used overviews to preview and recapitulate content; 16 used overviews only to preview;

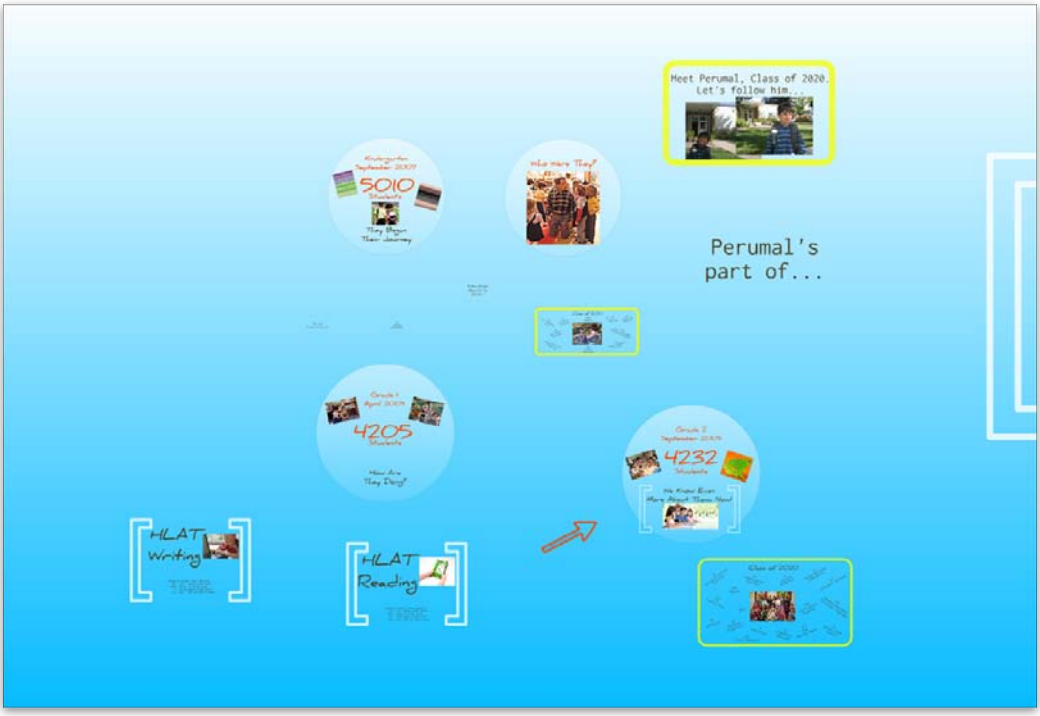

Figure 3.19: Prezi Canvas with Dramaturgy Structure (*Vision 2020*[a])

[a]http://prezi.com/vevg2dqkxss5/vision-2020/

and one used overviews only to recapitulate. See figure 3.21 for a summary of the presentations' distribution along the described properties.

As it was the case in the Fly user study (see section 3.2.1—"User Studies"), nearly all authors utilized scaling and zooming to achieve varying viewport resolutions. All presentation paths zoomed in on single or few elements to focus on the currently relevant information. Other common practices for focus were to zoom in on details of large graphics, such as diagrams and screenshots, and to zoom in on single words and phrases of larger texts.

All presentations drew attention to single content elements.

Another reoccurring pattern was that authors used Prezi's unlimited zooming capabilities to hide content, such as a footnote to a text, by scaling it down further than a recognizable scale. In the presentation path a dramaturgic zoom-in-movement reveals the hidden content.

Content was hidden and then surprisingly revealed.

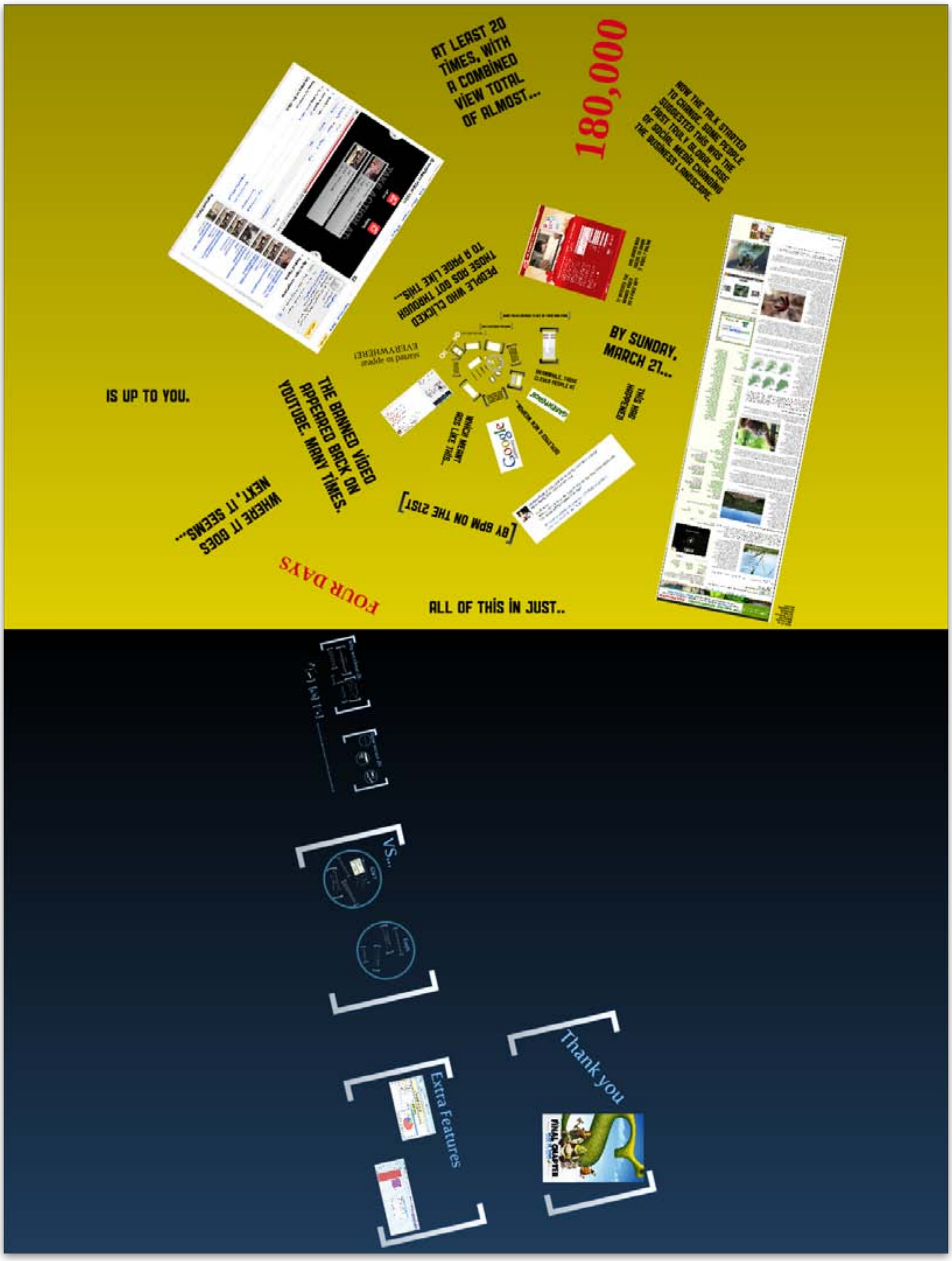

Figure 3.20: Prezi Canvases with Developing Structures (Top: *Nestle Kerfuffle*[a] ; Bottom: *ZK Framework*[b])

[a]http://prezi.com/kmrh4fmlzsen/nestle-kerfuffle/
[b]http://prezi.com/v7n9pbgpnugw/zk-framework/

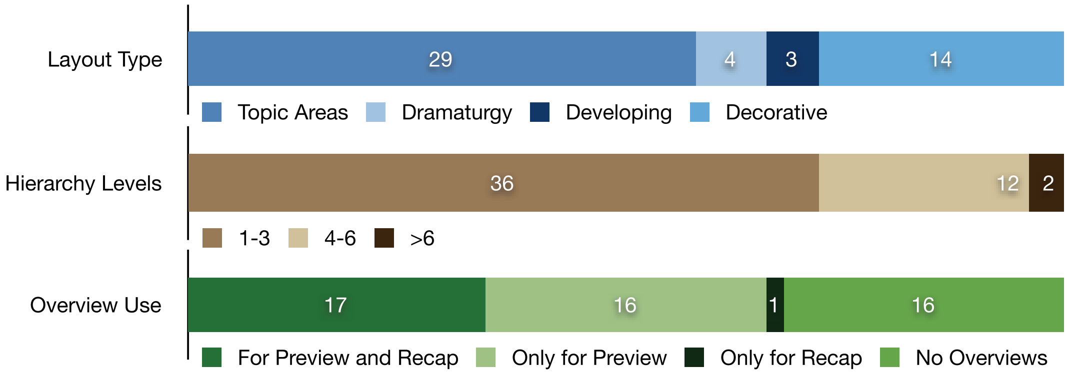

Figure 3.21: Classification of the Examined Public Prezi Documents

Rotation is the transformation that is unique to Prezi. As discussed before (see section 3.2.2—"Content Authoring"), it is easy to misuse it in non-meaningful and even harmful ways. Three of the examined presentations used rotation in meaningful ways, in particular, when the canvases had circular arrangements (see figure 3.22 for an example).

However, 29 of the 50 presentations used rotation primarily for decorative purposes. Most often to provoke impressive viewport transitions and to realize decorative canvas layouts. To make transitions dramatic, elements were often rotated by 90 degrees or more and in opposed directions. The resulting transition animations of such large rotations are, however, harmful to the communication of the spatial layout and, consequently, for the conveyance of the content structure. In decorative layouts, content elements were often rotated to make them fit into the intended shape. See figure 3.23 for examples of rotation overuse.

Rotation was used to cause sensational transitions and for decorative layouts.

The evaluated presentations were also inspected with regard to the use of frame elements. As aforementioned, Prezi only later introduced invisible frame elements. Consequently, in presentations that were created before, the visible frames sometimes cluttered the canvases. See figure 3.24 for an example.

Nine of the 50 examined presentations used the rectangular frame shapes like slide frames. This might be because of the aforementioned affordance of the frame elements (see section 4.2.3—"Presentation Authoring"), but also because

Some authors used frame elements like slide frames.

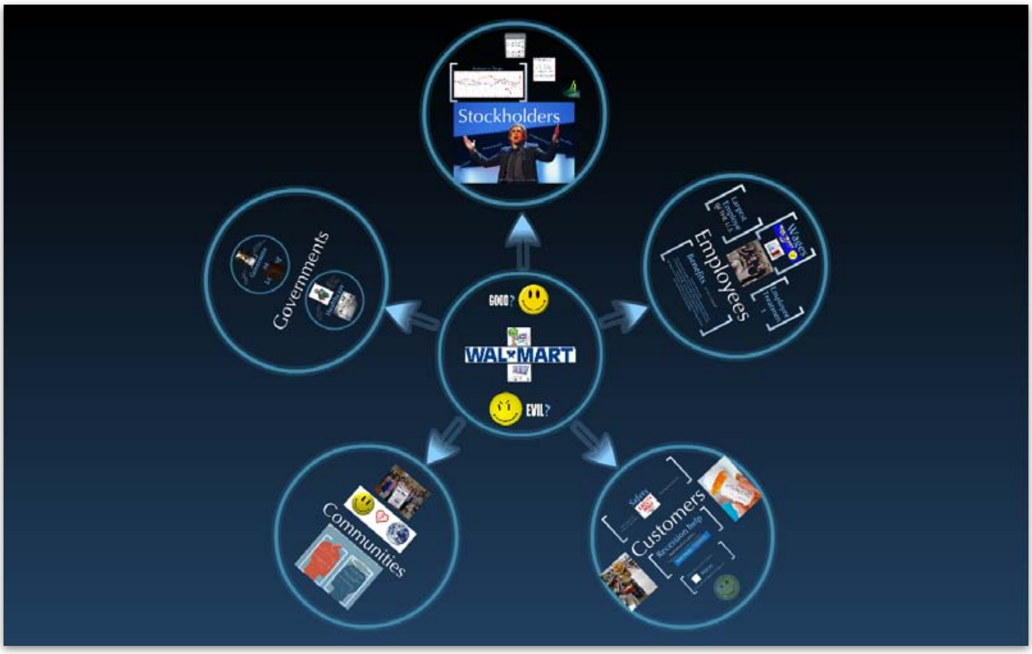

Figure 3.22: Prezi Canvas with Rotation in Circular Layout (*Walmart*[a])

[a]http://prezi.com/rvryqupq8fok/walmart-prometisdesigncom/

of the authoring practices learned from slideware. See figure 3.25 for an example.

3.3 Non-linear Slide-based Systems

The following two systems break up the slide deck's linearity by allowing for scripted non-linear traversals. The systems enable the presenter to adapt the visuals during presentation delivery. This also improves reuse support as a single document can be used for different presentation versions.

3.3.1 Moscovich's Customizable Presentations

The slides are organized into nested sections.

Moscovich et al. [2004] developed a research prototype, that consists of an editor and a navigation interface. The

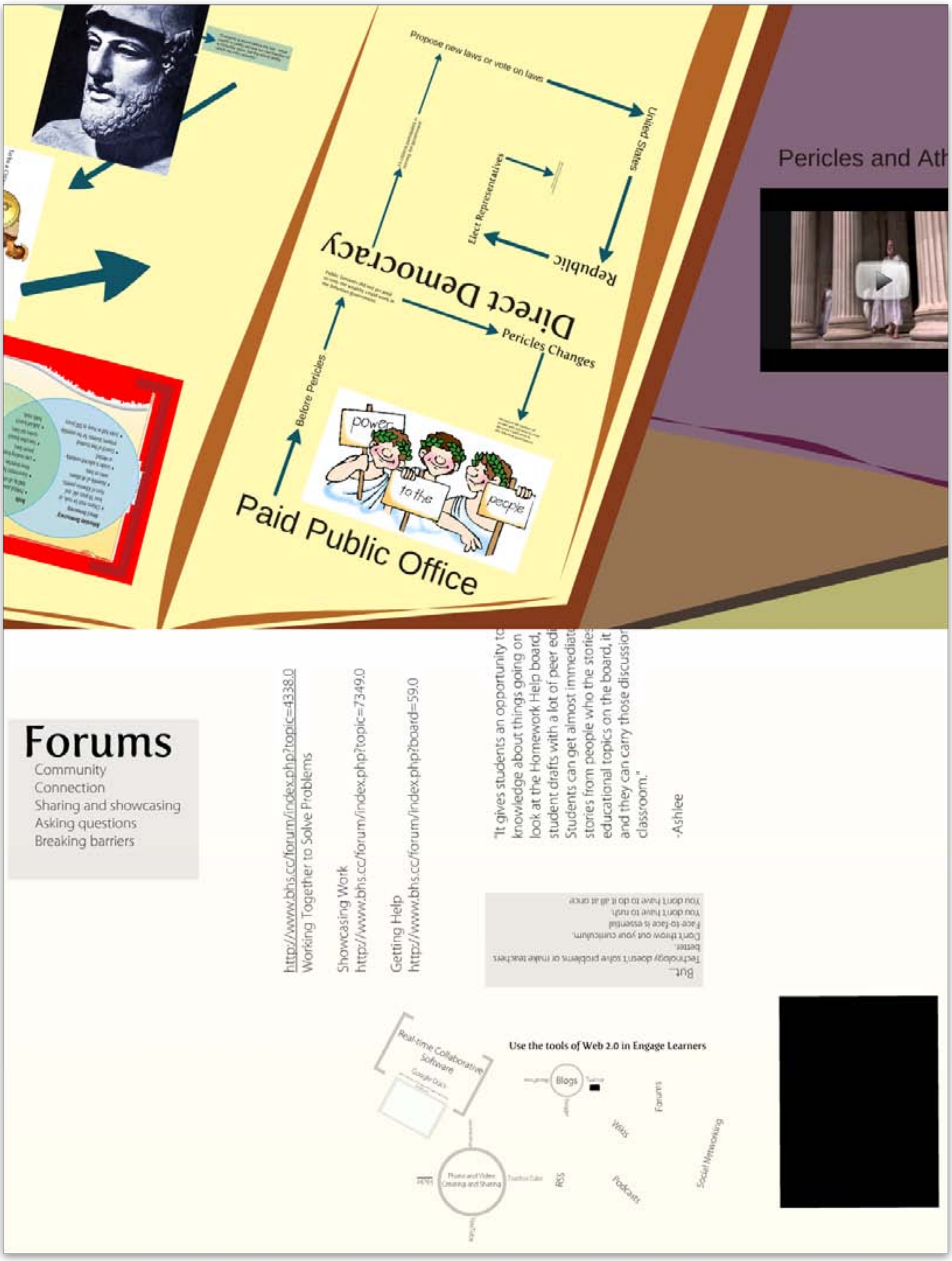

Figure 3.23: Rotation Overuse in Prezi Canvases (Top: *Classical Greece*[a] ; Bottom: *Web 2.0 in the Classroom*[b])

[a] http://prezi.com/r0hubhczg9ui/chapter-8-section-1/
[b] http://prezi.com/obqzirjhtf-q/web-20-in-the-classroom/

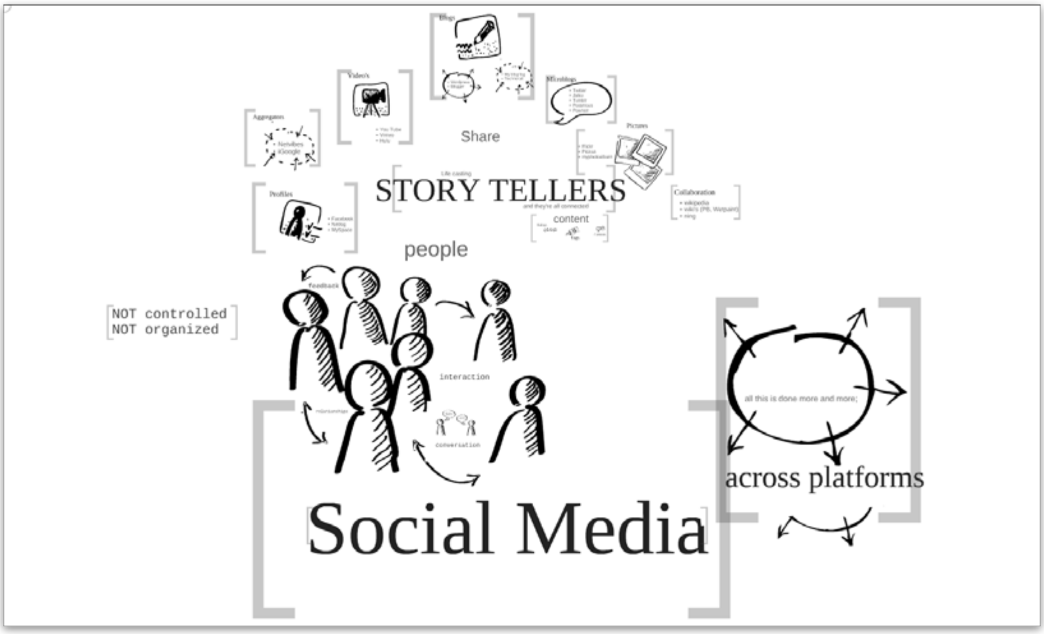

Figure 3.24: Prezi Canvas Cluttered with Frame Elements (*Social, Who Me?*[a])

[a]http://prezi.com/xvl9cndahfed/social-who-me/

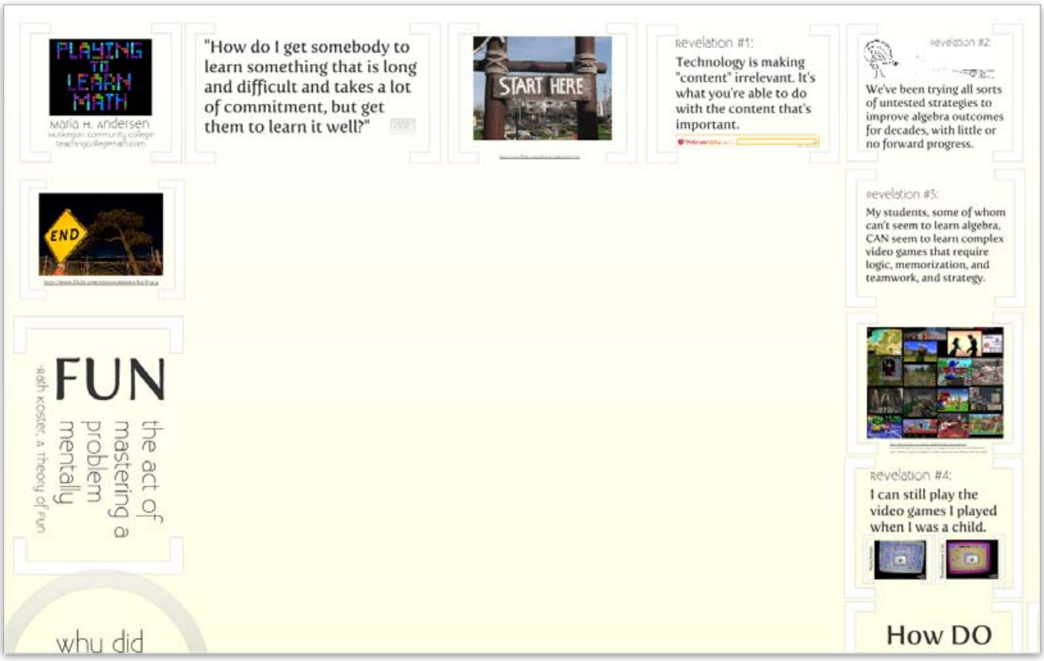

Figure 3.25: Prezi Canvas with Slide-like Viewports (*Playing to Learn Math?*[a])

[a]http://prezi.com/r2lbb3lfomg5/playing-to-learn-math/

system allows to organize the slides of a deck into nested sections and to create a presentation path with alternative branches.

Presentation Authoring

An author can define one or more routes through each of the nested slide sections. For example, one extensive route that covers all slides and one summarizing route that only traverses through the most important slides. The section paths are concatenated into an overall presentation path.

Each section of the slide deck can have alternative traversals.

The slide sections are laid out on a canvas. They are displayed out as colored boxes that contain thumbnails of the slides. The paths are shown as lines that connect the section boxes and the slides within the boxes. See figure 3.26 for a screenshot of the editor interface.

The presentation paths are created within a graph view.

Presentation Delivery

During presentation delivery, the system's navigation interface is shown on a private presenter screen. The public audience screen shows PowerPoint in presentation mode, controlled by the navigation interface.

The navigation interface shows the traversal paths, as in the editor interface, ordered from top to bottom. The currently active path in shown in the center column and potential alternative paths are shown left and right of it.

The presenter screen shows a path navigation interface.

The presenter can step along the current active path with keyboard controls and switch to alternative branches by selecting them with the mouse whenever the presentation arrives at a branching point. After shifting to another branch, the display is rearranged and the selected branch is moved to the center column. See figure 3.27 for screenshots of the navigation interface before and after a path switch.

The navigation interface adapts itself to the chosen path.

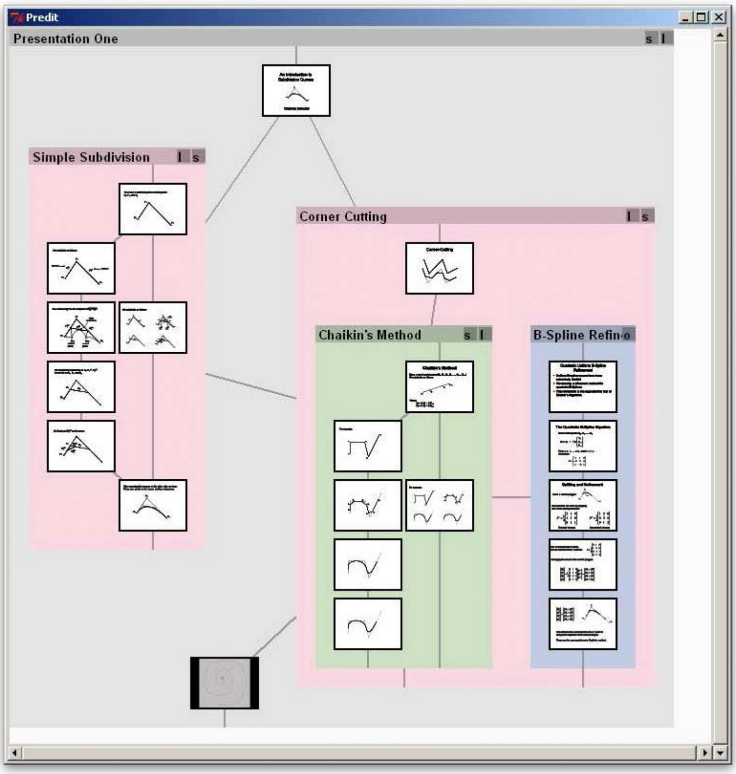

Figure 3.26: Customizable Presentations: Editor (From [Moscovich et al., 2004])

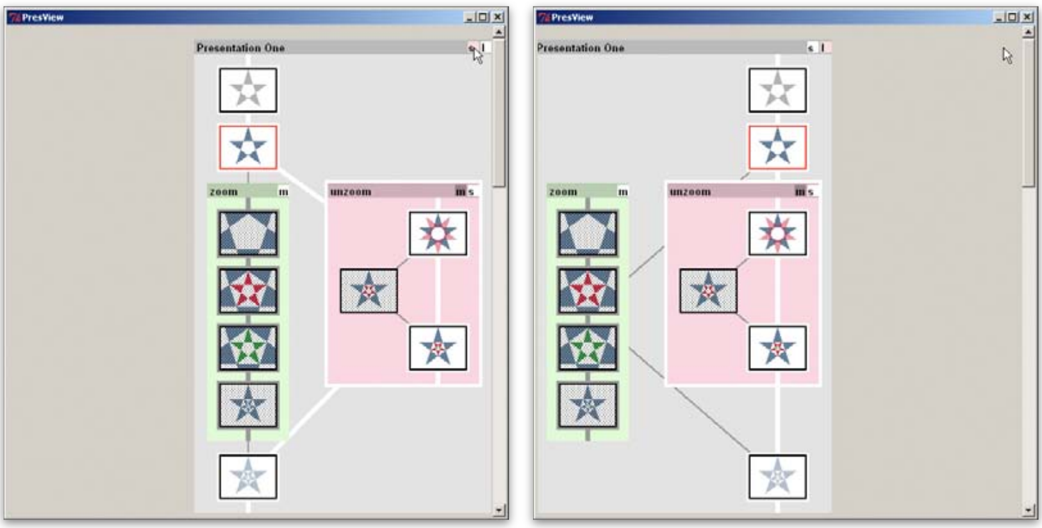

Figure 3.27: Customizable Presentations: Navigation View (From [Moscovich et al., 2004])

3.3.2 NextSlidePlease

NextSlidePlease[9] is a research prototype [Spicer et al., 2009, Spicer and Kelliher, 2009a,b] that adds a hyperlink-inspired graph-structure to slideware. The slides of a deck are organized into a directed, weighted graph that allows for *late linearization*. A presenter can navigate dynamically through the presentation in response to the audience's needs.

NextSlidePlease uses late linearization to allow for flexibility during presentation delivery.

NextSlidePlease consists of an editor for authoring the slide graph, a presentation interface with a separate private presenter screen, and an engine that recommends an optimal path through the slide graph. The system assists the presenter in time managing the presentation.

Presentation Authoring

In order to use a slide deck in NextSlidePlease, the finished slides must be exported as images that then can be imported into NextSlidePlease. NextSlidePlease, therefore, does not support animated builds or slide transitions. As in the other third-party slide-based systems this sets the authoring task order: first the slide content is authored, then the presentation is organized.

Imported, finished slides are used.

Instead of scripting path alternatives for a limited number of possible presentation courses, as in Moscovich's system, the approach of NextSlidePlease is to arrange the slides in a highly interconnected graph, in which each slide is connected with all possible successions. See figure 3.28 for an example graph.

In place of a fixed presentation sequence, the slides are connected within a graph.

The graph editor allows to arrange thumbnails of the slides freely on a two-dimensional plane where they can be connected with arrows (see figure 3.29). Users have to define one slide as the start slide and one as the end slide. Apart from that, the slides can be connected freely. For each connection, the author can specify transition priority, time cost, and time cost flexibility. All three parameters apply to the

The slides can be prioritized and time budgets can be assigned.

[9] http://rl.ame.asu.edu/projects/11

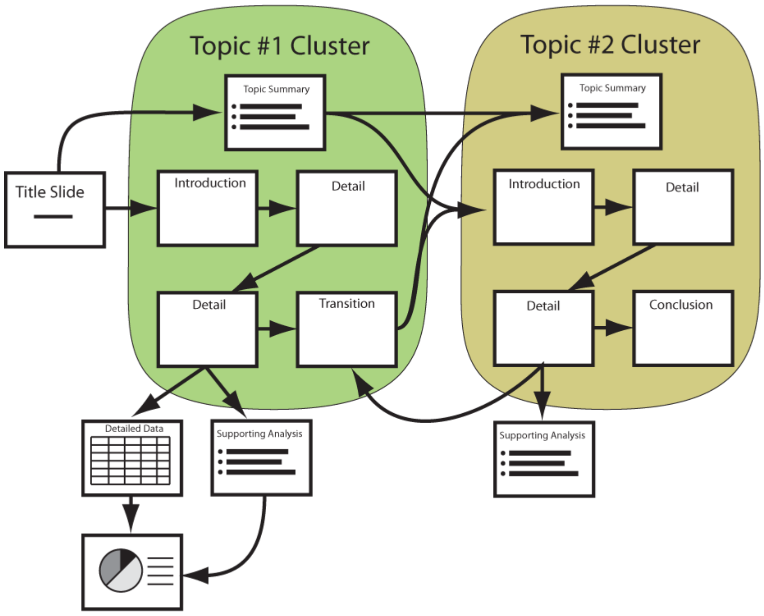

Figure 3.28: NextSlidePlease: Example Slide Graph (From [Spicer and Kelliher, 2009a])

target slide of the connection. The transition priority indicates how important the slide is; the time cost is an estimate of how long it takes to present the slide; and the flexibility stands for how much faster the slide can be presented, in percent, if pressed for time.

Finally, the author has to define the total time constraint and time constraint relaxation for the overall presentation. The relaxation stands for how much the presentation time can be potentially extended.

Presentation Delivery

In presentation mode, NextSlidePlease requires two separate screens. One public audience screen that shows the current slide and one private presenter screen that shows the navigation interface.

The presenter screen shows the time

The presenter screen (see figure 3.30) shows the time progress and the remaining time for the total presentation

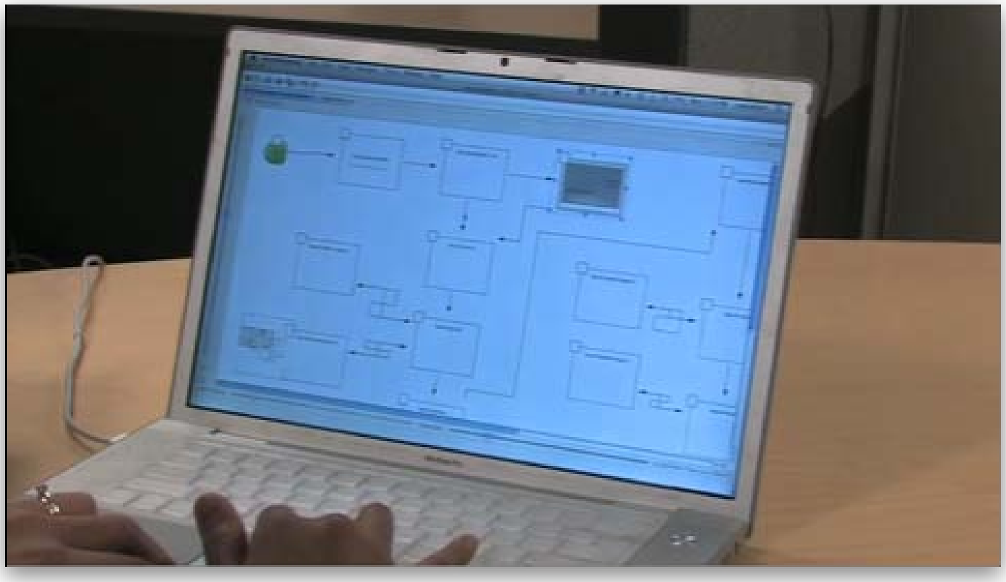

Figure 3.29: NextSlidePlease's Graph Editor (From rl.ame.asu.edu[a])

[a]http://rl.ame.asu.edu/projects/11

and the current slide. The presentation progress display indicates if the total time constraint will be exceeded and if the presenter should present faster. The slide progress display shows when the time for slide runs out and the presenter should move on. Both time budget displays help the presenter to make informed decisions about wether to include or omit information in the presentation.

progress for the current slide and the whole presentation.

For navigation through the slide graph the screen shows thumbnails of the possible successive slides. The slide suggested by the system's auto-path algorithm is pre-selected.

The presenter can choose among the possible successor slides.

Moreover, a search interface for finding slides by full-text search is provided. The slides in the search results can be selected as next slides. This allows for "agile search-driven jumps through content" [Spicer and Kelliher, 2009a].

Slides can be searched during presentation delivery.

For the main area of the private screen, the user can switch between a view of the current slide—as shown on the public screen—or a view of the slide graph—as shown in the editor. The graph is shown in an overview and detail in-

The graph view shows the current position and the currently suggested path.

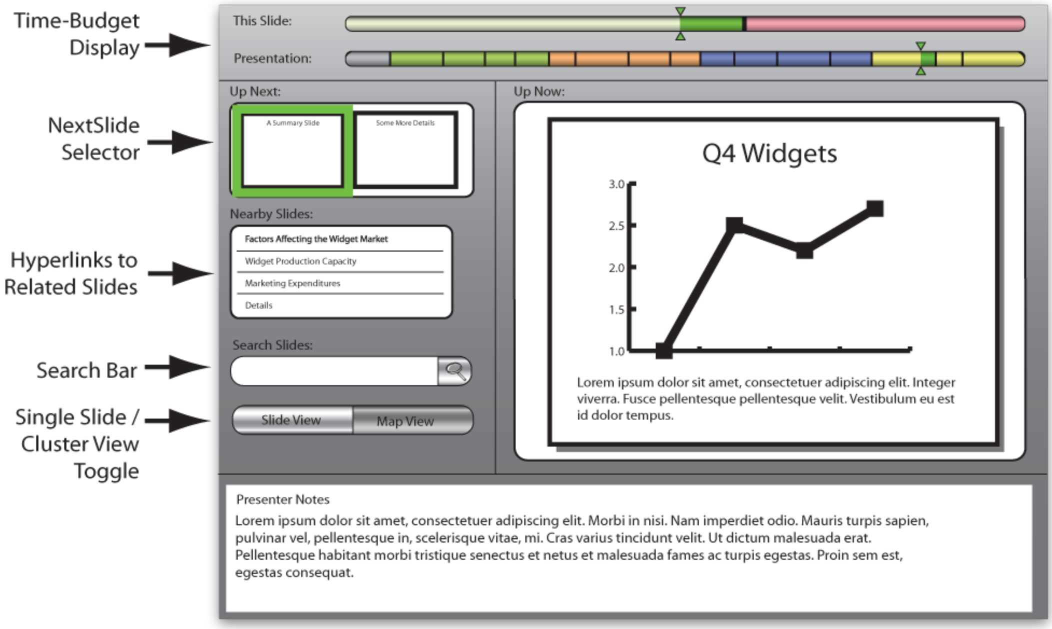

Figure 3.30: NextSlidePlease's Presenter Screen (From [Spicer and Kelliher, 2009a])

terface (see section 2.3—"Zoomable User Interfaces"). The current slide and the currently suggested path are highlighted. In the graph view, the presenter can select an arbitrary slide as the next slide. In [Spicer and Kelliher, 2009b] the authors mention that the graph can also be shown to the audience during slide transitions. But no further details are provided.

The system suggests a path that traverses the most important slides that fit within the time constraint.

To reduce the complexity of navigation and time management for the presenter, the auto-path algorithm suggests an optimal path from the current slide to the end of the presentation. The path is constantly updated taking into account to the remaining time, the presented content, and the current slide. The algorithm uses a "linear constraint optimization technique" [Spicer et al., 2009] to include as many important slides as possible into the path (by maximizing the total priority of all traversed slide transitions) and at the same time to stay within the global time constraint. The algorithm thereby tries to minimizes slide time adjustments and total time deviation.

Chapter 4

Design

The design of this thesis' Fly is based on the previous Fly version by Lichtschlag et al. (see section 3.2.1—"Fly"). The concept was refined to address the usability issues that were revealed by the previous version's evaluation and was extended with new features. The new capabilities are, on the one hand, features that take advantage of the canvas format to increase Fly's value for presentation authors, presenters, and audiences and, on the other hand, features that are adapted from slideware to achieve a more comparable feature set between Fly and the established slide-based systems. For the adoption of Fly it is important that authors can utilize the means they know from slideware.

The Fly design was refined and extended with new features.

4.1 Concept

4.1.1 ZUI Design

Fly's format is based on a ZUI with a planar canvas. The content elements are placed atomically onto the plane. Thereby, authors have complete design freedom for the canvas layout. They can create a visualization that represents the presentation topic's structure. As the evaluation of Prezi documents (see section 3.2.2—"Evaluation of Public Prezi Documents") has shown, different presenta-

The canvas-based format allows to create individual layouts without space constraints.

tion purposes require different document layouts. In Fly, there are no standardized templates that impose document features, as in slideware. While topics with only one dimension can be represented well in the flat, linear structure of a slide deck, topics with more complex structures benefit from the layout possibilities of a canvas-based format. After all, presentation authors can easily emulate the linear structure of a slide deck in Fly.

The format facilitates iterative authoring.

The canvas format allows for easy content reorganizations and thereby encourages authors to explore alternative structures. The layout can evolve naturally in an iterative authoring process. Users are free to use and switch between top-down and bottom-up authoring strategies. The Fly format addresses the limited drafting support problem of slideware (see section 2.2.1—"Limited Drafting Support").

The canvas format also solves the content cutting, content squeezing, and content overflow problems, known from slideware (see section 2.2.1—"Fixed Chunk Size"). There is infinite space available on the canvas, which can be viewed from varying distances, creating viewports of arbitrary resolutions.

The zoom level range is limited to reduce the complexity. Most authors use only a small range of zoom levels.

As in Leonhard's Fly, the ZUI's zoom level range is limited. This reduces the complexity and the risk of getting lost in the zoomable space. A limited range of zoom levels makes interface elements possible that provide orientation to the users, such as a scaling background pattern and a zoom level slider. The evaluation of the previous Fly version showed that most users arranged their content primarily spatially and used only a small range of zoom levels [Lichtschlag et al., 2009]. This practice was also applied in nearly all evaluated Prezi documents. Only the two documents with developing structures used a broader range of zoom levels (see section 3.2.2—"Evaluation of Public Prezi Documents").

The canvas size is not limited. The zoom range is automatically adjusted for larger canvas layouts.

Despite the limited zooming range depicted by the zoom level slider in Fly's authoring interface (see figure 4.1), the size of the canvas is not limited. Even if the slider is set to the lowest value—showing the biggest canvas overview—the user can still zoom out further (using menu items, keyboard shortcuts, or trackpad gestures) and pan in all di-

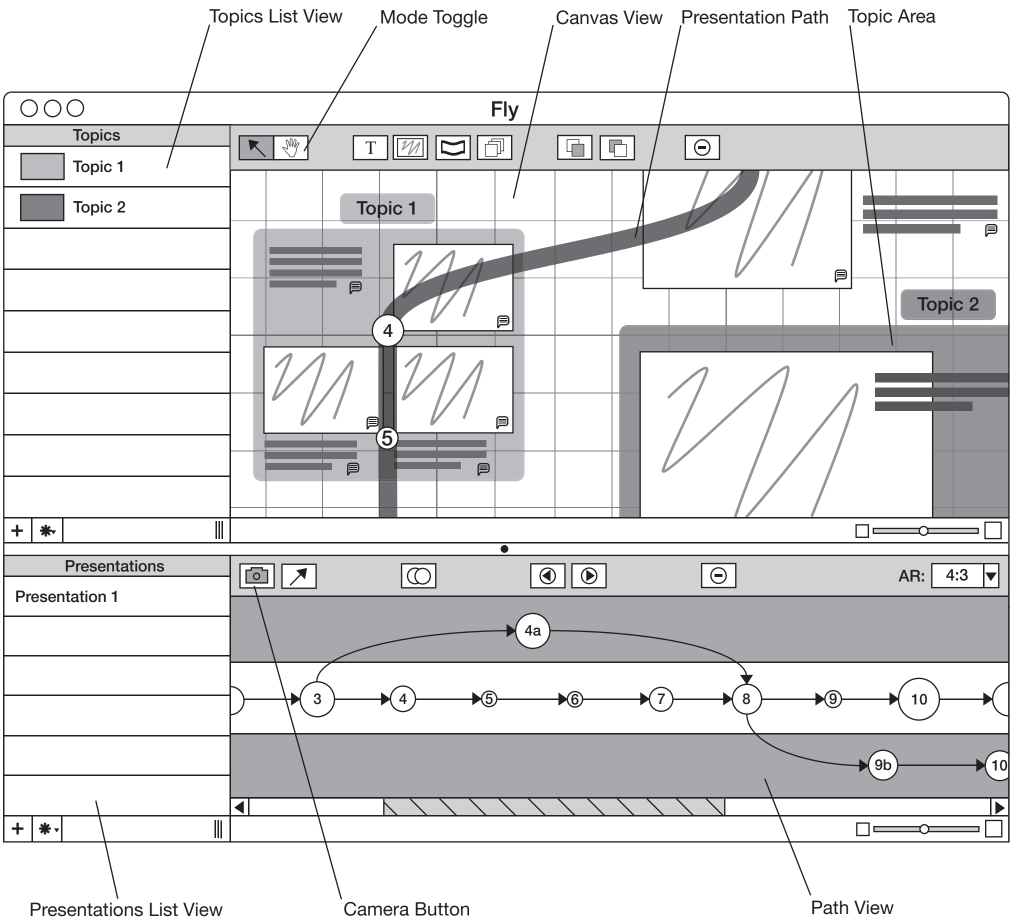

Figure 4.1: Fly's Authoring Interface

rections. If the size of the created canvas layout exceeds the viewport size that the lowest value of the zoom slider represents, the scale of the slider is automatically adjusted. This allows to create layouts of any size with any range of zoom levels and at the same time makes the slider control possible. However, in the other direction the zoom range is limited. It is not possible to zoom in further when the slider is set to the maximum value. This limitation is necessary to make a scaling background pattern possible.

4.1.2 Content Classification

The division into topic and detail zoom levels caused problems for the users and was dismissed.

As described in section 3.2.1—"Content Authoring", Lichtschlag's Fly divided the available zoom range into topic and detail zoom levels. The content elements placed onto these two ranges behaved differently. But, this functionality required that users paid attention to the current zoom level when adding content. This caused problems in the user study. Most testers accidentally placed detail content onto the topic zoom levels [Lichtschlag, 2008]. The functionality interferes with the top-down authoring strategies in the early authoring stages, in which authors assemble and roughly sort the content. For these tasks, a zoom level is useful that provides an overview over a large canvas area. The necessity to use a detail zoom level during the creation of detail content makes this impossible. This dilemma resembles the fact that slideware forces users to constantly work on the detail level (see section 2.2.1—"Limited Drafting Support"). Furthermore, the linking of element types with zoom ranges, silently changes the actions behind the toolbar buttons and menu items for creating new elements.

Topic elements provided content classification and canvas structure.

The primary purpose of topic level elements in Lichtschlag's Fly was to classify the content and to structure the canvas by applying labels to canvas areas. In overviews a viewer can recognize what topics are on the canvas and in detail views it is communicated which topic the currently visible content belongs to (see section 3.2.1—"Content Authoring"). This addresses the unstructured linearity problem of slideware (see section 2.2.1—"Unstructured Linearity").

In the new design, the content elements can be associated with topics for explicit classification and to form canvas areas.

The developed design uses a new solution for content classification and canvas structuring. The segmentation of the zoom levels is dismissed and, instead, *semantic topics* are introduced. These are managed separately from the canvas view (see figure 4.1). Authors can associate the content elements on the canvas with the topics and thereby explicitly classify the content. This also establishes topic areas, since the content elements that belong to the same topic are likely placed in close proximity to each other. The associated elements automatically define the areas' dimensions.

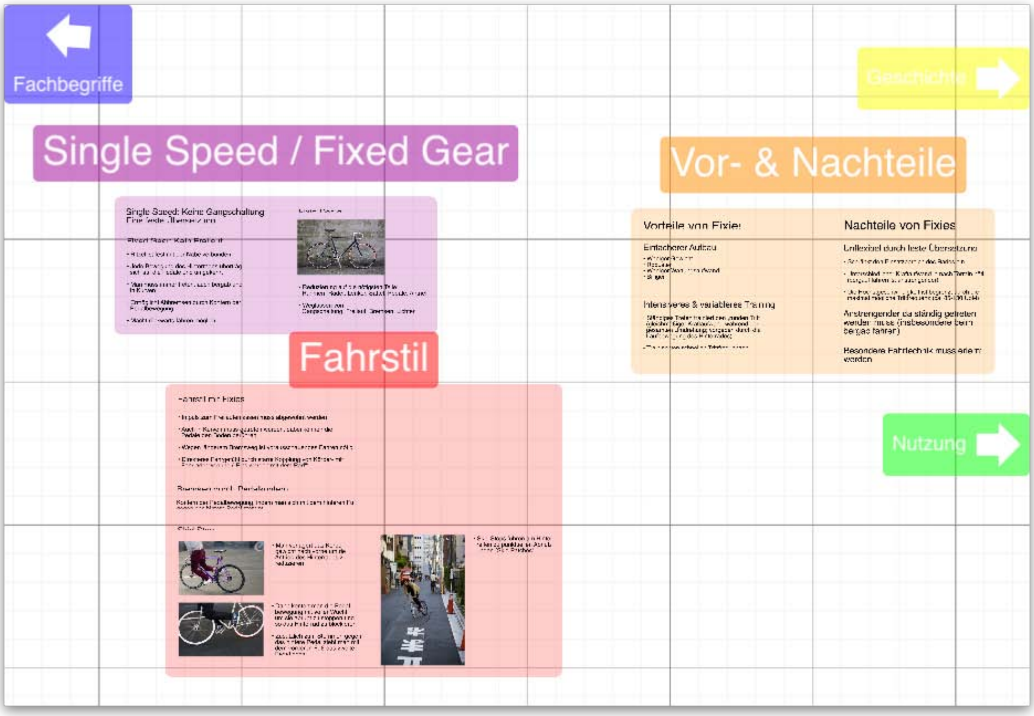

Figure 4.2: Fly Canvas with Semantic Topics

When content elements are modified, the topic areas are automatically adjusted. Users can name and assign colors to the topics. Section 4.2.1—"Topic Authoring" describes the management of semantic topics.

On the canvas, the topic names are displayed as text fields centered in the foreground of the corresponding topic areas. The topic areas themselves are visualized with colored backgrounds. These give a strong structure to the canvas in overviews and indicate which topic the content of a detail viewport belongs to. The off-screen topic indicators that Lichtschlag's Fly introduced (see section 3.2.1—"Presentation Delivery"), point now towards the topic areas instead of the topic elements and are displayed in the topics' colors. See figure 4.2 for a screenshot of a canvas with semantic topics.

Topic areas on the canvas are colored and labeled.

The separate management of topics reduces the complexity of the ZUI and should eliminate the usability issues of the previous version. To keep the complexity low, Fly does not allow for nested topics. Also, users can associate content elements only exclusively to one topic. Consequently, the semantic topics only allow for a one-level classification.

The topics provide a formal classification in addition to the format's inherent informal classification possibilities.

But, as the Prezi document evaluation showed, in many documents the content is not only structured into topics, but also into subtopics (see section 3.2.2—"Evaluation of Public Prezi Documents"). For these subclassifications, authors need to revert to the informal classification possibilities that are inherent to the canvas-based format. As authors have done in the Prezi documents, users can express hierarchies by using different content scales. Within the formal topic areas, the content can be spatially grouped into subtopics.

Authors can illustrate the relationships between the semantic topics by means of spatial proximity of the topic areas and by using similar or distinct topic colors.

4.1.3 Task Switches

In Fly, content and presentation sequence authoring are decoupled.

In Fly, authors describe the presentation sequences as paths through the canvas with path stops that show views of the canvas. During presentation delivery, Fly connects the stops with animated viewport transitions. This decouples the contentual and the temporal authoring. During the organization of the content, an author does not need to think about the presentation sequence and, therefore, can focus on the best way to represent the presentation topic's structure.

Switching between the activities should be easy.

While the primary task order in Fly is content authoring first and presentation authoring second, the application should allow to switch seamlessly between the activities. This is important to prevent any reluctance for making changes to the canvas and thereby making compromises with regard to the presentation's content and content structure.

The previous version did not facilitate activity switches.

Most of the related canvas-based systems, including the previous Fly version, make these task switches difficult or even impossible. During the creation of the presentation paths it is likely that an author wants to refine content or even make significant changes to the canvas layout. For example, to fine-tune the individual viewports or because the existing layout is recognized as not the best solution. The previous Fly version made the task switches difficult because path stops were not associated with the content that was visible in their viewports and also because users could not modify the viewports of existing path stops. This made it difficult to detect if layout changes affect the content of existing path stops and required to delete and recreate path stops when the canvas layout had been changed.

The developed Fly design addresses these issues by visualizing when canvas edits affect stops and by enabling the modification of existing stops' viewports. These capabilities are described in section 4.2.3—"Presentation Authoring".

4.1.4 Path Alternatives

Fly allows for multiple presentation paths within a single document. This makes it possible to create different versions of a presentation, e.g., for different audiences or time constraints, while reusing the content. Consequently, there is no need to duplicate documents. This addresses the limited reuse problem of slideware (see section 2.2.1—"Limited Reuse Support").

A Fly document can have multiple presentation paths.

The developed concept adds another form of path flexibility. That is, alternatives within a path, similar to the capabilities of Moscovich's system (see section 3.3.1—"Presentation Authoring"). While separate paths allow for different presentation versions for different occasions, path alternatives allow for flexibility within a presentation. For example, for a content section an author can create an extensive path that covers the section completely and a brief traversal that only covers the main points. Moreover, with path alternatives, authors can add shortcuts that skip sections of the presentation completely. During presentation delivery, the presenter can switch between the path alternatives, for example, in response to the audience or to changing time constraints. Section 4.2.3—"Presentation Author-

For additional flexibility during delivery, alternatives within paths have been added.

ing" describes the authoring and section 4.3.2—"Presenter Screen" describes the use of path alternatives.

Improvised canvas navigation is always possible.

Thereby, path alternatives supplement the other form of improvisation in Fly. That is, free navigation across the canvas. During any point in the presentation delivery, the presenter can show arbitrary views of the canvas by navigating within a canvas view similar to the one in authoring mode. This feature has also been refined in the new Fly version (see section 4.3.2—"Presenter Screen").

Path alternatives and improvised canvas navigation address the inflexible linearity problem of slideware (see section 2.2.1—"Inflexible Linearity").

4.1.5 Design Guidelines

A native application should be well integrated and use established means.

As the previous version, the new Fly version was designed as an application for Mac OS X. It was paid special attention to design the application's interface and the interactions in compliance to the OS's guidelines [App, 2009] as well as to the de facto standards that are established by other similar applications. The application should be a "good citizen" that is easy to use, especially for new users.

The previous version used controls that were unfamiliar to the users.

Unfamiliar interactions were the reason for usability problems of the previous Fly version. The *mouse-centered zooming*, in which zooming was controlled with the mouse scroll wheel, was new to all participants in the previous versions' evaluation. Five of the 18 users did not understand the interaction until it was explained to them [Lichtschlag, 2008, Lichtschlag et al., 2009].

The control for panning was also unfamiliar. It required to use the right mouse button for grabbing and dragging the canvas. The grabbing and dragging interaction is established for document handling applications (see section 4.2.2—"Canvas Navigation and Element Modification"), but it is normally executed with the left mouse button. Any form of interaction with the right mouse button, except for opening context menus, is uncommon on the Mac platform, since many Mac mice and all Apple laptop trackpads have only one button. Consequently, this interaction was especially hard to perform on laptop trackpads.

For a good discoverability of the functions in Fly, all interactions have a visible representation in the user interface, either in the form of button controls or at least menu items. There are no hidden functions that are only accessible through mouse or keyboard interactions.

Functions should be discoverable.

4.2 Authoring Mode

4.2.1 Topic Authoring

The semantic topics are managed in a list view left of the canvas view (see figure 4.1). The list view has two columns for color and name. The list entries are selectable; clicking on a topic entry will change the viewport of the canvas view to fit the topic area. This allows for a quick navigation between topics.

Topics are managed outside the canvas view.

To add content elements to topics, move elements between topics, and remove elements from topics, buttons are displayed dynamically in the list view. If no content element is selected, no buttons are displayed. If one or multiple elements are selected that are not yet associated with a topic, an *Add to Topic* button is shown next to every topic entry. If one or multiple elements are selected that are already associated to a topic, a *Move to Topic* button is displayed next to every topic entry except the topic the element(s) currently belong to. Also, a *Remove from Topic(s)* button is shown below the list view for deleting the topic association. See figure 4.3 for the different states. The dynamic button approach was preferred over a drag and drop solution because this would have conflicted with the interactions to position content elements.

The controls in the topic list view are automatically adapted to the current content selection.

In the canvas view, the topic areas have rounded rectangular colored backgrounds and the topic labels are displayed in the foreground at positions where they do not obscure content elements. Fly adjusts the font size of the topic la-

The topic area display is adapted to the current zoom level.

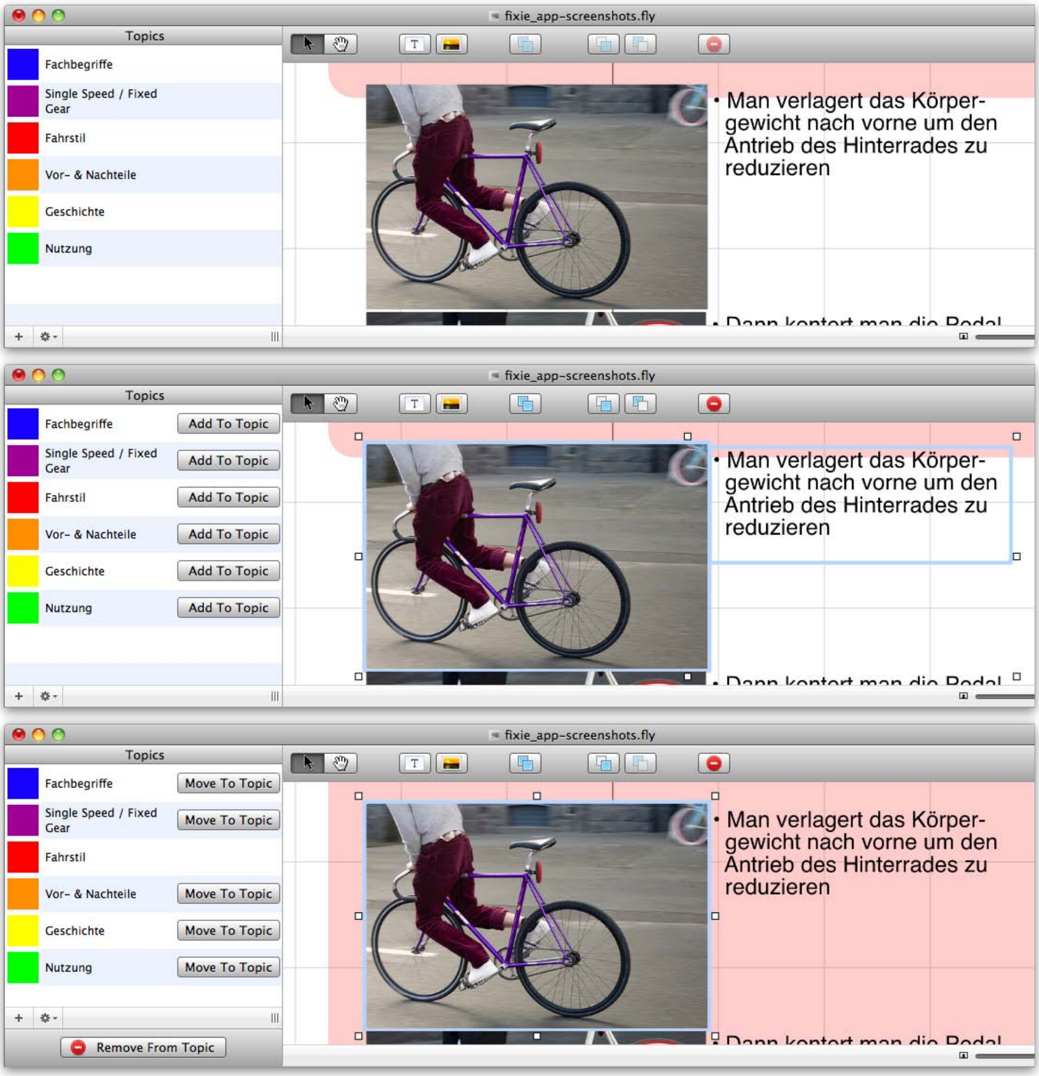

Figure 4.3: Dynamic Button Display in Fly's Topics List View (Top: No Content Selected; Middle: Unassociated Content Selected; Bottom: Associated Content Selected)

bels automatically so that the labels are properly visible from the current zoom level. See figure 4.2 for a canvas overview with topic areas and figure 4.4 for a detail view within a topic area.

Figure 4.4: Content Elements Within a Topic Area in Fly

4.2.2 Content Authoring

The background of the canvas view was changed from dark grey to white. The majority of pictures that are used in presentation visuals have white backgrounds, e.g., diagrams, tables, and screenshots. On the dark canvas background, those pictures appeared too dominant in overviews.

The canvas background has been refined.

The pattern background was changed to a grid background. As the pattern background, the grid is scaling and thereby provides constant orientation about the current zoom level. Furthermore, the grid lines can help authors to align the content elements. See figure 4.5 for views of the background when zoomed out and when zoomed in.

The design of the zoom slider control was changed. Since the distinction between topic and detail zoom levels was discarded, the partitioning of the slider and the buttons

A common design was used for the zoom sliders.

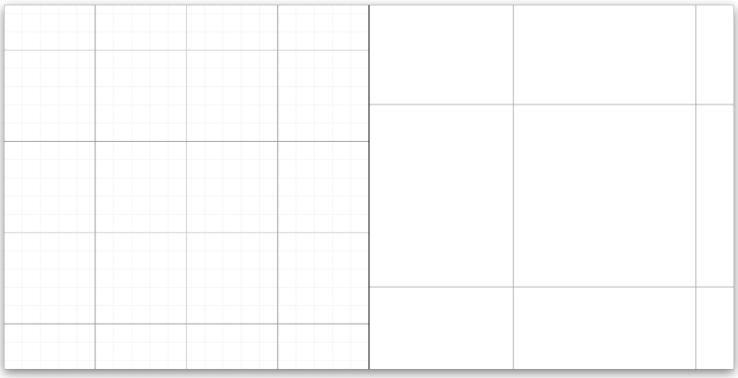

Figure 4.5: Canvas Background Grid in Fly (Left: Completely Zoomed Out; Right: Completely Zoomed In)

to access the different zoom level ranges were no longer needed. Furthermore, the slider is now arranged horizontally, right below the canvas view, as this is the established form for zoom sliders in Mac applications. See figure 4.6 for zoom controls in common Mac applications.

Canvas Navigation and Element Modification

Canvas navigation, element selection, and element modification are performed with established controls.

As discussed before, the canvas interaction controls of the previous version caused problems for the users because of unfamiliarity. Therefore, these interactions were dismissed and a new mode-based approach for panning and element selection was introduced. The approach is similar to controls that common document viewers and image processing applications, such as Apple's *Preview*,[5] *Adobe Acrobat*,[6] *Adobe Photoshop*,[7] *Adobe Illustrator*,[8] and Omni Group's *OmniGraffle*,[9] provide. The canvas view has two modes: the *navigation mode* and the *select/edit mode*.

In navigation mode, the cursor has a hand shape and the canvas can be grabbed and dragged to change the viewport

[5] http://support.apple.com/kb/ht2506
[6] http://www.adobe.com/products/acrobat.html
[7] http://www.adobe.com/products/photoshop/
[8] http://www.adobe.com/products/illustrator/
[9] http://www.omnigroup.com/products/omnigraffle/

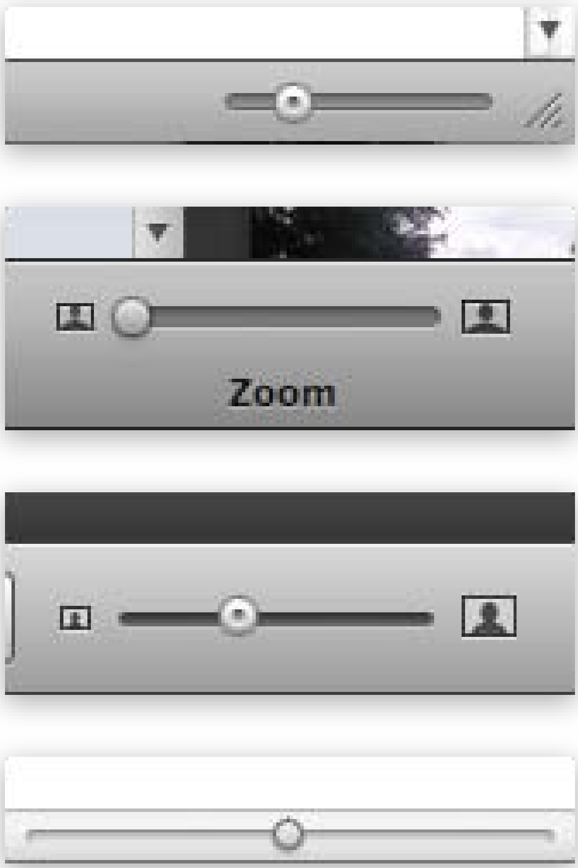

Figure 4.6: Zoom Sliders in Mac Applications (From Top to Bottom: *Finder*,[1] *iPhoto*,[2] *iMovie*,[3] *Numbers*[4])

position. In contrast to the previous Fly version, the action is executed with the left mouse button. Elements cannot be selected or modified in this mode. This allows to click anywhere to perform a panning action. In addition, users can also pan using the mouse scroll wheel, the corresponding trackpad gestures, menu items, keyboard shortcuts, and by dragging elements to the canvas view edges.

In select/edit mode, an arrow cursor is shown and elements can be selected and repositioned by dragging. Holding the Shift modifier key will add an element to the current selection. Furthermore, users can select multiple elements at once by drawing a selection frame around them (see figure 4.7).

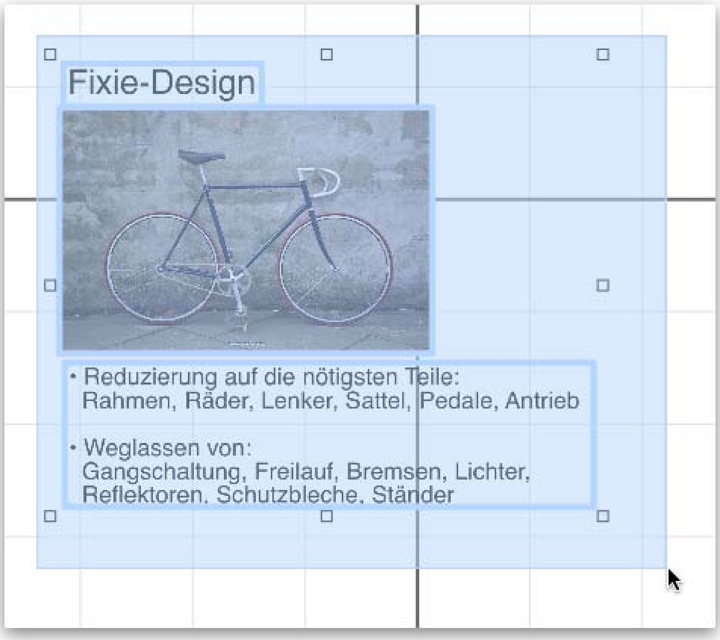

Figure 4.7: Multi Selection Frame in Fly

The user can switch between the two modes with a toggle control in the canvas view's toolbar (see figure 4.1) and with menu items with keyboard shortcuts. Furthermore, to enable quick switches between the modes, the navigation mode is available as a quasimode. When the application is in select/edit mode, pressing and holding the Space bar will switch to the navigation mode. This allows for an effective way of editing in which the user is usually in select/edit mode to add and modify the content elements and temporarily switches to navigation mode to change the viewport.

Standard keyboard shortcuts are provided for zooming interactions.

For changing the zoom level of the canvas view, there are menu items and keyboard shortcuts in addition to the slider control. The shortcuts are the same as in other document viewer and graphic applications: Command - + to zoom in and Command - – to zoom out. There is also a menu item with keyboard shortcut for showing all the content: Command - 0. This action changes the viewport to fit the complete canvas layout. Moreover, users can zoom using trackpad pinching gestures.

Selected content elements are highlighted with a colored border. Attached to the selection are eight resize handles (see figure 4.8). Holding the common modifier keys changes the resize behavior: Shift for maintaining the aspect ratio and Option for performing a centered resize. For the reasons discussed in section 3.2.2—"Content Authoring", rotation modification is not supported. Users can change the z-axis arrangement of elements using toolbar buttons and menu items with keyboard shortcuts.

The element modification functionalities have been extended.

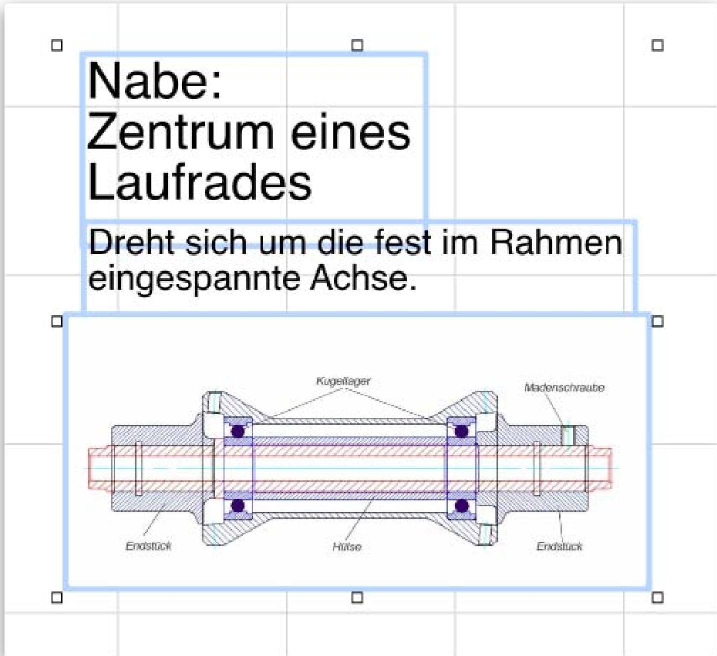

Figure 4.8: Selection with Resize Handles in Fly

Content Elements

The Fly concept was extended to not only support text and image elements, but also videos and animated builds. Users can create elements of all four kinds with toolbar but-

The new design has support for videos and animated builds.

tons, menu items, and keyboard shortcuts.

Scaling of text elements changes their font size.

The implementation of text elements has been changed. The size of elements is now set automatically by the contained text. Also the font size is no longer fixed. Users can now scale text elements like all other elements. Scaling not only changes the dimensions but also the font size. This allows to create different types of text elements, such as different levels of headlines, and thereby facilitates informal classification of the content.

Video elements have playback controls displayed on top, in the authoring as well as the presentation mode. See figure 4.9 for a video element during authoring and figure 4.17 for a video during delivery.

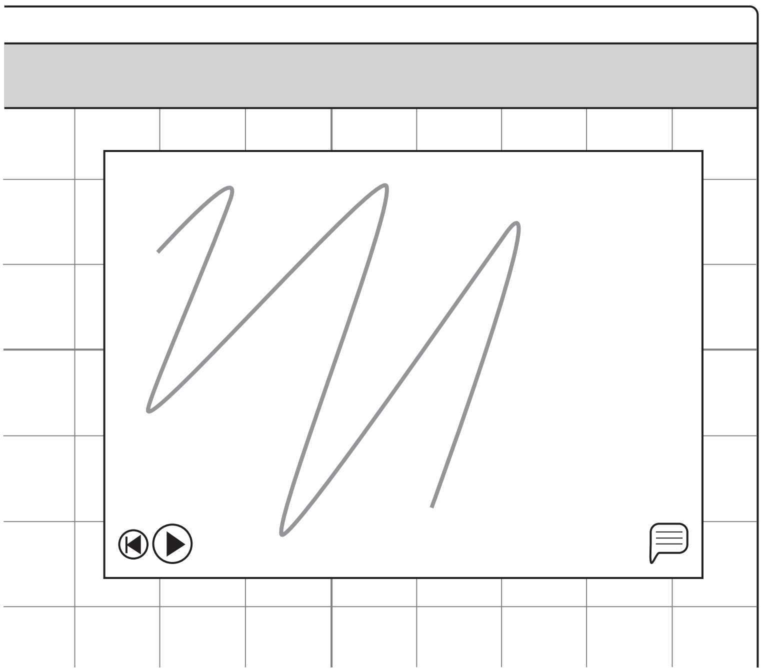

Figure 4.9: Video Element with Playback Controls in Fly

All common slideware applications support animated builds but so far the feature has not been adapted to a canvas-based presentation format. Presentation authors use builds to incrementally reveal content and to visualize developments and transformations.

By using path stops with overlapping viewports, content can be incrementally revealed and hidden in Fly without animated builds. However, without animated builds, users can replace or rearrange elements during presentation delivery only by placing the different element states onto distinct viewports. This practice would result in visuals with "wrong" animations that indicate position instead of state changes and would misuse the canvas layout whose purpose it is to encode conceptual and not temporal relationships.

With animated builds the state of elements can be changed.

A requirement for the implementation of animated builds is that it should be possible to traverse them fully and partially as well as skip them completely. This is not optimally realized in slideware applications that mix slide and build navigation. Both navigation tasks are performed with the same controls. This leads to unwanted build navigations when presenters navigate backwards in slide decks.

The navigation through the build sequences should be flexible.

Three implementation approaches have been considered. The first one was to arrange build states along the z-axis. This approach was dismissed because it would have misused the zooming movement, which stands for switches between context and detail views of the content. The approach would also have contradicted the new ZUI design in which all the content is visible from all zoom levels because it resides on the "bottom" of the zoomable space.

Two considered implementation approaches have been dismissed.

The second dismissed approach was to add visibility toggles to all content elements. The visibility states would have been stored for each path stop. Authors would have placed the content elements of all build states into the same canvas viewport and created separate path stops for each combination of element visibilities. This approach would have added complexity to all content authoring tasks and misused the presentation paths, which stand for changes of the spatial position and not changes within a viewport.

The chosen approach was the introduction of dedicated build elements. Authors can create rectangular build elements of any size and arrange them on the canvas like all other content elements. A build element can contain any number of states. In authoring mode, the states are managed within a HUD (head-up display) inspector window

Build elements add states to canvas areas.

that shows thumbnail views of the states (see figure 4.10). Users edit the content of the build states like regular canvas content. They use the HUD window to switch between the build states and in the canvas view they can modify the content of the selected state. For build navigation during presentation delivery, controls are displayed on top of the elements, similar to those of video elements (see figure 4.17). This concept separates build from path navigation.

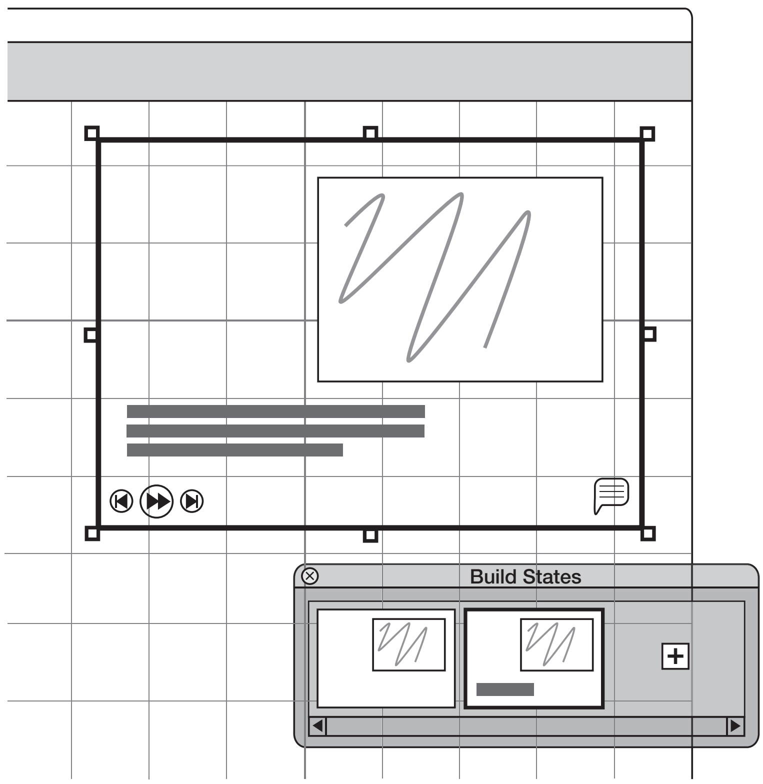

Figure 4.10: Build Element with Build States HUD Window in Fly

Presenter Notes

Notes are attached to content elements, not to path stops.

The extended Fly concept supports presenter notes. Unlike to slideware, the notes are not associated to slides respectively path stops but to individual content elements. This approach was seen as superior to the two other considered approaches: notes linked to path stops and dedicated note elements on the canvas.

In contrast to notes for path stops, the chosen approach allows to add notes even if the presentation path is not yet created. The approach makes the notes also robust to changes to the presentation path, for example, when content is moved between path stops or path stops are deleted. Furthermore, the presenter notes will also be available during an improvised canvas navigation and in all paths that cover the annotated content.

The alternative approach of dedicated note elements would have had the drawbacks of cluttering the canvas and making the creation of path stops more difficult. Authors would have to pay attention to include all relevant notes in the stops' viewports.

All content elements have a small note icon in their lower right corner that indicates if notes are attached. Clicking on the icon will open a small HUD window in which the notes can be edited (see figure 4.11).

4.2.3 Presentation Authoring

For presentation path management the authoring interface provides a list view with all created paths and a multi-row path view that shows the stops of the selected path (see figure 4.12).

A path display shows the straightened path outside of the canvas view.

The list view allows to add, name, select, and delete paths. The path view shows the currently selected path sequentially from left to right, similar to a timeline. The view has one main row for the default path and two additional rows for path alternatives. The path stops are displayed as sequentially numbered dots connected with arrows. The size of the dots corresponds to the size of the stops' viewports. A stop that shows an overview has a large dot, while a detail stop has a small dot.

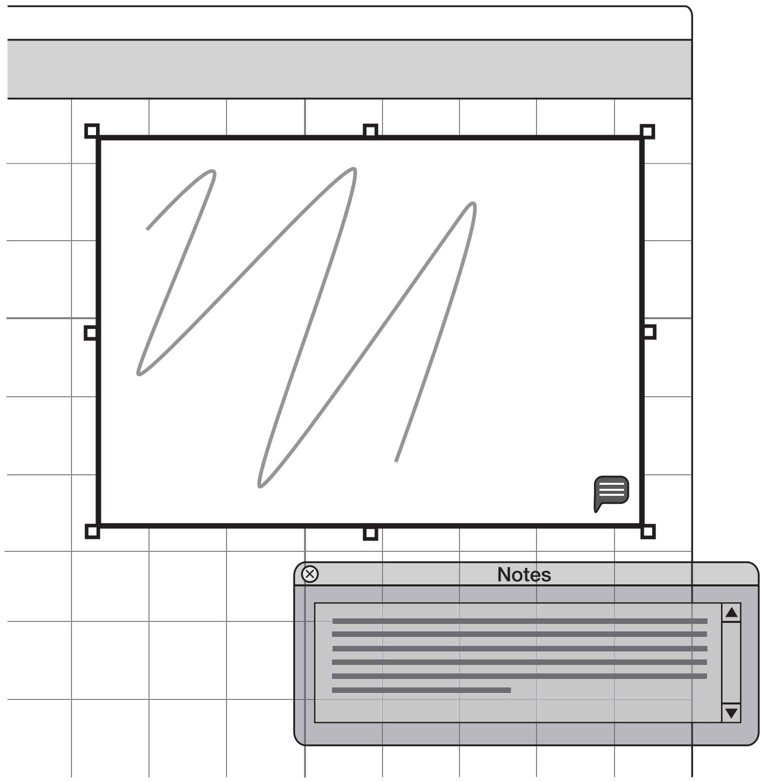

Figure 4.11: Content Element with Presenter Notes HUD Window in Fly

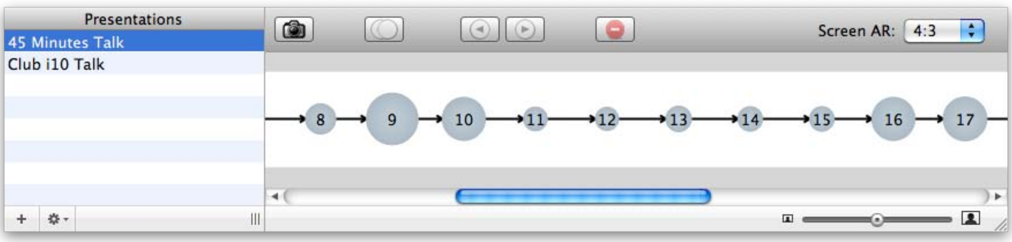

Figure 4.12: Paths List View and Path View in Fly

The selected path is also shown on the canvas.

As in the previous Fly version, the currently selected path is also displayed in the canvas view. Fly displays the path stops as sequentially numbered dots that are placed in the center of the stops' viewports. As in the path view, the dot size corresponds to the viewport size. A curved line connects the dots and indicates the course of the viewport transitions.

It would probably have been possible to develop a concept in which all path authoring tasks are performed within the canvas view, as it is done in Prezi. But, especially for an extensive presentation, the path display in the canvas view can become complex. The dedicated path view on the other hand always provides a much clearer, less complex view of the path. The path view has a zoom slider, similar to the canvas view. It scales the view which makes it possible to manage simple as well as complex paths and to get overview and detail views of a path.

Path stop viewports are visualized and can be modified.

Clicking on a stop's dot in the path and canvas views selects the path stop. The canvas view is adjusted to fit the stop's viewport. The viewport is shown as a half-transparent rectangle on top of the content elements (see figure 4.13). This provides an exact preview of a path stop's viewport. Authors can move and resize the viewport rectangle just as any other element on the canvas. This allows to edit existing path stops, for example, to adapt them to changes in the canvas layout. A user can move along the stops in the path view and thereby preview the presentation path including the viewport transitions.

Users create path stops by capturing the current viewport.

New path stops are created with a camera button in the path view's toolbar. It captures the current canvas viewport, utilizing the metaphor of creating photographs of the canvas. The new stop is added to the path after the currently selected stop or appended to the path's end if no stop is selected. The stop is automatically connected with its preceding and, if applicable, following stop. After a stop has been created it is automatically selected and the viewport rectangle is shown in the canvas view. This gives immediate feedback and allows to fine-tune the viewport. Fine-tuning is, in particular, necessary when the aspect ratio of the canvas view does not match the aspect ratio of the viewport.

Authors can define the aspect ratio of stop viewports.

In order to allow for exact definition of stop viewports, Fly has a per-path setting for the viewport aspect ratio. Users can set it to the common aspect ratios of projector screens: 4:3, 16:9, and 16:10 (see figure 4.14). The setting can also be changed later on and the existing path stops are automatically converted.

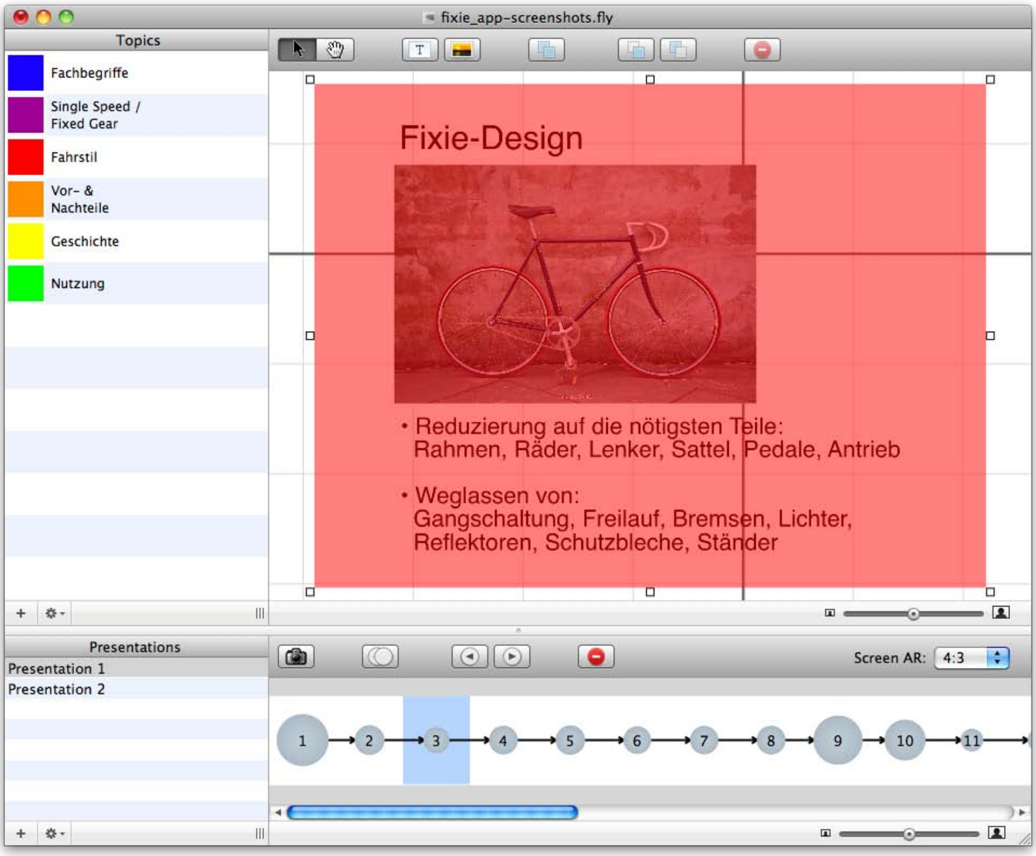

Figure 4.13: Path Stop Viewport Display in Fly

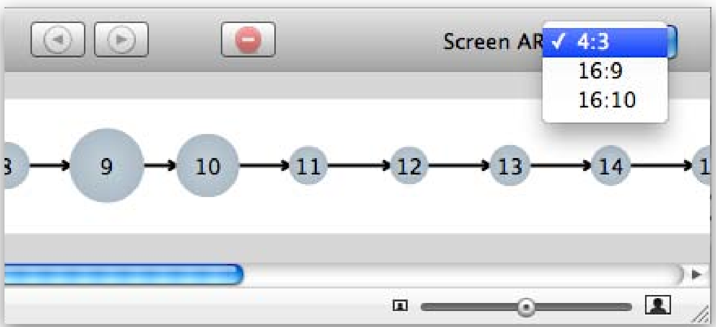

Figure 4.14: Viewport Aspect Ratio Setting in Fly

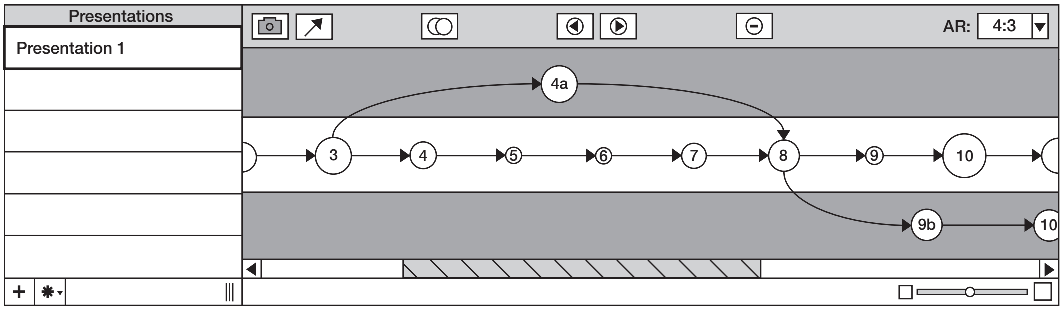

Figure 4.15: Presentation Path with Path Alternatives in Fly

In the path view, users can rearrange the path stops using drag and drop, toolbar buttons, or menu items. Path stops can also be duplicated, which allows for quick reuse of stops within a path, for example, for showing an overview at the beginning and end of a canvas section traversal.

Path stops can be duplicated and rearranged.

Users can drag the path stops onto the rows above and below the main row to create path alternatives (see figure 4.15). The stops of neighboring rows can be connected using the arrow tool provided in the path view's toolbar.

Path alternatives can be created within the path view with drag and drop.

As in Leonhard's Fly, path stops are defined by their viewport coordinates. This has the consequence that stops "break" if the content they show is moved or modified. By supporting the modification of existing stops, users can adapt paths to changes on the canvas. To make it easier to detect when canvas changes affect path stops, a *clean/dirty state* for stops was introduced.

Path stops have a state that indicates if they are affected by canvas changes.

When a path stop is created, it is associated to all the content elements that are visible within the stop's viewport. In the case that the content elements are modified in a way that removes them from the viewport, the stop's status changes to dirty. A different stop dot color in the path and canvas views visualizes this. When users select dirty stops, they can make the necessary changes and mark the stops as clean. This approach makes affected stops easy to discover without patronizing the users.

Users can review and adapt affected stops.

These two features, editable stop viewports and stop clean/dirty states, should make it comfortable for users to switch between the content and path editing activities.

4.3 Presentation Mode

In presentation mode, Fly provides the public display for the audience and an additional private presenter screen.

4.3.1 Audience Screen

The animations have zoom-out and easing components.

The public audience screen shows only the canvas without the background grid. The canvas views are related with animated transitions. The animations incorporate an intermediate zoom-out movement that reveals the context of the viewports and makes the animation easier for the viewer. Easing functions make the animations feel organic. The course of the transition animations resembles flight trajectories.

The display of content elements depends on whether they have already been shown.

On the audience screen, Fly displays the content elements differently depending on their state. The elements can have three states: already presented content is displayed fully visible; content that has not yet been presented is displayed blurred to avoid spoiling; and content that will not be presented because the presentation path does not cover it is not shown at all.

Different features can be shown to provide orientation.

In addition to the content, presenters can show other elements that assist the audience. To visualize the semantic topics, the topic area backgrounds, the topic labels, and the off-screen topic indicators (topic hints) can be shown. For orientation about the presentation sequence, the path can be displayed. See figure 4.16 for a screenshot of the presentation mode preferences.

The path display is not always useful.

It depends on the individual presentations how useful these means are. Especially the path display can clutter and distract if the path is complex. If the presentation has path alternatives, the displayed course may not be accurate as it is not foreseeable which alternatives the presenter will follow.

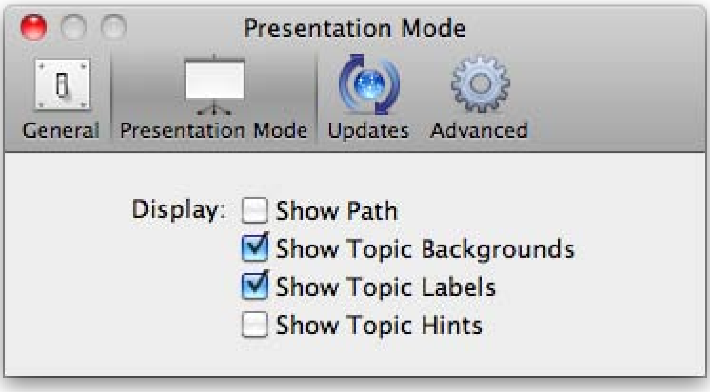

Figure 4.16: Visibility Settings for the Presentation Mode in Fly

4.3.2 Presenter Screen

The presenter interface (see figure 4.17) must allow for agile real-time control of the presentation visuals with as little cognitive load for the presenter as possible. The designed interface allows to sequentially step along the main presentation path, to switch between path alternatives, to perform improvised navigations across the canvas, and to control the video and build elements on the canvas. It also shows the time progress and the presenter notes.

The simple sequential traversal of the presentation path is as easy as with slideware and can be performed using a single key press (Space or Right Arrow).

The path navigation view resembles the path view of the authoring interface. However, the path stops are not shown as dots but as viewport thumbnails to provide previews. The stops are arranged so that the current stop is shown at the leftmost position and the possible next stops are placed above each other (see figure 4.17). In addition to stepping along the path with key presses, the user can click on any path stop to select it. This allows to switch to path alternatives and to skip stops. The public screen will always show a transition animation from the current viewport to the selected path stop.

The path navigation provides previews of the upcoming path stops and allows to switch between path alternatives.

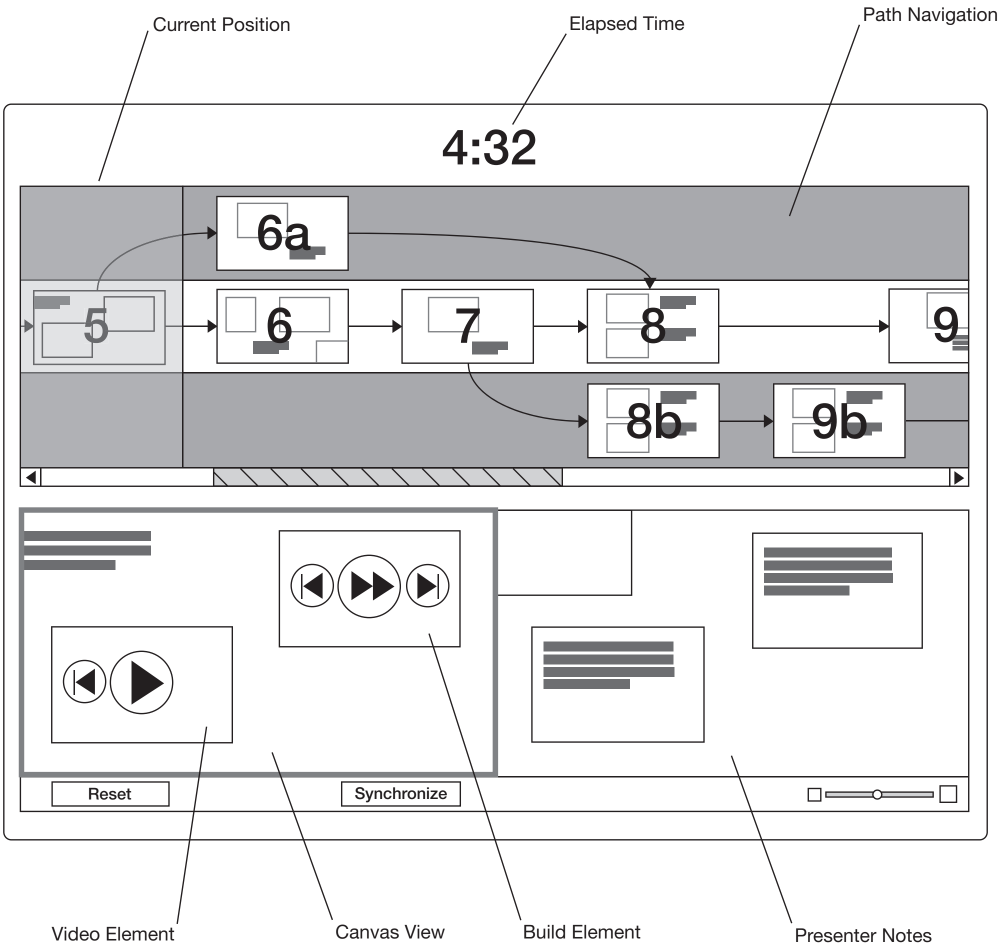

Figure 4.17: Fly's Presenter Interface

The presenter can use the canvas view in the bottom left pane (see figure 4.17) for improvised navigation and for controlling the video and build elements. The view behaves like the authoring canvas view in navigation mode, i.e., the content elements cannot be selected or modified. When the presenter shows the path, the canvas view mirrors the public screen, showing the current canvas viewport. The controls of video and build elements are larger than in authoring mode, making them easier to target with the mouse.

The improvised canvas navigation is asynchronous to

The functionality for improvised navigation works asynchronously, i.e., when the user changes the viewport in the canvas view, the public screen does not change automatically. Instead the border of the canvas view changes its color, indicating that the two views are out of sync. Only after the presenter has navigated to the desired viewport and presses the *Synchronize* button the public screen changes its viewport with an animated transition.

provide a better experience for the audience.

This mode of interaction has two advantages. First, it allows to use the canvas view also for private explorations of the canvas, for example, to locate content. Second, this results in better visuals for the audience since Fly can show a proper transition animation. The presenter would not be able to create a comparable transition. In particular, because it is not possible to seamlessly control panning and zooming simultaneously using keyboard and mouse.

After an improvised navigation the path will be continued from where it was left off. Functionalities that take the current viewport into consideration, like in CounterPoint or pptPlex, are only reasonable for systems in which the views of the canvas are strongly formalized. In Fly, with free improvised navigation, this would make the path continuation unpredictable.

The scripted path is always continued from where it was left off.

Right of the canvas view, the presenter notes are shown. The view mirrors the canvas view, but instead of the elements, the attached notes are shown (see figure 4.17). The mirrored arrangement should make it easy for presenters to locate the notes for individual elements.

A dedicated canvas view shows the presenter notes.

Chapter 5

Implementation

The design described in the previous chapter, has been implemented as a software prototype. Not all features of the concept could be implemented within the scope of this thesis. Instead, mainly the features that were necessary to use the application for the audience study were realized. To facilitate future work on Fly, special attention was paid to a maintainable and extensible software architecture.

Not the complete concept was implemented.

The most important criteria for using the application in the audience study was that authoring should work well. Especially, because an external author who neither knew the Fly format nor the software implementation was going to use the application. The prototype had to run stable and be easy to understand and use.

Mainly the functionality required for the audience study was realized.

The application had to be error-tolerant to avoid user frustration. For that reason, throughout undo and redo support as well as autosave support were implemented. The autosave functionality regularly saves the document to avoid the loss of work in the case of application crashes. Undo and redo was implemented for all actions that modify the data state of a document, i.e., for all the topic, content, and path editing actions. The undo and redo histories did not include the actions that only modified the view of the data, for example, zooming and panning in the canvas and path views. To make authoring comfortable, cut, copy, and paste were implemented throughout the application and keyboard shortcuts were defined for all regularly used actions.

The support for videos and animated builds as well as the features for the presenter were not implemented.

Since the documents for the audience study did not include videos and animated builds (see section 7.2.4—"Presentation Visuals"), support for these content types was not implemented. In the audience study, the documents were not shown within live presentations but only as prerecorded videos (see section 7.2.1—"Human Factors"). Therefore, all features that support the presenter in a live presentation, such as the presenter notes, the path alternatives, and the presenter screen, were not realized.

Besides a good authoring experience, the implementation focused on well designed visuals for the audience. The display of the content elements and the means that provide orientation, such as the topic backgrounds, labels, and hints, as well as the path display, were properly realized. Also the animations for the viewport transitions were well implemented.

Admittedly, some features that would have been useful in the audience study, such as the path stop clean/dirty states and the content element states, were not realized due to time constraints.

See figure 5.1 for a screenshot of the Fly application's authoring interface. The enclosed CD-ROM contains the compiled software prototype and the source code (see section C—"CD-ROM Contents").

5.1 Technologies

The software prototype was developed as an application for Mac OS X 10.6. It was implemented as a document-based *Cocoa*[1] application using the *Core Data*[2] and *Core An-*

[1]http://developer.apple.com/technologies/mac/cocoa.html

[2]http://developer.apple.com/technologies/mac/data-management.html

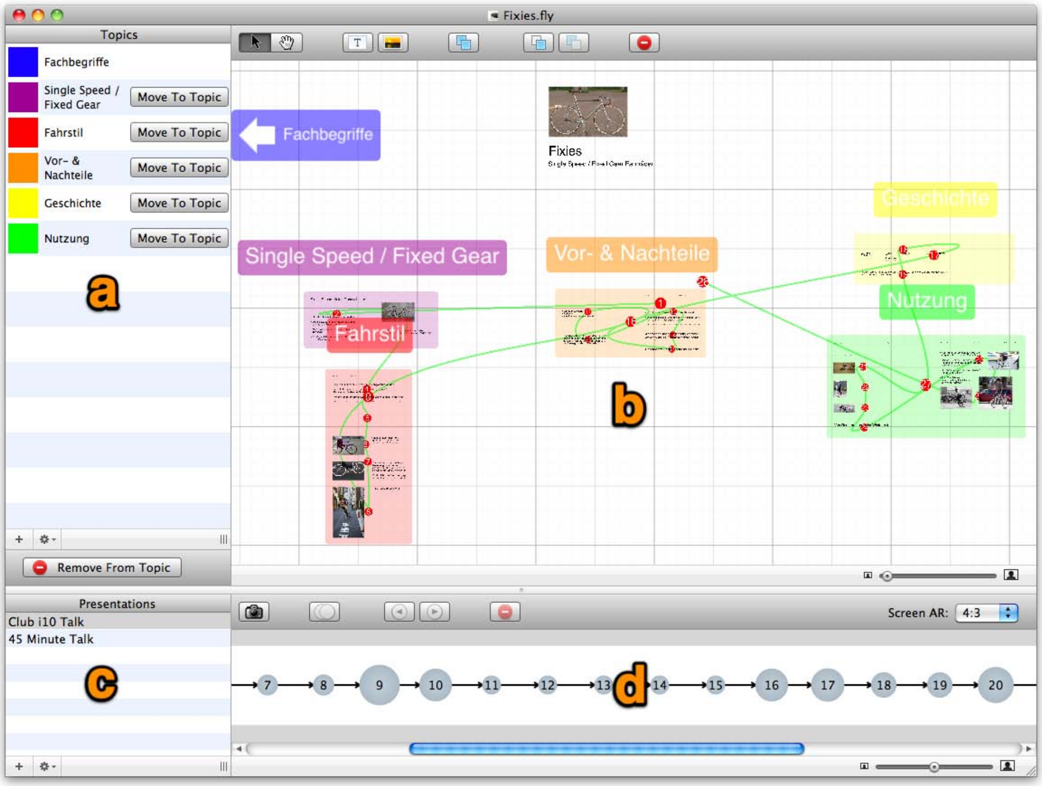

Figure 5.1: Authoring Interface of the Fly Software Prototype (a: Topics View, b: Canvas View, c: Paths View, d: Path View)

imation[3] frameworks for data modeling and for fluent animations.

The Fly application uses a packaged file format[4] that stores the media files that are used in a document together with the XML file that contains the persisted data model.

5.2 Software Architecture

The architecture of the application follows the MVC

The architecture is based on the MVC pattern.

[3]http://developer.apple.com/technologies/mac/graphics-and-animation.html

[4]http://developer.apple.com/library/mac/documentation/CoreFoundation/Conceptual/CFBundles/DocumentPackages/DocumentPackages.html

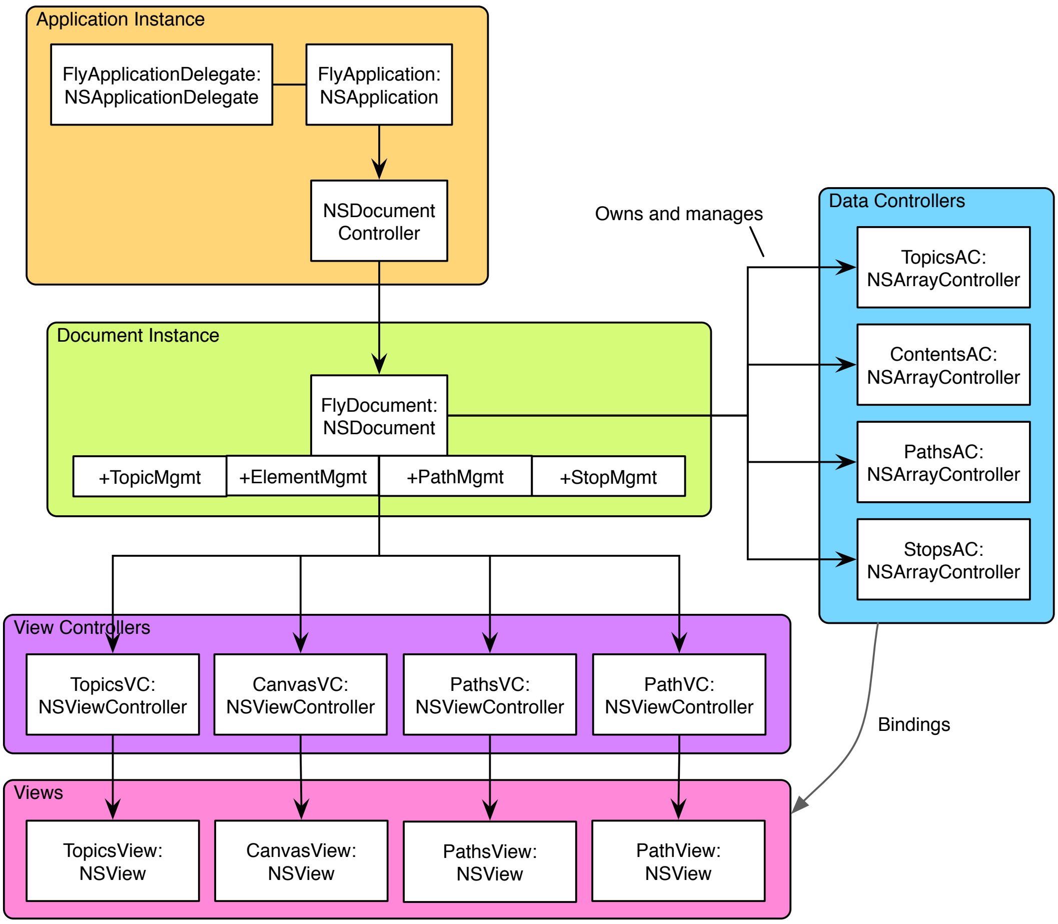

Figure 5.2: Software Architecture of the Fly Prototype

(Model-View-Controller) pattern that is inherent to the Cocoa frameworks. See figure 5.2 for an overview of the architecture and the main classes.

The `FlyDocument` class manages a document instance, including its data state. It has separate categories[5] for the topic, content element, presentation path, and path stop management. Array controller classes manage the `Topic`, `Element`, `Path`, and `Stop` entities of the data model (see figure 5.3).

The class hierarchy of the authoring interface is organized along the four main panes (see figure 5.1). For each pane

[5]http://developer.apple.com/library/mac/documentation/Cocoa/Conceptual/ObjectiveC/Articles/ocCategories.html

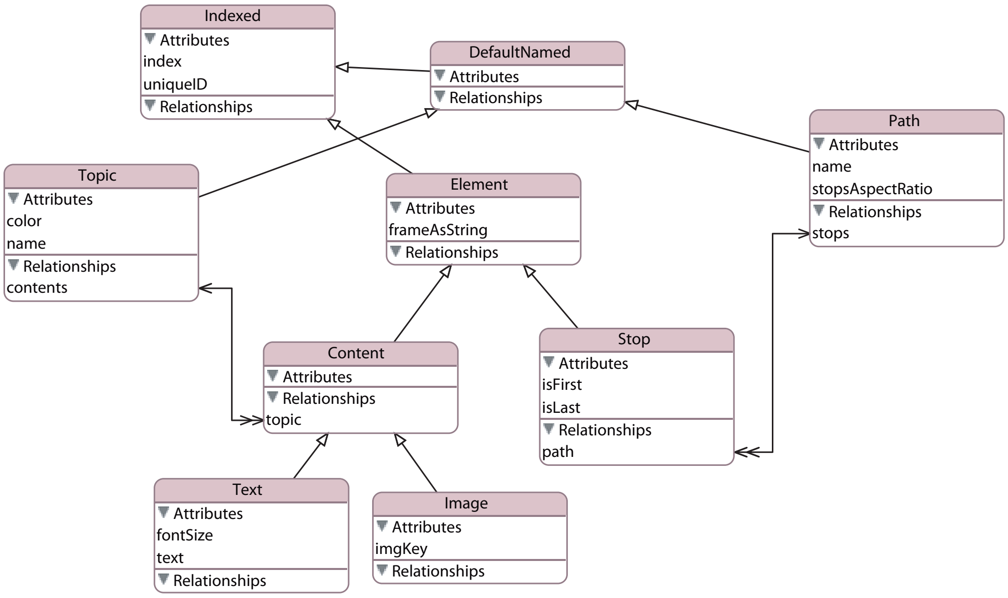

Figure 5.3: Data Model Used by the Fly Prototype

there is a view class and a corresponding view controller class. The user interface elements that display entity items, such as the topics list view, the paths list view, and the path stops view, have bindings[6] to the corresponding array controllers.

5.3 Data Model

The data model of Fly documents is shown in figure 5.3. It has the following particularities.

A parent entity provides unique IDs and indexes to all entities.

The `Indexed` parent entity provides the `index` and `uniqueID` properties to all entity objects. The `index` property is used to maintain object orders. For the topics and paths it is used for the orders in the list views; for the content elements the property is used for the z-axis ordering; and for the path stops the `index` values represent the stop sequence. The `uniqueID` is primarily used to identify the

[6]http://developer.apple.com/library/mac/documentation/Cocoa/Conceptual/CocoaBindings/CocoaBindings.html

objects of items that are displayed on the canvas. Core Data provides the `NSManagedObjectID` property for entity objects, but this ID is fragile and changes, for example, when a document is saved.

The `DefaultNamed` parent entity provides a serially numbered default name. When new Topic and Path items are created, their name properties are automatically set to "Topic 1", "Topic 2" ... respectively "Presentation 1", "Presentation 2" ...

All `Element` sub-entities are elements on the canvas and, therefore, have a frame property that specifies their position and dimensions.

5.4 Canvas View

The ZUI stores the absolute coordinates and dynamically transforms them to screen coordinates.

The ZUI was developed as a stack of Core Animation layers (see figure 5.4). The implementation handles two coordinate systems. The one at the "bottom" of the zoomable space, i.e., the *absolute coordinates* of all elements, and the *screen coordinates* that represent the position of the elements within the current canvas viewport. The absolute coordinates for all canvas elements are stored in the data model. Transform matrixes that encode the current viewport's scale and translation are used to convert the coordinates.

For performance reasons, small and large canvas elements are implemented differently.

For performance reasons and because of the limited maximum Core Animation layer size, two different strategies are used for element display. All small elements are created as layers in absolute coordinates and sublayer transform matrixes are applied to their parent layers to convert the elements to screen coordinates. For example the text and image content elements (`ContentLayers`) that are sublayers of the `ContentsLayer` (see figure 5.4).

The layers for larger elements, such as the topic backgrounds, are, however, created in screen coordinates. Since large layers severely decrease the application performance and because the size of Core Animation layers is limited

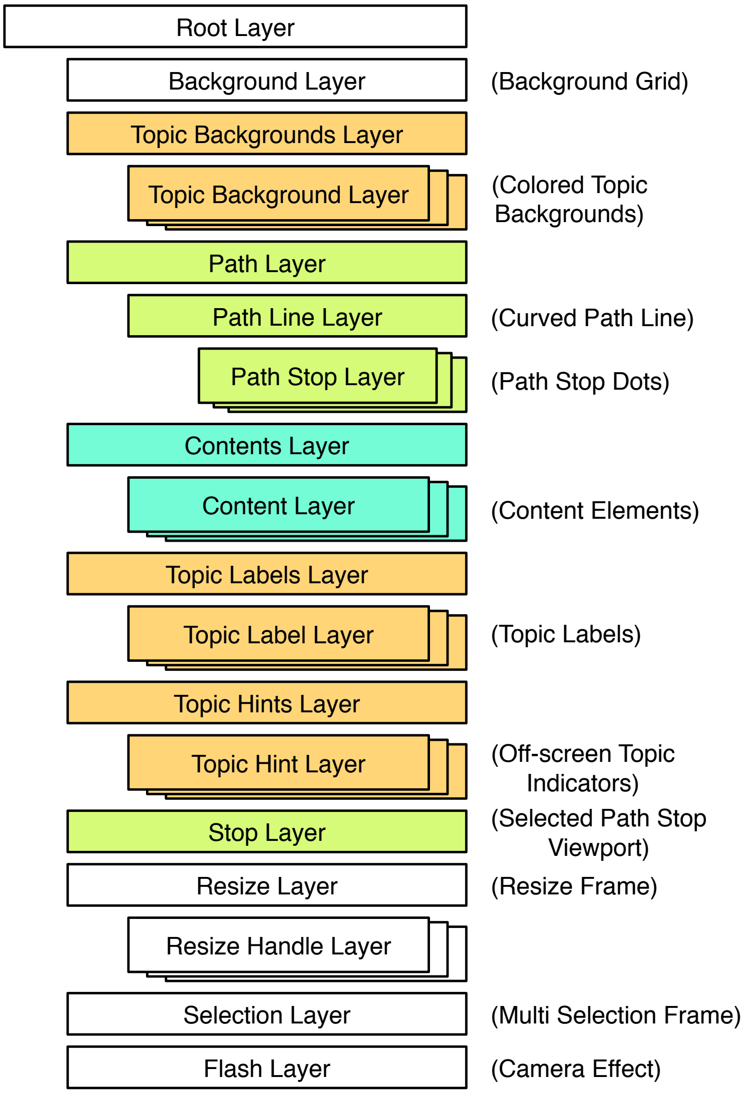

Figure 5.4: Fly's Canvas View Layer Stack (Ordered from Back to Front)

by the maximum OpenGL texture size of the graphics card. Especially elements than cover large areas of the canvas, such as the presentation path, easily exceed the maximum layer size in absolute coordinates. This approach, however, requires that the layers are updated whenever the canvas viewport changes. In contrast to the strategy for smaller elements in which the layers are only modified when their data changes. On viewport changes, only the sublayer transform matrix needs to be updated.

The zoom level is a transient property that is not stored.

The implementation does not store zoom levels but only the x- and y-coordinates as well as width and height dimensions. The zoom levels of viewports are always dynamically calculated in relation to the overall canvas size. The zoom levels are not used internally, but only needed for the user interface—for the zoom level slider and for the path stop dot sizes.

Chapter 6

Argument for Fly as Better Presentation Support

The previous evaluation of Fly with regard to presentation authoring by Lichtschlag et al. [2008, 2009] showed that Fly provides superior authoring support in comparison to slideware (see section 3.2.1—"User Studies").

We argue that the Fly format also has benefits for the audiences of presentations. The Fly approach, designed to address the shortcomings and problems of slideware, can make it easier for audiences to follow presentations and to understand and learn their content.

Slideware and Fly are not different media types but rather tools for authoring the same media type.

We do not esteem slideware and Fly as different media types, as used by Clark [1994], Kozma [1994], and Ullmer [1994], but rather as different tools for creating the media type of computer-based presentation support. Presentation authors can create visual support for presentations with a variety of applications—slideware, graphics and animation software, or novel approaches such as Fly. The outcome of these tools are visuals that are displayed on a large screen visible to the audiences to enrich the speaker's oral presentation. The speaker may have an additional private presenter screen or other materials, such as paper notes, and can control the visuals that are shown on the public screen.

Authors can apply the same good and bad methods and practices in all of the various tools. Moreover, the applications can even simulate each other. Visuals similar to those of a Fly presentation can also be generated with graphics and animation software or, to a certain degree, even with slideware. Consequently, Fly and slideware are no different media types.

Fly's superior authoring support leads to better visuals and the spatial format has cognitive benefits for the viewers.

The argument for Fly is two-fold. On the one hand, Fly, as an authoring tool, affords to create better presentation support than the common slideware applications. Fly has the potential for a better *usual use*, as defined by Clark [1994]. Authors are encouraged to apply good methods and practices due to the way presentations are created in Fly. To create presentation support with the same qualities with other tools would take more effort.

On the other hand, Fly, as a presentation delivery tool, has a better "cognitive style" [Tufte, 2003] than slideware. The Fly format has cognitive and attention advantages that help audiences to follow presentations and to remember the delivered content. Fly can also assist speakers better during presentation delivery.

6.1 Expressive Visuals Because Of Superior Authoring Support

Like slideware, Fly has specific affordances.

Powerful authoring tools, such as slideware and Fly, allow the user to create a broad range of document qualities. Presentation authors can apply good and bad practices. But, like slideware applications (see section 2.2.2—"Encouraged Practices"), Fly encourages certain practices during the authoring process, that lead the author into a certain direction. These affordances of Fly should result in presentations that assist the audiences better.

6.1.1 Meaningful Presentation Structures

A spatial organization of the content allows for and affords a top-down mode of authoring [Lichtschlag et al., 2009]. A ZUI further supports this pattern by enabling to work on various levels of detail [Good, 2003]. Authors do not have to decide early where to put the content exactly, but can place elements on temporary positions. In contrast to slideware, where users can place content only onto slides that are part of the presentation sequence, as described in section 2.2.1—"Limited Drafting Support". Being able to explore alternatives leads to a better content organization [Good, 2003]. Especially for complex topics with multiple dimensions, authors initially have to determine the best way to structure and order the content. Similar to a physical workspace, the canvas of a ZUI allows to spread and compare the content while constantly maintaining an overview [Good, 2003].

The spatial format affords to work top-down which should lead to refined content structures.

The previous evaluation of Fly (see section 3.2.1—"User Studies") showed that authors find it easier to a lay out content on the planar canvas than onto slides and that they could express the structure of strongly connected content better. The users created meaningful canvas layouts in which they placed the content along multiple dimensions, independent of the presentation sequence [Lichtschlag et al., 2009]. The new feature of colored topic areas further enriches Fly's capabilities for expressive canvas structures.

6.1.2 More Content

Since the path stop viewports in Fly have no fixed resolution, authors do not need to revert to content cutting (see section 2.2.1—"Fixed Chunk Size"). Lichtschlag et al. [2009] showed that content cutting is a common practice in slideware and that in Fly less content was left out which resulted in more verbose documents. The virtually unlimited space on a Fly canvas not only allows to use more content, but also removes the need to edit the content to fit it into slide frames, e.g., to extensively abbreviate text.

The flexible viewport resolutions make content cutting unnecessary.

Additional material does not affect the quality of the visuals.

Authors can also comfortably add additional content that they may only need in case of questions or other indications that additional explanations are needed. It can be placed at the right conceptional position in the layout and is accessible by improvised navigation or more extensive path alternatives. Because of the different content states at presentation time, content that is not part of the foreseeable presentation path does not compromise the visualization on the public screen.

6.1.3 More Overviews

Overviews should be used to preview and to recapitulate.

Overviews are useful to give outlooks on the upcoming content and to recapitulate the presented content. The good practice to do so is summed up in the saying: "Tell them what you are going to tell them. Tell them. Tell them what you told them." Overviews help the audience to understand a presentation's structure and to maintain the orientation about a presentation's scope and progress.

In Fly, overviews are effortless to create and fit naturally into the presentation flow.

Overviews are intrinsic to ZUIs. It is always possible to zoom out to get more context. In Fly, it is, therefore, easy to add overviews into the scripted presentation paths and to spontaneously show an overview during presentation delivery. In contrast to slideware, where overview slides have to be manually created beforehand. The colored and labeled topic areas make the overviews more expressive. Consequently, authors incorporate overviews in Fly more often than in slideware, as shown by Lichtschlag's evaluation [Lichtschlag et al., 2009].

6.1.4 Better Content Partitioning

The resolution of slides does not correspond to the content chunk size.

The fixed chunk size of slides does not relate to the partitioning of presentation topics. Consequently, slides often contains the content for multiple aspects of the oral presentation. As a result, content is displayed that is not directly relevant to the current narration, which can distract and increase the cognitive load for the audience.

In Fly, on the other hand, authors can use different zoom levels to adapt the viewport resolution to the amount of the currently relevant content. For example, when discussing an illustration or graph, it is useful to zoom in on only this single visual element or even single parts of it. In the evaluation of the previous Fly version, nearly all authors used zooming in their presentation paths (see section 3.2.1—"User Studies"). Also all paths in the analyzed Prezi documents drew attention to single elements (see section 3.2.2—"Evaluation of Public Prezi Documents"). As a result of this better practice, less irrelevant material is show. This reduces the cognitive load on the viewer's visual channel and distracts less from the topic at hand.

Fly viewports can contain any amount of content, from overviews to single elements.

6.1.5 Better Content Integration

The layout freedom of Fly makes it easier to group corresponding elements together. For example, visual elements with the corresponding explanatory texts. In the slide format, authors must often place content where there is still space available on a slide. Fly does not have these format and resolution limitations. Consequently, the previous Fly evaluation showed that authors place text right next to pictures [Lichtschlag, 2008].

Content can be tighter integrated in Fly.

In correspondence with the gestalt law of proximity, elements are perceived as belonging together when they are spatially close to each other. Moreno and Mayer [2000] have shown that students learn better when on-screen text and visual materials are physically integrated rather than separated.

6.1.6 Less Text on the Screen

For the reasons described in the previous section 6.1.2—"More Content", authors can use more and less abbreviated text in Fly. But, as the Fly authoring evaluation (see section 3.2.1—"User Studies") and the Prezi document evaluation (see section 3.2.2—"Evaluation of Public Prezi Documents") showed, the amount of text on the individual de-

Viewports that focus on single aspects show less text on the screen at a time than slides.

tail viewports is less than on slides because of their lower resolution that puts the focus on single elements.

Much textual content distracts the audience.

Having less text displayed at a time has cognitive benefits, as on-screen text competes with the oral narration over the audience's verbal capacity. Too much text on the screen prevents audience members from following the spoken words [Mayer et al., 2001]. Verbal content is sequential in written and oral form. Since the human cognitive systems cannot process two sequential entries simultaneously, if the screen shows a lot of text, a viewer can only either read the on-screen text or listen to the speaker's words at a time [Doumont, 2005].

Relevant text reinforces the oral presentation.

Textual content on the screen works only well together with the oral narration if it is directly related to it. This creates good synchronic redundancy (see section 2.4.5—"Strategies for Reducing Cognitive Load"). In the Fly format, authors can focus the visuals on the currently relevant content.

6.1.7 Less Extraneous Material

In Fly, there is no fixed size that affords to be filled.

Fly does not support or at least does not encourage the use of the content elements that tend to clutter PowerPoint presentations, such as clip art, font formatting, meaningless animations, and solely decorative build effects. The flexible resolution of the Fly viewports should also lead to a lesser use of irrelevant decorative material since there is no fixed slide size that authors need to fill. Moreno and Mayer [2000] have shown that students learn better when extraneous material is excluded rather than included in multimedia instructions.

6.2 Benefits of Fly During Presentation Delivery

The Fly format has some inherent advantages for viewers that can facilitate knowledge transfer, especially of the content macrostructure, the concept relations and the main ideas. Fly's spatial format has cognitive benefits that can reduce the cognitive load for the audience and, therefore, reduce the risk of cognitive overload. More memory resources become available for active learning (see section 2.4.1—"Active Processing Assumption").

6.2.1 Utilization of Human Spatial Abilities

On a Fly canvas, the content macrostructure is incorporated into the spatial layout. Overviews and animated viewport transitions communicate the layout and thereby the content structure to the audience. Since the content relations are encoded implicitly, they must not necessarily be expressed verbally by means of text or speech, as in a slide-based presentation. This shifts load from the verbal to the visual cognitive channel and, as a result, can exercise a larger portion of the audience's memory resources [Good, 2003]. O'Donnell et al. [2002] have expressed this advantage for knowledge maps: "Implicit in the availability of a macrostructure is some inherent redundancy in the content that makes some of the microstructure less necessary." The audience automatically takes in the information encoded in the layout. Especially the meaningful animations can shift some of the viewer's cognitive load to the human perceptual system by exploiting the perceptual phenomenon of object constancy that enables viewers to track element relationships without thinking about it [Robertson et al., 1991]. Individuals can process this visual flow pre-consciously and build a mental map of the information [Bederson, 2010].

The macrostructural information that is encoded in the spatial layout is processed independently of the explicitly stated information.

Viewer's should be able to acquire at least landmark and route knowledge (see section 2.4.3—"Human Spatial Abilities") of the canvas. This especially benefits low verbal learners (see section 2.4.4—"Individual Cognitive Differences") [O'Donnell et al., 2002]. Because all the content is associated with spatial positions, it is also spatially encoded in addition to the verbal encoding. This dual-coding effect provides the viewers with additional retrieval paths that facilitate the retention of the presented information [Good, 2003].

Content on the canvas has an additional spatial encoding.

6.2.2 Better Orientation

The Fly visuals use different means to provide orientation about the current context.

The spatial overviews, the animated viewport transitions, the topic backgrounds and labels, the off-screen topic indicators, the content states, and the path visualization provide orientation to the audience. These features communicate the currently visible information's context and the presentation's progress. In contrast to slideware, where the presenter must explicitly communicate the content hierarchy and the content relationships. Fly makes it easier to stay oriented about the contentual context and the temporal progress.

The spatial layout provides orientation about the structure.

The visibility of the macrostructure will potentially allow the audience to better understand the high-level concepts of a presentation. To see the content in a spatial layout can be helpful especially for the structural understanding of complex concepts. When presentations start with zoomed out overviews and then drill into topics by zooming in, the audience can process the content top-down.

The viewports are related with animations; this prevents disorientation.

Fly relates the viewports of a presentation path with animated transitions. The stops are connected into a narrative flow that is easy to follow. After a completed transition animation, no time is needed for reassimilation [Robertson et al., 1991]. Successive stop viewports do not necessarily show completely new content, but can overlap each other. This drastically reduces the risk for disorientation at stop switches. In contrast to slide decks, where every slide contains completely new content and the slides instantaneously replace each other by default. Authors would need to put great effort into the authoring of slides to connect them with transition animations that are similar meaningful as those in a canvas-based format [Zongker and Salesin, 2003].

Even during improvisation, the layout's consistency is preserved.

The meaningful layout also does not "break" when the presenter shows additional content during an improvised navigation since the additional material is placed at the conceptually right spatial positions. The audience stays oriented [Good, 2003]. Even when the presenter jumps to a completely different section, the transition animation will communicate the corresponding semantic distance. In contrast to slide decks, where there is either no visual support for additionally explanations or presenters must jump to slides outside of the linear sequence and then find their way back to the point from which they left off (see section 2.2.1—“Inflexible Linearity”).

Fly’s orientation means help to reorientate.

Fly shows hints about the spatial and thus conceptual context of the currently visible content. These assist viewers for quick reorientation when they lost track of the presentation flow. In the case that the visible content belongs to a topic area, the background has the color that is associated with the topic. If viewers have seen an overview with the colored topic areas before, they should have associated the topics with spatial positions. The labeled and colored off-screen indicators point to the other topics on the canvas and thereby give viewers further indications about the current spatial position. Consequently, the viewers can integrate the current visual information into their mental map of the presentation content.

Features of the Fly visuals convey the presentation progress.

The different display of the content that has been presented and the upcoming content as well as the display of the presentation path give the audience an indication of the presentation’s progress. Also repeatedly shown overviews of large areas of the canvas can provide temporal orientation. The overviews will naturally indicate to the audience when a topic has been completed and remind them of topics that are yet to come [Good, 2003]. This progress indication is more detailed than slideware authors’ common practice of showing a slide counter on the bottom of the slides. The counter describes only the global presentation progress, whereas in Fly also the progress within subtopics is communicated.

6.2.3 More Diachronic Redundancy

Overviews repeat the content over time.

As described before, Fly makes it easy for authors to incorporate overviews into their presentations to introduce the upcoming content or to recapitulate the presented content. Apart from the aforementioned advantages for understanding and orientation, these overviews, together with the overviews that arise automatically by the zoom-out-movement during viewport transitions, add diachronic redundancy that reduces the cognitive load. In contrast to slideware, where users must author all content revisiting explicitly by reformulating and copying content.

6.2.4 Less Content Fragmentation

In Fly, all content is connected which makes it easier to remember.

All the content in Fly is part of the overall canvas. Since the views of the canvas are related to each other with animated transitions and since viewports can overlap, the boundaries between viewports are weaker than the boundaries between slides.

The presentation content is not fragmented into discrete chunks, but is always embedded into its context and part of the presentation path's narrative flow, which makes it easier to remember. According to cognitive psychology, people do not remember freestanding points very clearly. Instead they remember what is connected in a emotive, logical or narrative context [Kjeldsen, 2006].

6.2.5 More Attention Grabbing

The animations of Fly make the visuals more engaging.

The dynamic nature of the Fly format makes it easier for the audience to follow and for the presentation author to create a narrative. Mallon and Webb [2000] describe research that suggests that presentations with a narrative structure are better in sustaining attention. In addition, the animated transitions make the visuals fluid and cinematic and thereby visually attention grabbing [Bederson, 2010].

The individual canvas layouts make Fly visuals more interesting.

Because of the fact that Fly does not work with standardized document templates, but instead requires authors to create individual layouts, each Fly presentation will have different visual characteristics. In contrast to slideware, where usually one of the built-in templates is used with little modifications, which makes the presentations look alike. The human perceptual systems are geared toward detecting novel stimuli [Sprenger, 1999]. The new and unexpected gestalt of a Fly presentation should grab an audience's attention more than a slide deck based on a standardized template.

6.2.6 Greater Support for Adaptation

As described in section 2.1—"Presentations", depending on the scenario of a presentation, there can be many outside influences that require to adapt the presentation. A live audience reacts to the presentation with direct questions and interruptions or with signs of incomprehension, confusion, or boredom. Maybe the audience needs additional material and explanations or a more exhaustive or more compact topic coverage. There can also be environmental influences, such as changing time constraints.

Fly's features allow presenters to adapt the presentation flexibly.

With support for authored path alternatives and improvised navigation, a presenter can react to outside influences more flexibly and with less effort than with a linear slide deck. The spatial organization of the content makes it easier for presenters to locate specific content elements compared to slide decks [Robertson et al., 1998]. Especially when the presenter is also the document author, the presenter will have a great spatial awareness since the canvas layouts corresponds to the mental model.

Fly may even support more open presentation formats.

The Fly format may even permit to allow for more interruptions, for example, in a meeting-like scenario, where audience members could ask questions right when they come up. The spatial overviews and the visible presentation structure may help the audience to ask questions timelier [Good, 2003].

Chapter 7

Audience Study

As part of this thesis, Fly was evaluated with regard to audience reception. The research question was how presentation attendees perceive canvas-based presentation visuals, in particular, if Fly visuals can convey information better than slide-based visuals. The goal was to substantiate the argument for Fly as a better presentation support made in section 6—"Argument for Fly as Better Presentation Support".

How do audiences perceive Fly presentations? Can Fly convey information better?

The evaluation was performed as an experimental audience study against the baseline PowerPoint, as the most commonly used slideware application. As discussed in section 2.1.1—"Presentation Formats", there are different kinds of presentations with distinct purposes. Knowledge transfer, however, is most important for instructional presentations that aim for efficient and accurate communication of ideas. Therefore, instructional presentations were used for this evaluation.

A comparative, experimental study was performed. Informational presentations were shown.

The chapter is structured as follows:

Section 7.1—"Study Format" briefly introduces the format of the study.

Section 7.2—"Independent and Confounding Variables" describes the variables of the format, include the authoring process of the presentation documents.

Section 7.3—"Study Implementation" describes the implementation of the study in detail.

Section 7.4—"Hypotheses" lists the hypotheses.

Section 7.5—"Analysis" reports the analysis results.

Section 7.6—"Study Results" summarizes the findings.

Section 7.7—"Conclusion and Discussion" assesses the results.

7.1 Study Format

Two groups of students watched PowerPoint and Fly presentations.

The format of the experimental evaluation was a 2×2 test with a mixed within and between groups design. Instructional presentations were shown to two groups of university students. Each group attended two presentations on two different topics. One of the presentations was supported by PowerPoint slides and one had a Fly-based support.

The format sequence was counterbalanced. The topics were independent of each other.

The sequence of the PowerPoint and Fly formats was counterbalanced. The topic order, however, was not counterbalanced, instead, topics were chosen that were independent of each other (see section 7.2.4—"Presentation Topics"). Consequently, the knowledge transfer for the first topic should have had no influence on the learning outcome for the second topic. Both topics were presented in both conditions to cancel out topic-format dependencies. See table 7.1 for the presentation order for both groups.

	Group 1	Group 2
Presentation 1	Topic 1 with Fly	Topic 1 with PowerPoint
Presentation 2	Topic 2 with PowerPoint	Topic 2 with Fly

Table 7.1: Order of Presentations in the Audience Study

The participants were tested for retention and understanding and

After the presentations, the students were tested for the recall of content facts and content macrostructure (e.g., main ideas and concepts). The content understanding was tested with problem-solving transfer tests. Furthermore, the participants were asked about their attitude towards and satisfaction with the presentations and asked which format of visuals they preferred. See section 7.3.4—"Post-presentations Questionnaire" for details.

were asked about their attitude and satisfaction.

To test if there are differences between short- and long-term learning, the students were tested once more for content retention and understanding four days after the presentations (see section 7.3.5—"Follow-up-questionnaire").

A follow-up-questionnaire tested long-term learning.

7.2 Independent and Confounding Variables

Conducting a comparative evaluation of knowledge transfer by presentations is not easy as there a several independent and confounding variables that can influence the learning outcome. These factors, how they were controlled, and the resulting consequences for this evaluation are discussed below.

Independent and confounding variables had to be controlled.

7.2.1 Human Factors

Because presentations are an act of communication between presenter and audience, the human aspects on both sides play an important role. In addition to the presenter's general influence on the quality of a talk, as discussed in section 2.1.2—"Role of the Presenter", the speaker's interaction with the audience makes it difficult to achieve a controlled and comparable test setup. It is an essential part of presentation delivery to interact with the audience, e.g., by means of eye contact, facial expressions, and gestures, and to react to the audience's signals, interruptions, and questions. Consequently, two presentations will, despite of equal content, unlikely be of equal quality.

A speaker's performance and communication with the audience influence the presentation quality.

The audience, on the other hand, will have different attitudes towards different presenters and a varying form of day at distinct presentation sessions. Different audiences

An audience's attitude varies.

will interact differently with a speaker—creating differing momentums that lead to varying presentation experiences.

Recorded presentations instead of live presentations were used.

To neutralize the human factors as a confounding variable and to gain more control over the test environment, presentation recordings were used instead of live face-to-face presentations. The video recordings showed the presentation visuals together with a spoken commentary. The presenter was not shown to reduce the speaker's influence, in particular, the compensating effect (see section 2.1.2—"Role of the Presenter").

The recorded setup allowed for a better control of independent variables.

By using recordings that could be prepared beforehand, multiple independent variables could be controlled better than in live presentations. Topic coverage, commentary content and quality, and presentation duration could be kept similar between conditions.

Admittedly, it cannot be ruled out that the audience might have had a different attitude compared to face-to-face presentations. But the use of recordings should not have introduced any significant influence on learning since several studies (summarized in [Ellis and Mathis, 1985]) have shown equal learning achievements between live and recorded lectures.

Obviously, because of the recorded setup this study produced no data about the experience of presentation delivery with Fly. It could not been evaluated how Fly supports the speaker in reacting to the audience and adapting the presentation. This needs to be the subject of a future evaluation (see section 8.2—"Future Work").

7.2.2 Language Skills

The study was executed in German with German native speakers.

To avoid varying language skills as a confounding variable for comprehension and, consequently, learning, the presentations and questionnaires were carried out in German since the participants' first language was German. This assured that all participants could comprehend all the content without problems. While the students might have been used to attending English lectures, it could not be assumed that their English language skills were comparable.

7.2.3 Prior Knowledge

High prior knowledge can falsify the test of retention and understanding.

Prior knowledge has a falsifying effect for this evaluation, in particular, because the potential advantages of Fly rely heavily on the dual-coding effect, which is most effective for low-experience learners [O'Donnell et al., 2002]. In case of existing relevant prior knowledge, there is already a mental model in which the new information can be integrated. Learners can retrieve appropriate familiar knowledge from long-term memory as they receive new information, and thus, they can build connections between the retrieved information and the new information. On the other hand, when there is no prior knowledge in long-term memory, receiving information multimodally becomes more important since then the different representations allow for the creation of a strong new mental model [Mayer and Sims, 1994].

To eliminate high prior knowledge as a confounding variable, the participants were asked to rate their existing knowledge on the presentation topics in a questionnaire before the presentation. The records of students with a high prior knowledge were excluded from the data analysis. See section 7.3.2—"Self-reporting/-assessment" for the details of the self-assessment and section 7.5.1—"Excluded Data" for the data exclusion.

7.2.4 Presentation Visuals

The visuals of both conditions had to contain the same content.

An important independent variable for the evaluation was the authoring of the presentation documents. Since presentation visuals for each of the two topics were needed in both formats, the challenge was to ensure that the documents on the same topic contained the same content. Because of the fundamental different formats of Fly and PowerPoint there was no exact way to match document content. Only the format differences and not preconceptions or personal authoring styles should be the reason for potential differences between the documents on the same topic with regard to content, layout, and structure.

The visuals should be typical for their format.

Furthermore, the documents should be typical for their formats. To achieve this, they should be authored along the affordances of the corresponding applications. The difficulty was to find a way of authoring that was not biased by prepossession.

Only static texts and images were used.

In the documents, only static texts and pictures were used. Videos and animated builds were excluded because the differences in the implementation of these content types are only relevant for authoring and presenting. For the audience there is no difference in how the content of videos and animated builds looks on the screen. Therefore, these content types were not directly relevant for the format comparison.

Authoring Strategies

The strategy to author along derived guidelines was dismissed.

Two strategies for authoring the presentation documents were considered. The first strategy was to define authoring guidelines that would allow to create the documents along the systems' affordances and the common practices that were revealed by the previous evaluations of presentation authoring. For example, the guidelines could specify that the documents of both formats need to have the same temporal structure or that there must be the same number of overviews. These policies could be derived from the evaluation of the previous Fly version (see section 3.2.1—"User Studies") and from the evaluation of public Prezi documents (see section 3.2.2—"Evaluation of Public Prezi Documents"). To ensure that no deliberately bad PowerPoint documents were created, an experienced external PowerPoint user could review the slide decks afterwards. As it would have been difficult to develop guidelines that could have guided in all aspects of the authoring processes, another strategy was chosen.

An external author created the visuals with assistance.

An external, uninvolved author created all four documents, assisted in a peer authoring mode. In this strategy, the risk for potential bias was lower and, furthermore, observing the author gave valuable qualitative information about the authoring experience. The document authoring was performed together with the author in an open discussion format in which the author was encouraged to talk aloud about his reasonings and decisions. The external author always made the final decisions about how things should be done.

The participating author was a 31 year old male senior software developer for mobile web applications who is not associated with the university. He is used to give PowerPoint presentations at work and considers himself familiar with PowerPoint. He did not know Fly or any of the related systems before.

The author did not know Fly before.

Prior to the authoring sessions, the author was briefed about the audience study. He was told that an alternative format of presentation visuals was going to be evaluated. For this evaluation, presentations on two different topics had to be created. For each topic two documents were needed, one PowerPoint slide deck and one document of the new format. The documents of the different formats should cover the same content and have approximately the same length. The author was told that first the two slide decks were going to be created, then there was going to be an introduction to Fly, and concluding the Fly documents were going to be created.

First, the slide decks were created, second, Fly was introduced, and last, the Fly visuals were created.

The authoring process was divided into three sessions: in the first session it was decided upon and researched about the two presentation topics, in the second session the PowerPoint documents were created, and in the third session the Fly documents were authored.

Presentation Topics

The topics for the two presentations had to fulfill a number of criteria. The topics had to be of sufficient scope and complexity to make the visual support relevant for the audience's understanding. The easier a topic is, the less an audience needs a good visual support for learning. To be able to compare data not only between groups, but also within

The topics needed to be of comparable scope and complexity and be independent of each other.

groups, the complexity and scope of the two topics had to be comparable. Because of the study format in which the topic order was not counterbalanced, the topics also needed to be independent of each other. Furthermore, the topics had to be unfamiliar to the audience to avoid high prior knowledge (see section 7.2.3—"Prior Knowledge"). And finally, if possible, the author should already be familiar with the topics to reduce the necessary research effort.

The first chosen topic was *single speed and fixed gear bicycles*. The author introduced this topic since he rides these kinds of bikes as a hobby. The topic was considered suitable since probably not many audience members are familiar with it and because it is possible to achieve the required complexity by going into the details of bicycle technology.

The second chosen topic was *convergent evolution between placentals and marsupials*. The topic was researched together with the external author. It was considered interesting, likely unfamiliar to the audience, and independent of the first topic. Furthermore, it had the necessary depth for creating presentations that could match the first topic's scope and complexity.

After the topics had been determined, the content for both was researched together with the author. The content was collected in two outline documents and illustrating images were assembled.

PowerPoint Authoring

The slide deck structures were drafted outside of PowerPoint.

In the next session, the slide decks on both topics were created. Before the author started to use PowerPoint, he drafted the structures of both presentations within the outline documents that had been used for the content collection. This practice confirmed the limited drafting support of slideware (see section 2.2.1—"Limited Drafting Support").

Because Fly is a Mac OS X application, we used the, at the time of the evaluation, current Mac version of PowerPoint.[1] And since the documents should be typical of their format, the basic standard template of PowerPoint was used.

To fit the content onto the slides was challenging.

During the authoring process, the problems that are rooted in slideware's fixed chunk size problem (see section 2.2.1—"Fixed Chunk Size") occurred constantly. For almost every section, it was challenging to fit the content onto the slides. All the aforementioned techniques, content cutting, content squeezing, and content overflow, were used. Especially the texts had to be abbreviated multiple times and incorporating the images was challenging.

Various strategies were used to integrate the images.

Images had to be excluded because there was not enough space and those that were used, had to be scaled, cropped, rotated, and overlapped. For examples, see the slides in the figures 7.1 and 7.2.

Figure 7.1: Slide With Squeezed Images

It was not easy to place the images next to the texts that they should illustrate. For that, the author most often used two column layouts in which one column contained the texts and the other column showed the images. For examples,

[1]http://www.microsoft.com/mac/products/powerpoint2008/default.mspx

Figure 7.2: Slides With Image Columns

see the slides in the figures 7.2 and 7.3.

Sometimes it was not possible at all to integrate the images with the texts. In these cases, the author created dedicated picture slides that illustrated the content of the preceding slides. Figure 7.4 shows two examples.

Fly Authoring

Initially, top-down authoring strategies were used.

After the author had been introduced to the concept of Fly and had tested the software prototype, the Fly canvases were created. The author approached the Fly authoring task with a top-down strategy, similar to the participants of the previous user study (see section 3.2.1—"User Studies").

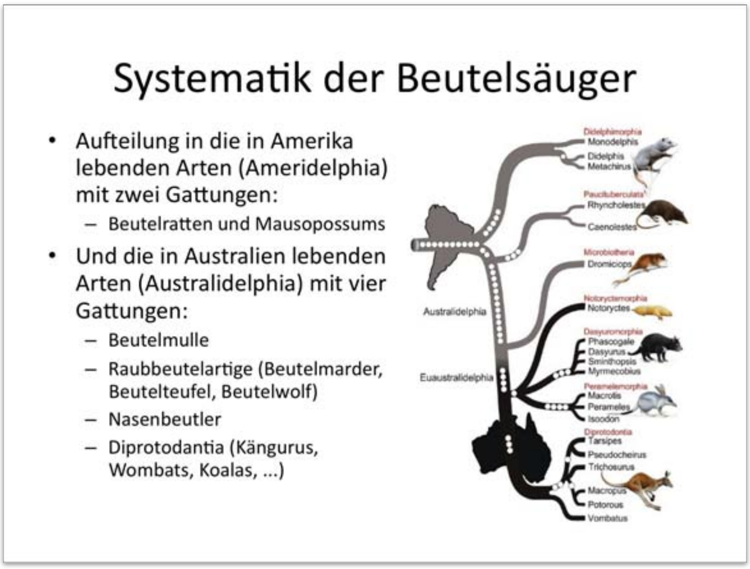

Figure 7.3: Slide on the Systematics of Marsupials

Figure 7.4: Slides Illustrated by Dedicated Picture Slides (Left: Preceding Text Slides, Right: Consecutive Picture Slides)

Figure 7.5: Fixies Fly Canvas (Sections Are Numbered Chronologically; Arrows Show the Layout Direction Within Sections)

Figure 7.6: Convergent Evolution Fly Canvas (Sections Are Numbered Chronologically; Arrows Show the Layout Direction Within Sections)

The canvas layouts were oriented from left to right. The individual sections were organized from top to bottom.

First, semantic topics were created in the topic list view for the content sections that were known from the PowerPoint documents. Distinct colors were assigned to the topics. In the Fixies presentation, the author assigned the same color to all technical sections to express their coherence. After that, the content elements were imported, roughly arranged on the canvas, and associated with the corresponding topics. After the author had defined the overall canvas layouts, he created the inner layouts of the content sections. In the process, it was natural to arrange the sections horizontally from left to right in order of their appearance in the presentations and to structure the individual sections vertically from top to bottom. See figures 7.5 and 7.6 for the canvas layouts of both topics. These arrangements correspond to the reading directions of western culture.

The content sequences used in PowerPoint were questioned.

During the refinement of the individual sections, the overall layout was continuously adjusted. In addition, the author made bigger changes to the presentation sequences whenever he noticed that the topic sequences were not optimal. To work with the canvas format led to additional reasoning about which topics belong together. Seeing the whole content on the canvas instead of always looking at single slides helped to see the big picture and to gain a clearer idea of the content's structure. This effect is known from tools like mind maps. The problems of the unstructured linearity (see section 2.2.1—"Unstructured Linearity") and the limited drafting support (see section 2.2.1—"Limited Drafting Support") are the reasons for PowerPoint's deficiencies in this regard.

Spatial organization required to think about the relations of topic sections.

For example, in the technical part of the presentations about fixies, the subtopics were not arranged in any particular order in the slide deck. When the question occurred how the sections should be arranged on the canvas, this state became obvious. It was decided that, for one thing, it makes sense to sort all technical subtopics according to their positions on a bicycle and, for another, to group the subtopics together that belong to drive technology.

The presentation paths traversed the sections in small steps.

After the content was organized, the presentation paths were created. Since the overall presentation sequence was already determined during the canvas authoring, the remaining decisions that had to be made during the path authoring were where to place the individual path stops within the sections. While the path was authored, the canvas layout was constantly refined to make sure that only the desired content was visible in the stops' viewports. The author created many more path stops than there were slides in the PowerPoint documents. The reason was to focus on single aspects.

Content was incrementally revealed.

With smaller steps, content could be revealed incrementally. This technique was also used for larger graphics, for example for the illustration about the inner systematics of marsupials in the convergent evolution presentation (see figure 7.7 for the Fly viewports). The created presentation paths confirmed the argument made in the sections 6.1.4—"Better Content Partitioning" and 6.1.6—"Less Text on the Screen".

After all four presentation documents were finished, the external author was satisfied with all of them, with the slide decks as well as with the Fly canvases. He regarded the slide decks as of good quality but felt that the Fly visuals

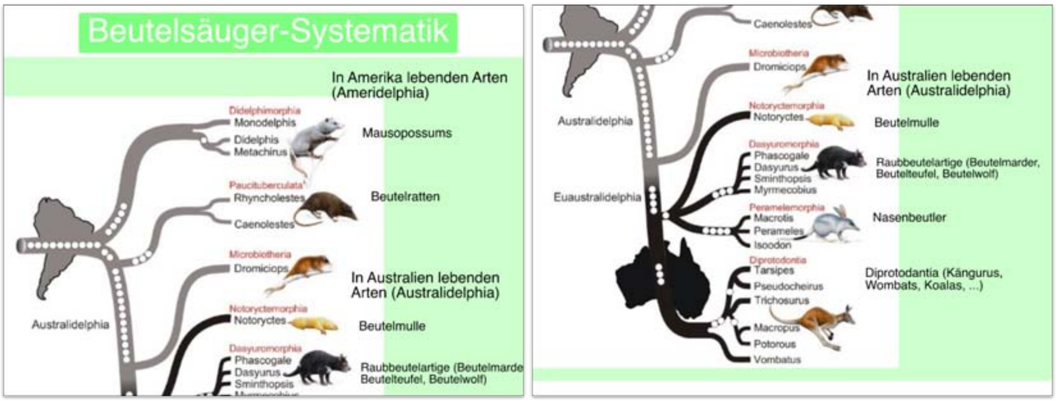

Figure 7.7: Viewports on the Systematics of Marsupials

will provide a better and more engaging visual support because of their unique layouts. The enclosed CD-ROM contains the final slide decks and Fly documents (see section C—"CD-ROM Contents").

Authoring Observations

During the creation of the Fly documents the following observations about the differences between authoring in Fly and authoring in PowerPoint were made.

The missing space constraints allowed for easier text authoring in Fly.

Texts had to be less abbreviated in Fly because the available space was not limited. This made the creation of text elements easier. Also, all topic aspects could be included in the texts. There was no content cutting. In PowerPoint, on the other hand, minor points were excluded from the slide texts because of limited space. Consequently, these points were only mentioned in the spoken commentary.

More images were used in Fly.

The author could use more pictures in the Fly presentations and the pictures also had to be less modified. Because of the missing space restrictions, also minor aspects could be illustrated. For example, in the presentations about convergent evolution, the development of fins and wings in different species was mentioned as an example for convergent evolution. On the corresponding slide, this example was not illustrated, whereas, in Fly, an illustrative graphic was shown. To add the graphic to the PowerPoint document

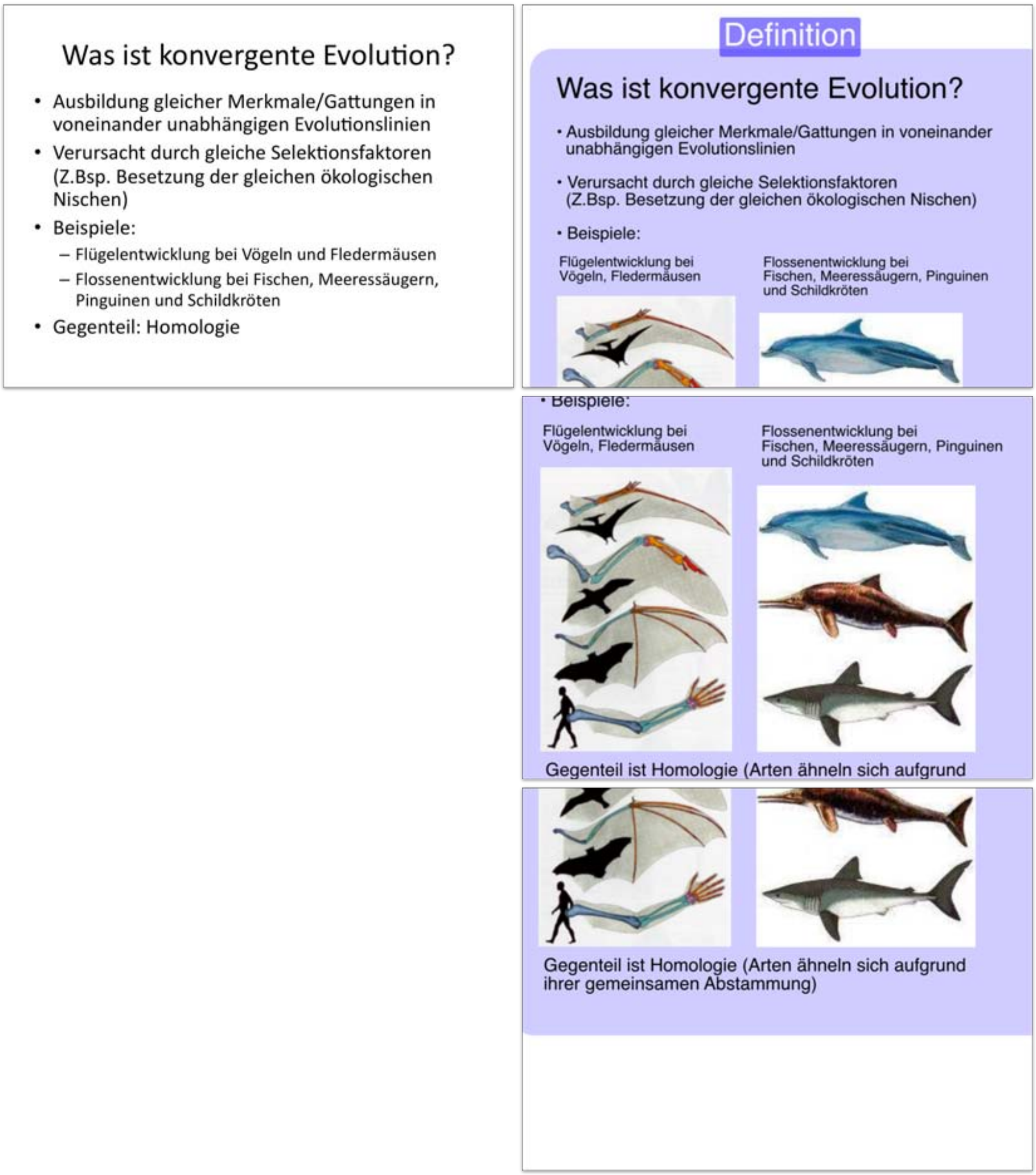

Figure 7.8: Slide and Viewports on the Definition of Convergent Evolution

would have required an additional slide, which the presentation author regarded as disproportional. See figure 7.8 for the PowerPoint slide and the Fly viewports.

The fact that the texts were more verbose and more images were used in the Fly documents, confirms the argument of section 6.1.2—“More Content”.

Texts and images could be tighter integrated in Fly.

In Fly, texts could always be placed next to the corresponding images. In fact, the author perceived the mode of practice different from PowerPoint. In PowerPoint, he had to placed pictures next to the corresponding texts. In Fly, on the other hand, he placed the texts next to the pictures, thereby annotating them. For example, in the illustration of the marsupial systematics, in the Fly document, the texts could be placed right next to the parts of the illustration that they described. See figure 7.7 for the Fly viewports and figure 7.3 for the corresponding PowerPoint slide. This observation confirms the argument made in section 6.1.5—"Better Content Integration".

Many overviews for preview and recapitulation were created.

The author created more overviews in Fly than in PowerPoint since it was effortless to do so and because it felt natural. Overviews were not only used to preview the upcoming content, but also to recapitulate the content that has been presented. This did not feel artificial, as it did in PowerPoint, and also did not interrupt the presentation flow. It felt natural to zoom out again within the presentation path after a topic had been covered. This confirmed the argument made in section 6.1.3—"More Overviews".

Some sections were structured differently in Fly than in PowerPoint because the format allowed for unique layouts that were not possible with slides. These designs are described in section 7.2.4—"Document Comparison".

Design Transfers

Improvements from Fly were transferred to the slide decks.

After the Fly documents had been created, the presentation author returned to the slide decks to make changes. He was explicitly allowed to do so.

The improved section sequences were adopted.

First, the changes to the presentation sequences, mentioned in section 7.2.4—"Fly Authoring", were adopted for the PowerPoint presentations. For example, the organization of the development history section in the convergent evolution presentations. In the first slide deck version, it was organized by continents. During the Fly authoring the structure was changed to a geologic era organization, which made more sense.

Second, the additional images that were used in the corresponding Fly canvases were added to the slide decks to make the content of the two formats more comparable. Originally, the author considered the amount of illustration in the slide decks as sufficient. But after the Fly documents had been created, he noticed that the presentations benefit from more illustrative images. He invested additional effort to incorporate more pictures into the slide decks. However, in the end the Fly documents still contained more pictures than the PowerPoint documents, corresponding to the argument in section 6.1.2—"More Content".

Additional images were added to the slides to balance out the formats.

Last, more overview slides were added to the slide decks to make the use of overviews more comparable between the formats. Originally, the decks had just one overall overview at the beginning. After the Fly documents with more overviews had been created, the presentation author added intermediate structure slides and a recapitulating overview slide at the end.

Also, the overview use was adapted.

Document Comparison

Naturally, the overviews in Fly are of a spatial nature and the overviews in PowerPoint of a textual nature. See figure 7.9 for a side-by-side comparison. The Fly visuals contained additional overviews that previewed and recapitulated single topics.

For some sections, the Fly visuals contained unique layouts. These layouts were only possible because of Fly's canvas-based format and could not be adapted to PowerPoint. For example, for the introductory section of the fixies presentation, a big bicycle background graphic was used on which the explanations of the basic concepts of bicycle technology were placed. The PowerPoint version contained a standard slide with a bulleted list. See figure 7.10 for the PowerPoint slide and the Fly layout that was traversed with several path stops. Another example from the fixies presentations is the layout of the advantages and drawbacks section. In Fly, the author could place the advantages and disadvantages opposed of each other, while in PowerPoint, he had to place them onto two sepa-

The canvas format allowed for unique large-scale layouts.

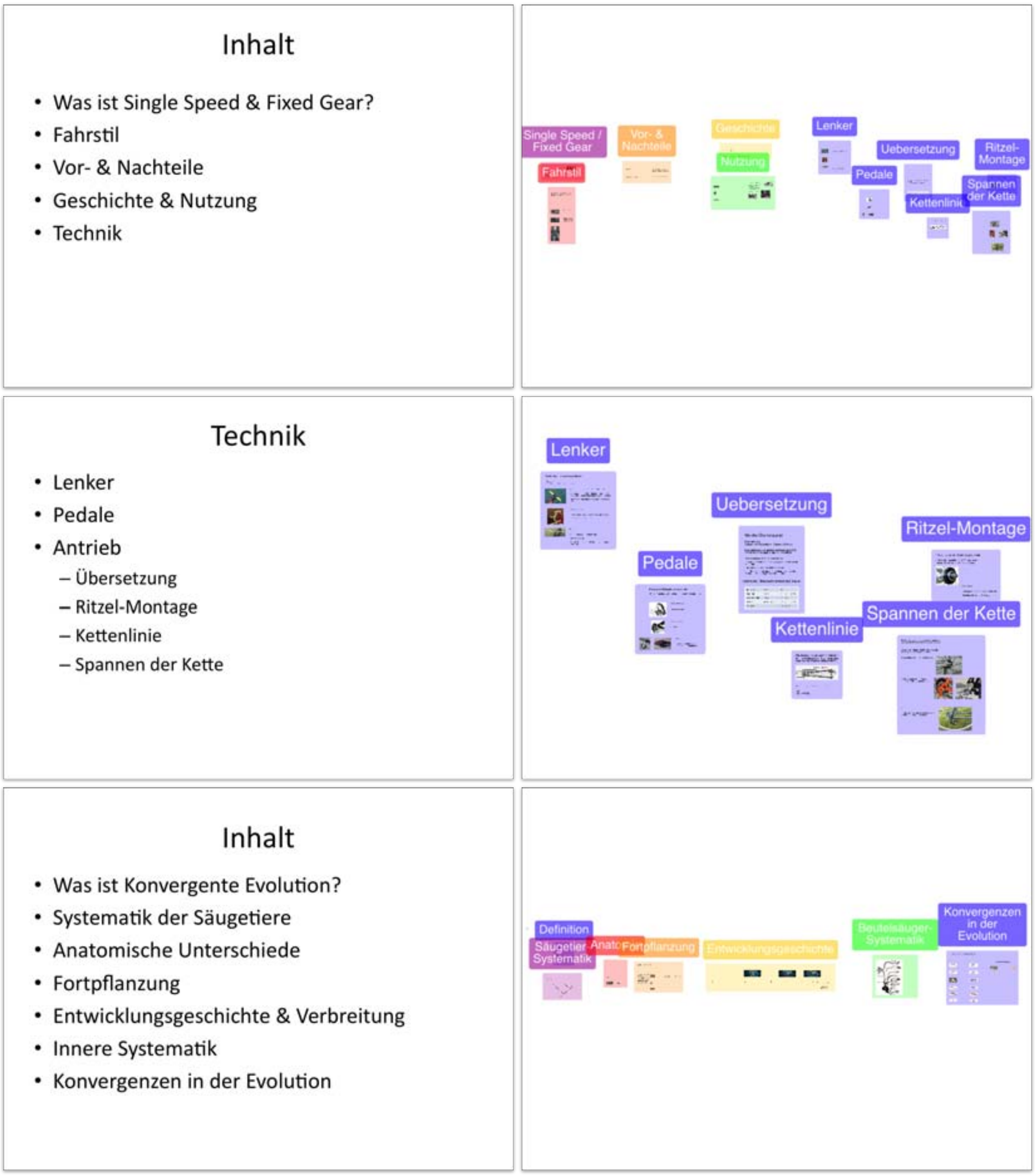

Figure 7.9: Overviews in PowerPoint and Fly (Top: Fixies Overall, Middle: Fixies Technologies, Bottom: Convergent Evolution Overall)

rate slides. See figure 7.11 for the slides and the Fly layout that was covered by multiple path stops. The section about the use of fixies in sports and on the street had a similar opposing design. In Fly, these two fields of use were arranged side-by-side, whereas, in PowerPoint, two successive slides were used, which did not convey the oppositional relation-

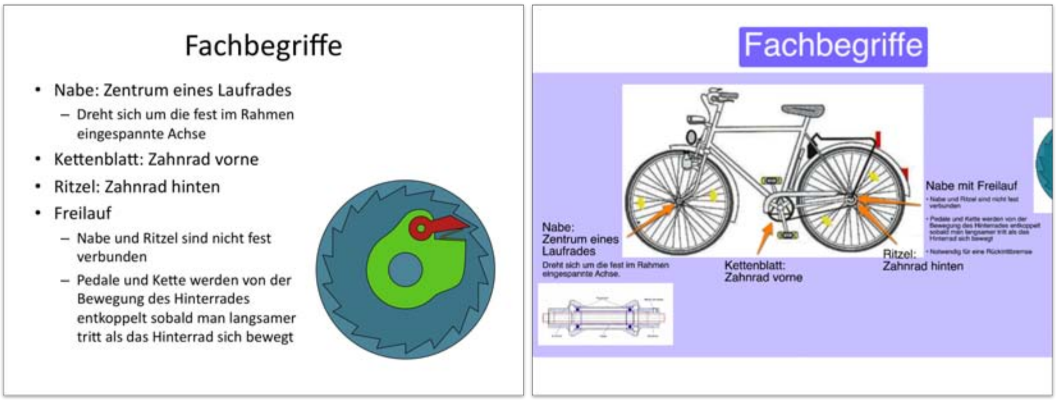

Figure 7.10: Slide and Fly Layout on the Basic Concepts of Bicycle Technology

ship. See figure 7.11 for the two slides and the Fly layout that was traversed with several path stops. Slideware's unstructured linearity (see section 2.2.1—"Unstructured Linearity") is the main reason for its unsuitability to represented more complex macrostructures.

Horizontal timeline layouts were used for historical content.

The biggest layout difference between the formats was in the convergent evolution presentations, where in the Fly version the topics history of development and present-day distribution could be integrated into a big timeline layout with illustrations of the marsupial distribution in the different geologic eras. In PowerPoint, on the other hand, the development history was covered with a series of text-based slides that showed one era per slide. The present-day distribution that results from the development history was shown on an extra slide after the last era. See figure 7.12 for the slides and the viewports. In Fly, the section was previewed and recapitulated with the overview shown in figure 7.13. The horizontal left-to-right timeline layout was also used in the history section of the fixies presentations. See figure 7.14 for the Fly layout (that was covered by three viewports) and the corresponding PowerPoint slide, which lists the dates from top to bottom.

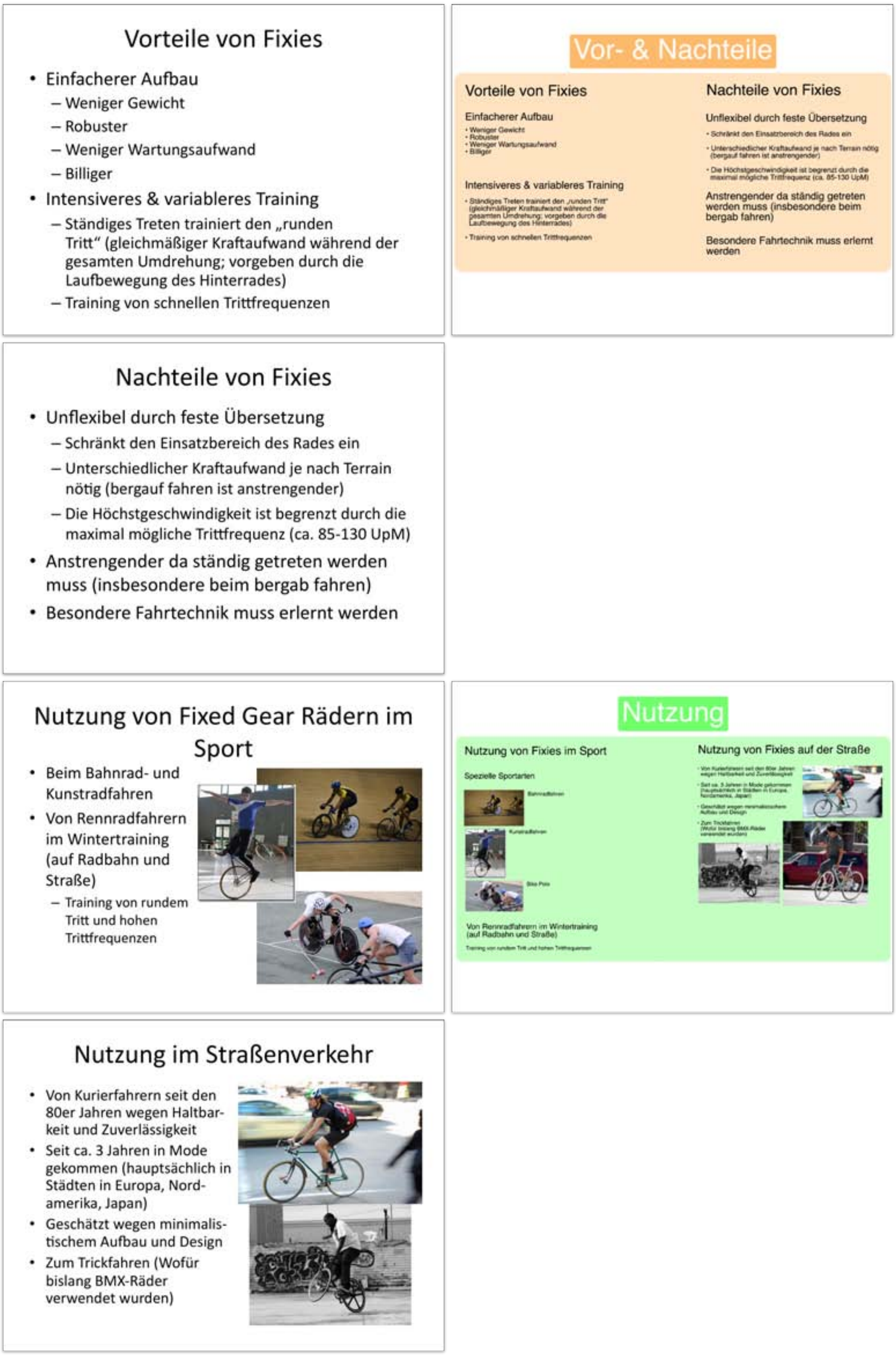

Figure 7.11: Slides and Fly Layouts on Opposed Content (Top: Advantages and Drawbacks of Fixies, Bottom: Use of Fixies in Sports and on the Street)

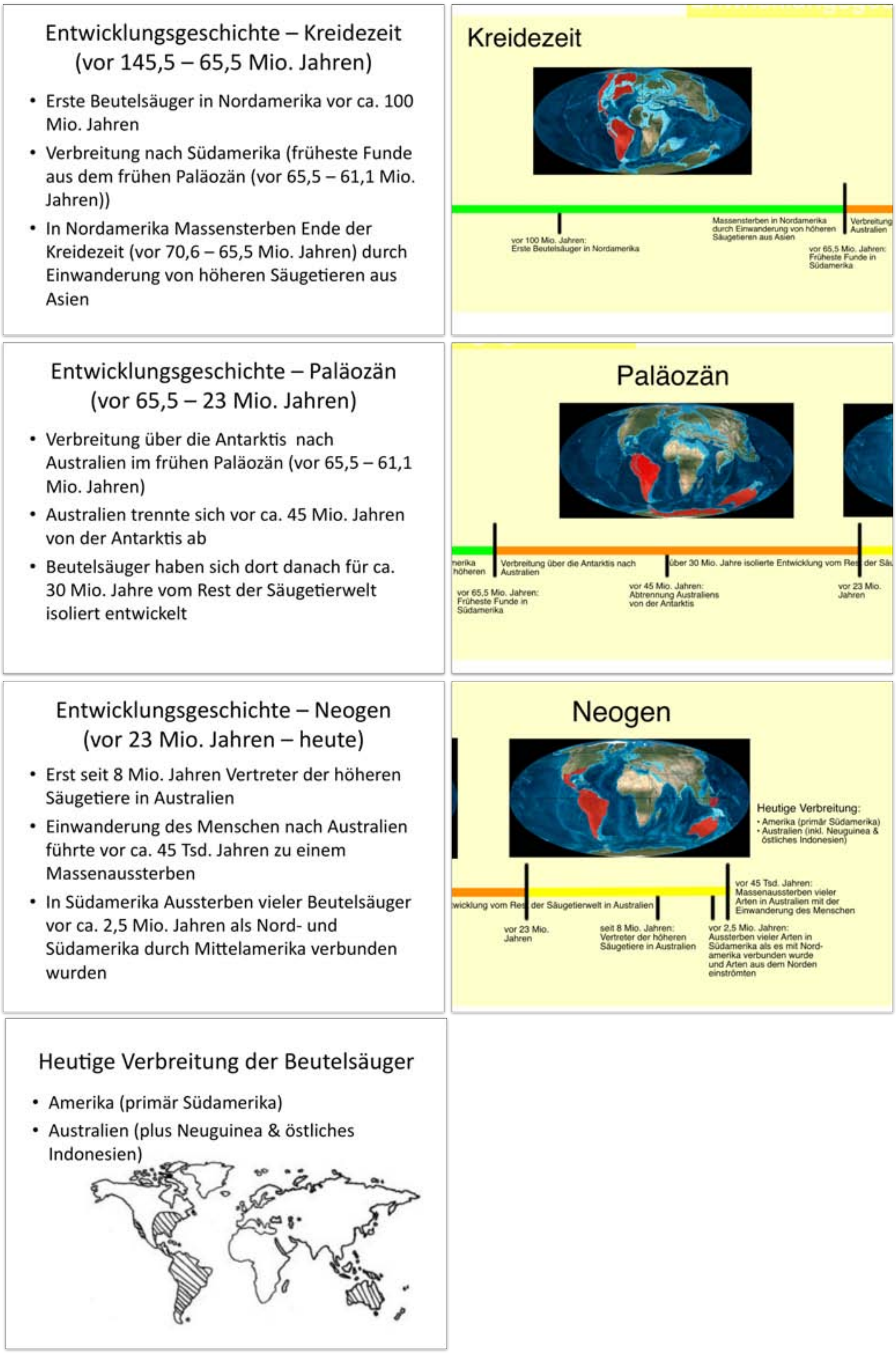

Figure 7.12: Slides and Viewports on the Development History of Marsupials (Presentation Sequence from Top to Bottom)

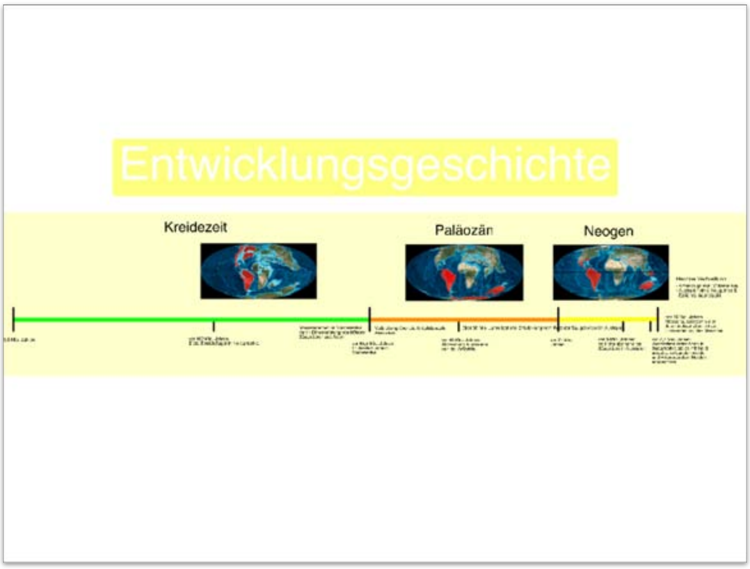

Figure 7.13: Overview of the Marsupial Development History Section in Fly

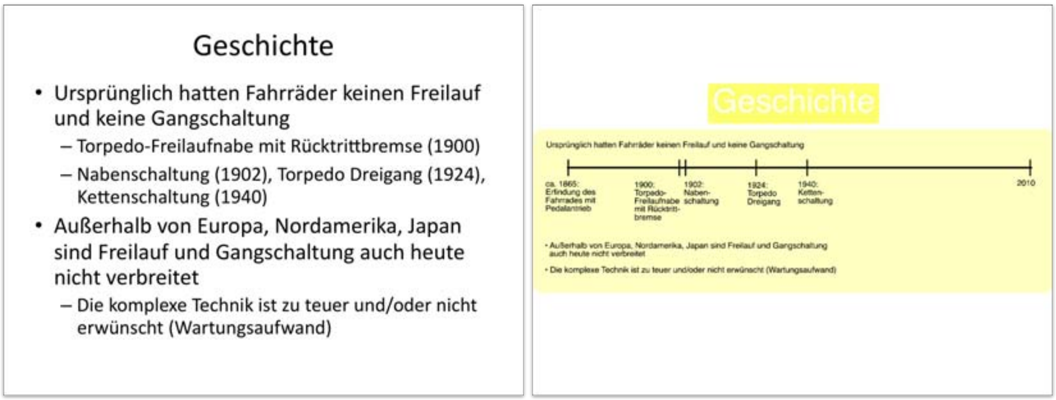

Figure 7.14: Slide and Fly Layout on the History of Fixies

7.2.5 Presentation Commentary

The commentary should be as similar as possible between the conditions.

Another independent variable for the study was the spoken commentary for the presentations. To neutralize the variable, the commentary for the presentations of different formats on the same topic needed to be as similar as possible.

In consultation with the author of the presentation visuals, commentary texts were written that could be used for both formats, assuring that the narration of both formats had the same content. The language of the texts was kept simple and colloquial as it would be in a face-to-face presentation.

To avoid differences in pronunciation, emphasis, and elaborateness, the commentaries were not recorded separately for the two formats, but instead the texts were split into segments that could be mapped to the visuals of both formats. The enclosed CD-ROM contains transcripts of the original German commentary texts (see section C—"CD-ROM Contents").

The commentary was recorded in samples that could be used for both formats.

Because of the study's recorded setup without a visible presenter, it was important to have an engaging commentary. For that reason, a professional broadcast speaker spoke the commentary samples and professional studio equipment was used to record them.

After the samples had been recorded, they were mapped to the visuals. The samples had the same chronological order in both formats, only the timing differed slightly.

7.2.6 Novelty Effect

The fact that the Fly format was novel and unfamiliar to the test audience made the Fly presentations more interesting and attention grabbing then "yet another" slide-based presentation. But, as discussed in section 6.2.5—"More Attention Grabbing", we believe that, independent of format familiarity, greater interestingness is one of the advantages of Fly. The novelty effect on attention [Sprenger, 1999] may, therefore, not be as biasing for Fly.

The participants were not familiar with the Fly format.

7.2.7 Awareness of Test Procedure

The participating students were aware that they attended a test. This might have influenced their attitudes, but as this was true for all four presentations this was not a variable for the format comparison.

Knowledge of the question format could have changed the attention.

However, detailed knowledge about the questionnaire following a presentation could have impacted the attention and, therefore, the audience's learning achievements. If the students had been questioned directly after each presentation, they would have paid more attention to the second presentation as they would have known what kind of questions they could expect subsequently.

The students were tested about both topics after the second presentation.

Therefore, the students were tested about both presentations after the second presentation. To attenuate the effect of the different time intervals after the presentations, the students first answered questions about the first presentation and then questions about the second. In fact, the data analysis showed no significant better performance for the questions on the second presentations (see section 7.5.4—"Post-presentations Questionnaire").

7.3 Study Implementation

7.3.1 Course of the Study

The study participants were students of a basic HCI course.

The study was performed within the scope of the weekly lab sessions of the basic HCI (Human-Computer Interaction) course[2] offered by the Media Computing Group. Most of the participants were students enrolled in this course. Some additional participants joined the lab sessions to take part in the study. There were 26 participants in total.

Participation was voluntary and anonymous.

The study was designed in a way that assured anonymous participation. The records of the different questionnaires were linked with randomly assigned participant IDs. There was no connection between names and IDs and, therefore, no association between the data sets and the subjects. This study design was especially important because of the use of a cognition test. Of course, participation in the study was entirely voluntary.

[2] http://hci.rwth-aachen.de/dis

At a first lab session, two weeks before the presentations, the participants were briefed about the study procedure, asked to sign a consent form, pick their IDs, fill out a short self-reporting and self-assessment questionnaire, and perform a brief experimental cognition test. These tasks were performed in a preceding session to reduce the actual study session's duration and, consequently, to avoid fatigue. The fact that the students were briefed about the whole study procedure and, therefore, knew that they will be tested about the presentations' content should not have weighted the results, as knowing to be tested about a presentation is nothing unfamiliar to university students. If anything, this should have raised students' attention.

Pre-presentation tasks were dealt with in a preceding lab session.

At the second session, the participants were divided into two groups of 13 students each. Each group watched two presentation recordings, with an approximate length of 15 minutes each, successively with a short break in between. Afterwards a questionnaire about both presentations was handed to the participants. The questionnaire's first part asked about the first presentation and the second part about the second presentation. The students had to complete the questionnaire sequentially. Afterwards, the participants were debriefed and were thanked for their participation. They were told that they will receive a follow-up-questionnaire in a couple of days and were asked not to learn about the presented topics in the meantime.

The groups watched the presentations at the same time. Afterwards, they answered a questionnaire.

After four days, the participants received an email with a link to the final follow-up-questionnaire about both presentations. They were asked to answer it within 24 hours.

The follow-up-questionnaire was sent out after four days.

7.3.2 Pre-presentations Questionnaire

The brief pre-presentations questionnaire, handed to the participants at the first lab session, consisted of two pages of self-reporting and self-assessment questions and a brief timed trial test of spatial cognitive ability.

Self-reporting/-assessment

Basic demographic data was collected.

The self-reporting part of the pre-questionnaire asked for basic demographic information, such as year of birth, gender, course of studies, and number of semesters studied. Based on the collected data the participants could be divided into two groups with comparable demographics in the second session (see section 7.5.2—"Demographic Information").

The participants were asked to rate their interest and prior knowledge.

The self-assessment part consisted of Likert scale questions that asked the participants to rate their interest in and prior knowledge about the two topics. Moreover, non-native speakers were asked to rate their German language skills. An alternative approach to identify individuals with a high prior knowledge would have been to ask the participants after the presentations how much of the content they already knew. The pre-presentations approach was chosen because the students might not have given honest answers after the presentations. On the other hand, the pre-questionnaire questions may not have described the content exactly and, therefore, it might not been exactly clear to the students what knowledge to rate.

A final multiple-choice question asked the students for their preferred form of visual presentation support. See section A.1—"Pre-presentations Questionnaire" for the complete self-reporting/-assessment questionnaire.

Spatial Cognitive Ability

A spatial cognition test was performed to identify learner types.

The spatial cognitive abilities of the participants were tested, because individual cognitive differences can influence learning achievements [Moreno and Plass, 2006] and to be able to differentiate between primarily verbal and visual learners (see section 2.4.4—"Individual Cognitive Differences"). The different formats of presentation visuals can affect the learner types differently, as suspected in Good's [2003] evaluation discussion. Since learner types can be differentiated on the basis of spatial ability alone [Mayer and Massa, 2003], testing only the spatial ability

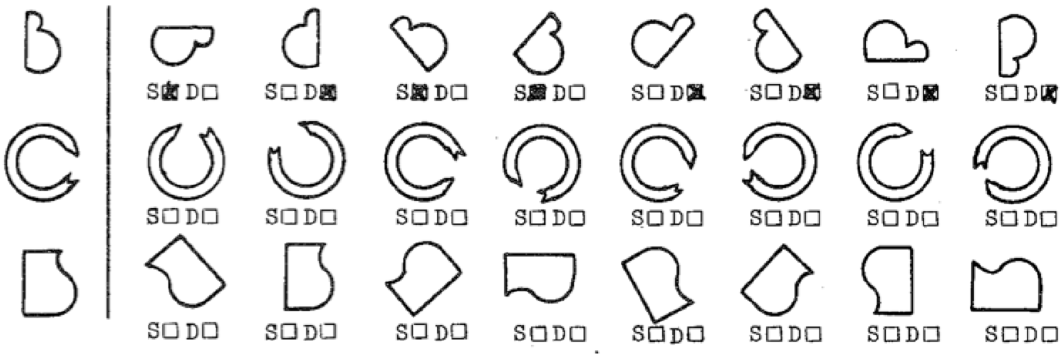

Figure 7.15: Card Rotations Example Tasks (From ETS manual for kit of factor-referenced cognitive tests. Courtesy of ETS.)

was sufficient. Visual/verbal learning preference was not measured since there is no detectable direct influence on learning performance [Moreno and Plass, 2006].

The *Card Rotations* test from the ETS kit of factor-referenced cognitive tests [Ekstrom et al., 1979] was used. In this test, the subjects must decide if two shapes are the *same* or *different*. In the case that the shapes would match if one were rotated, then the correct answer is same. However, if one of the shapes must be flipped, then the correct answer is different. See figure 7.15 for three example tasks. The test consisted of two pages with 10 tasks each. Within a time limit of three minutes per page the students were asked to solve as many tasks as possible. The final score of the test was calculated from the number of items answered correctly minus the number of incorrect answers.

A brief timed trial test was used.

7.3.3 Presentation Delivery

In order to avoid the attention-reducing effects that the more passive activity of watching a video introduces, the screening setup was kept as similar as possible to a live presentation. The screenings took place in seminar rooms that are usually used for lectures and the recordings were shown on big projector screens that are indented for presentation visuals. The students watched the presentations together as groups as they would attend a lecture.

The recordings were shown similar to live presentations.

Taking notes was not allowed.

The students were not allowed to take notes. While note-taking can be regarded as part of the learning process, it could not have been made sure that the notes will not be used for answering the post- and follow-up-questionnaires, which would have falsified the results.

Paths and off-screen topic indicators were not shown.

In the Fly visuals neither the presentation path nor the off-screen topic indicators were shown to avoid cluttering the screen and because the topic background colors, together with the extensive use of overviews, already conveyed the canvas structures sufficiently. In particular, the path display would have cluttered the visuals because of the many path stops.

The video files of all four recordings can be downloaded:

Presentation Recording: Fixies in PowerPoint[a]

[a]http://hci.rwth-aachen.de/~hess/thesis/Fixies_PPT.mov

Presentation Recording: Fixies in Fly[a]

[a]http://hci.rwth-aachen.de/~hess/thesis/Fixies_Fly.mov

Presentation Recording: Convergent Evolution in PowerPoint[a]

[a]http://hci.rwth-aachen.de/~hess/thesis/Evolution_PPT.mov

Presentation Recording: Convergent Evolution in Fly[a]

[a]http://hci.rwth-aachen.de/~hess/thesis/Evolution_Fly.mov

7.3.4 Post-presentations Questionnaire

The questionnaire covered both presentations and also asked for format preference and comments.

After attending the two presentations, the students answered a self-administered, nine page questionnaire about both presentations. The questionnaire first asked about the first presentation, then about the second presentation, and finally about format preference and for comments. For each presentation, the questionnaire contained two pages of questions about retention and understanding of the content and two pages of questions about the attitude towards and satisfaction with the presentation. Both groups were handed the same questionnaire, i.e., the participants answered to the same questions independent of the formats of the attended presentations.

Retention and Understanding

The questions had a multiple-choice format with three answer options.

To measure knowledge transfer, the questionnaire tested the recall of content facts and macrostructure with retention questions and the content understanding with problem-solving transfer questions. A multiple-choice instead of an open question format was used since it takes individuals less effort to answer them. They must only recognize and not retrieve the correct answers [Fowler, 1995]. This was important, in particular, because of the study's extensive scope where fatigue was a risk. Admittedly, the multiple-choice format has the problem of false positives, but open questions, on the other hand, may provide only a low estimate of active knowledge [Fowler, 1995]. Not least, multiple-choice questions were easier to assess. Each of the questions had three answer options.

The fact and structure questions were classified based on the representation of the content. The transfer questions asked to solve novel problems.

The three question categories were: fact questions that asked about atomic facts, macrostructure questions that asked about concept relations and main ideas, and transfer questions that required to solve novel problems that were derived from the presented content. The questions about content facts and macrostructure were further classified based on a scheme similar to the one used by Blokzijl and Andeweg [2005] in their evaluation. Some questions asked about content that was shown in the visuals and at the same time was mentioned in the spoken narration. Others asked about information that was only mentioned in the narration. Consequently, only for the visuals and narration questions dual-encoding was in effect. Table 7.2 shows the distribution of the questions among the categories for both topics. See section A.2.1—"Retention and Understanding Questions" for the original German questions on both topics and English translations.

Question Category	Post-questionnaire		Follow-up-questionnaire	
	Fixies	Evolution	Fixies	Evolution
Fact Visuals & Narration	2	2	2	2
Fact Narration Only	2	2	2	2
Fact Total	4	4	4	4
Struct. Visuals & Narration	2	2	2	2
Struct. Narration Only	1	1	1	0
Structure Total	3	3	3	2
Transfer	2	1	2	1
Total	9	8	9	7

Table 7.2: Classification of the Retention and Understanding Questions According to Information Type and Information Representation

Attitude and Satisfaction

Attitude and satisfaction questions inquired how the presentations were perceived.

In order to gain insight into the participants' attitude towards and satisfaction about the presentations, the questionnaires contained a series of Likert scale and multiple-choice questions. In particular, with regard to attitude, the questionnaire asked if the presentations were interesting and if and what aspects the students liked. With regard to satisfaction, the participants were asked if the presentations were comprehensible, if the structure was easy to understand, if they were oriented about current context and presentation progress, how speed and amount of content were, and if they had to split their attention between the on-screen content and the narration. Furthermore, additional questions inquired what presentation features helped to remember information. See section A.2.2—"Attitude and Satisfaction Questions" for the original German questions and English translations.

Format Preference

The final part of the post-presentations questionnaire asked the participants if they preferred the PowerPoint or the Fly format and what the reasons for the preference were. Concluding, the questionnaire gave the possibility to make comments. See section A.2.3—"Format Preference Questions" for the German and English questions.

7.3.5 Follow-up-questionnaire

The follow-up retention and understanding questionnaire was sent to the participants four days after the presentations. It was conducted online using a Google Docs spreadsheet. The testers were asked to answer it within 24 hours.

The questionnaire contained two pages of questions for each topic. New sets of questions were used with the same distribution among the different categories as in the post-presentations questionnaire, except for the macrostructure narration only category where no good question for the convergent evolution topic could be found. See table 7.2 for the number of questions in the different categories and section A.3—"Follow-up-questionnaire" for the questions on both topics in German and English.

The follow-up-questionnaire contained new sets of retention and understanding questions.

The reason for using new questions instead of repeating the questions from the post-questionnaire was that the participants did not receive corrections of their post-questionnaire answers. Therefore, wrong answers might have been memorized which would have falsified the follow-up-questionnaire results. However, with different sets of questions, the results of both questionnaires were strongly dependent on the individual questions.

7.4 Hypotheses

Retention and Understanding

H1 There will be no significant difference between the conditions for fact retention since factual information is represented similar in both formats. While Fly's smaller steps that focus on single aspects can make sure that all information is apprehended, the PowerPoint slides that were created are not overloaded and, therefore, should not bury any information. A difference in fact retention was also not found in the related knowledge maps test by O'Donnell et al. [2002].

There will be no difference for fact retention.

Fly will be better for macrostructure retention and understanding.

H2 The participants will perform better for the Fly-supported presentations for macrostructure retention (as in [Dillon et al., 1996]) and transfer questions (as in [Mayer and Sims, 1994]). The canvas format's spatial arrangements, especially those that could not be adapted to slides, make it easier for the participants to understand the content relations.

Attitude and Satisfaction

The Fly presentations will be perceived as superior in various regards.

H3 The participants will like the Fly presentations better than the PowerPoint presentations. Certainly also because of Fly's novelty, but mainly because the Fly presentations have a more engaging nature compared to the slide decks that are based on the PowerPoint standard template.

H4 The audiences will perceive the Fly presentations, especially their structures, as easier to comprehend. Reasons are the spatial layout that integrates the content, the better and more numerous overviews, and the path stops with lesser content.

H5 The participants will In the Fly presentations, the participants will perceive the amount of content that is shown on the screen at a time as more adequate. Consequently, they will perceive the visuals as less distracting.

H6 The Fly visuals will provide the audience with a better orientation. It will be easier for the participants to stay on track and they will know better where the presentations are currently at.

Format Preference

H7 The audiences will prefer the Fly format over PowerPoint.

7.5 Analysis

7.5.1 Data Preparation

Collected Data

All 26 participants answered the pre- and post-questionnaires. Due to organizational issues and time constraints the spatial cognitive ability was only tested for 19 students. The follow-up-questionnaire was answered by 23 participants. Five participants answered the follow-up-questionnaire later than 24 hours after it was sent out (two to three days late).

Not all data could be collected from all participants.

In the post-questionnaire, two participants did not answer all questions. One person did not answer the format preference question and one person did not answer the attitude and satisfaction questions for the second presentation (likely due to an overlooked page).

Excluded Data

To ensure a comparable starting point for testing retention and understanding (see section 7.2.3—"Prior Knowledge"), data was excluded from the records of the five participants that selected four or five on the five-point Likert scale, ranging from one (poor) to five (excellent), for self-assessment of prior knowledge in the pre-presentations questionnaire. Two students each expressed a high knowledge about fixies and convergent evolution. One student expressed a high knowledge about both topics. From each record with a high prior knowledge on a topic, the retention and understanding scores on this topic were excluded. From the record with a high prior knowledge on both topics, all retention and understanding scores were excluded. Furthermore, one participant missed about three minutes of the presentation on convergent evolution. Therefore, the corresponding retention and understanding scores were excluded. The student, however, attended the presentation long enough

Data was excluded from the records of participants with a high prior knowledge.

to give valid answers to the attitude and satisfaction questions.

The data of the follow-up-questionnaires that students submitted late was not excluded since an independent samples t-test showed that there was no significant different between the total score means of the questionnaires that were returned in time and those that were returned late ($t(39) = -0.369, p = 0.714$).

7.5.2 Pre-presentations Questionnaire

Demographic Information

The first part of the pre-presentations questionnaire asked for basic demographic information (see section A.1—"Pre-presentations Questionnaire"). The data was analyzed to determine if the demographics of the two groups was comparable.

All 26 participants, 23 men and three women, were students of computer science or related courses of studies. All but two students were German native speakers. The two non-native speakers assessed their knowledge of German with four and five on a five-point Likert scale, ranging from one (poor) to five (excellent). It can, therefore, be assumed that varying language skills were not a confounding variable.

The two groups had comparable demographics.

The mean year of birth was 1984.65 ($SD = 3.752$) and the mean number of semesters studies was 9.27 ($SD = 4.813$). An independent samples t-test showed no significant differences between the groups for neither year of birth ($t(24) = -0.256$, $p = 0.800$) nor number of semester studied ($t(24) = -0.120$, $p = 0.906$). Because of the rather high number of semesters studied (minimum was 5), it can be assumed that all participants were used to attend university-level presentations. See table B.1 for the statistics of gender, year of birth, and number of semesters studied for all participants and separately for the two groups.

Interest and Prior Knowledge

The pre-presentations questionnaire's second part asked for self-assessment of the interest in and the knowledge about the two topics (see section A.1—"Pre-presentations Questionnaire"). The question format was a five-point Likert scale ranging from one (completely agree) to five (completely disagree) for interest and one (poor) to five (excellent) for prior knowledge.

The participants had a low interest in and little prior knowledge about the topics.

The participants expressed that they had little interest in fixies (median of 4), average interest in convergent evolution (median of 3), and little prior knowledge about both topics (median fixies: 1, median convergent evolution: 2). An independent samples Mann-Whitney U test showed no significant differences between the medians of both groups neither for interest (fixies: $p = 0.742$, convergent evolution: $p = 0.306$) nor for prior knowledge (fixies: $p = 0.904$, convergent evolution: $p = 0.339$). See table B.2 for the detailed statistics for all participants and separately for the two groups. The records excluded because of a high prior knowledge were not included in this analysis. Despite the low interest expressed in the pre-questionnaire, the analysis of the post-questionnaire records showed that the students found the presentations to be interesting (see section 7.6.2—"Attitude and Satisfaction" below).

Presentation Support Preference

The students preferred computer-based visual presentation support.

The final multiple-choice question of the pre-presentations questionnaire asked for the students' preferred form of presentation support. The answers were distributed as follows: 19 students chose *computer visuals*, four students chose *black-/whiteboard*, and one participant chose the *no preference* option. No one chose the options *overhead transparencies* and *no visual support*. Two records were excluded from the analysis because two options (computer visuals and black-/whiteboard) were checked. See table B.3 for the statistics for all participants and separately for the two groups. A one sample chi-square test showed that the preference for computer-based support is significant for all participants ($p < 0.001$), for group 1 ($p = 0.009$), and for group 2 ($p = 0.039$).

Spatial Cognitive Ability

The 19 students that were tested for their spatial cognitive ability achieved a mean score of 127.32 ($SD = 21.011$) out of 160. See table B.4 for the test score statistics for all participants and separately for the two groups. An independent samples t-test showed no significant difference between the mean scores of both groups ($t(17) = -0.209$, $p = 0.837$).

The analysis of the pre-presentations questionnaire showed that the two groups of participants were comparable with regard to their demographics, their interest in and prior knowledge about the topics, and their spatial cognitive ability. Furthermore, since there was a range of results for spatial ability, the visual aids might have had different effects on individuals.

7.5.3 Analysis Methods

Three data analysis methods were used.

Because of the mixed within and between groups study design, three analysis methods were available to compare the data of the Fly and PowerPoint presentations. The data was analyzed *between groups*: comparing the records of presentations on the same topics between groups and formats, *within groups*: comparing the records of presentations on different topics and formats within the two groups, and with *joined groups*: comparing the records for the different formats independent of their topics and audiences. See table 7.3 for an overview over all used analyses.

The scores of the two questionnaires were analyzed separately and combined.

The scores of the retention and understanding questions, in percent of correct answers, were analyzed separately for the post- and follow-up-questionnaires as well as combined from both questionnaires. The analysis was also broken down into the categories *fact*, *macrostructure*, and *transfer questions*. The fact and macrostructure questions were further subdivided into the questions about the content that

Between Groups		
Group 1: Fixies in Fly	↔	Group 2: Fixies in PowerPoint
Group 1: Evolution in PowerPoint	↔	Group 2: Evolution in Fly
Within Groups		
Group 1: Fixies in Fly	↔	Group 1: Evolution in PowerPoint
Group 2: Fixies in PowerPoint	↔	Group 2: Evolution in Fixies
Joined Groups		
Group 1: Fixies in Fly and Group 2: Evolution in Fly	↔	Group 1: Evolution in PowerPoint and Group 2: Fixies in PowerPoint

Table 7.3: The Three Methods Used for the Data Analysis

was included in the *visuals and* the spoken *narration* and the questions about the content that was *only* mentioned in the *narration*.

Group Comparison

In the between groups analysis method, the records for the different formats are also from different groups. To rule out that differences between the groups falsified the format comparison, all records of the two groups (combined for both formats and both topics) were compared.

The groups are comparable for most parts of the retention and understanding tests.

The scores for the retention and understanding questions (see figure 7.16 and table B.5) were compared with an independent samples t-test for equality of means. See table 7.4 for the results. Group 2 performed better than group 1 in both questionnaires. However, the difference is only significant for the narration only macrostructure questions, the macrostructure questions in total, and all questions in total in the combined scores. There is no significant difference for the total scores of the post- and follow-up-questionnaires. Therefore, the between groups analysis is reasonable for all retention and understanding scores except the three categories in which the means differ significantly.

Post-questionnaire

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	1.377	41.833*	0.176
Fact Narration Only	0.428	44	0.671
Fact Total	1.112	44	0.272
Struct. Visuals & Narration	0.597	44	0.554
Struct. Narration Only	1.794	44	0.080
Structure Total	1.774	44	0.083
Transfer	0.699	44	0.488
Total	1.436	44	0.158

* Significant different variability in the samples was taken into account.

Follow-up-questionnaire

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.327	39	0.745
Fact Narration Only	0.305	39	0.762
Fact Total	0.455	39	0.652
Struct. Visuals & Narration	1.095	39	0.280
Struct. Narration Only	0.747	39	0.459
Structure Total	1.405	39	0.168
Transfer	0.923	39	0.362
Total	1.469	39	0.150

Combined Scores

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	1.175	39	0.247
Fact Narration Only	0.553	39	0.583
Fact Total	1.330	39	0.191
Struct. Visuals & Narration	0.997	39	0.325
Struct. Narration Only	2.172	39	***0.036***
Structure Total	2.227	39	***0.032***
Transfer	0.383	39	0.704
Total	2.026	39	***0.050***

Significances at the 0.05 level are in ***bold italics***.

Table 7.4: T-test Results for the Group Comparison of the Retention and Understanding Scores

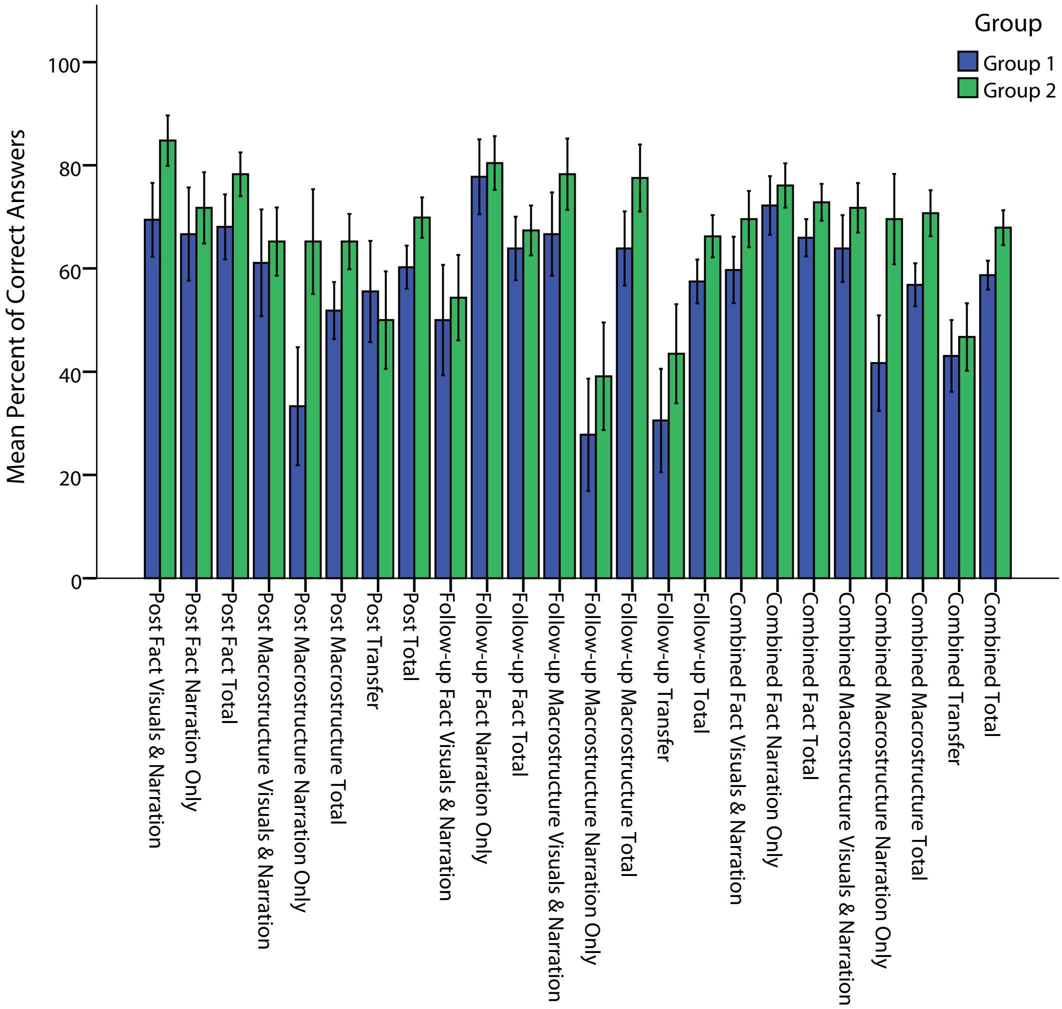

Figure 7.16: Group Comparison: Retention and Understanding Scores from Both Presentations (Error Bars: $\pm 1SE$)

The answers to the attitude and satisfaction questions of the two groups (see table B.13 for the statistics) have been compared with an independent samples Mann-Whitney U test. See table 7.5 for the results. The distribution of answers differed significantly only for the statement "The visuals distracted me from the spoken narration." The members of group 1 found the presentation visuals significantly less distracting. Therefore, the between groups analysis is reasonable for all attitude and satisfaction questions except this single statement.

The groups are comparable for all but one attitude and satisfaction questions.

Question/Statement	p
The presentation was interesting.	0.254
I liked the presentation's visuals.	0.922
I liked the presentation's commentary.	0.774
I liked the presentation overall.	0.510
The presentation was comprehensible.	0.797
The presentation did not loose me. I was never disoriented.	0.378
How was the speed of the presentation?	0.511
How was the amount of content shown at once?	0.884
The visuals distracted me from the spoken narration.	***0.043***
I had sufficient time to look at all the content on the screen.	0.310
The presentation's structure was easy to understand.	0.778
I always knew which part of the presentation was currently shown.	0.097
I always knew approximately how far advanced the presentation was.	0.544
I remembered information based on its spatial location.	0.292

Significances at the 0.05 level are in ***bold italics***.

Table 7.5: Mann-Whitney U Test Results for the Group Comparison of the Answers to the Attitude and Satisfaction Questions

Topic Comparison

In the within groups analysis method, the variables format and topic are mixed, i.e., records for the different formats are also about different topics. To rule out falsifications because of topic differences, the records for the two topics (combined for both groups and both formats) were compared.

The topics are comparable for only some retention and understanding tests.

The scores for retention and understanding (see figure 7.17 and table B.6) were compared with a paired samples t-test. See table 7.6 for the results. There were no significant differences between the total score means of both questionnaires and the combined scores. However, for many of the individual question categories the difference is significant. Consequently, the within groups comparison is only reasonable for the categories with no significant differences.

The topics are comparable for all but two attitude and satisfaction questions.

A related samples Wilcoxon Signed Rank test was used to compare the answers to the attitude and satisfaction questions. See table B.14 for the answer statistics and table 7.7 for the non-parametric test results. There was a significant

Post-questionnaire

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.826	20	0.419
Fact Narration Only	1.793	20	0.088
Fact Total	0.794	20	0.437
Struct. Visuals & Narration	3.347	20	***0.003***
Struct. Narration Only	1.826	20	0.083
Structure Total	2.019	20	0.057
Transfer	2.358	20	***0.029***
Total	1.909	20	0.071

Follow-up-questionnaire

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	3.923	18	***0.001***
Fact Narration Only	3.644	18	***0.002***
Fact Total	0.972	18	0.344
Struct. Visuals & Narration	2.348	18	***0.031***
Struct. Narration Only	*questions only for fixies*		
Structure Total	1.997	18	0.061
Transfer	2.024	18	0.058
Total	0.955	18	0.352

Combined Scores

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	2.557	18	***0.020***
Fact Narration Only	4.726	18	$<$ ***0.001***
Fact Total	0.399	18	0.695
Struct. Visuals & Narration	5.404	18	$<$ ***0.001***
Struct. Narration Only	0.383	18	0.706
Structure Total	3.987	18	***0.001***
Transfer	1.222	18	0.238
Total	1.523	18	0.145

Significances at the 0.05 level are in ***bold italics***.

Table 7.6: T-test Results for the Topic Comparison of the Retention and Understanding Scores

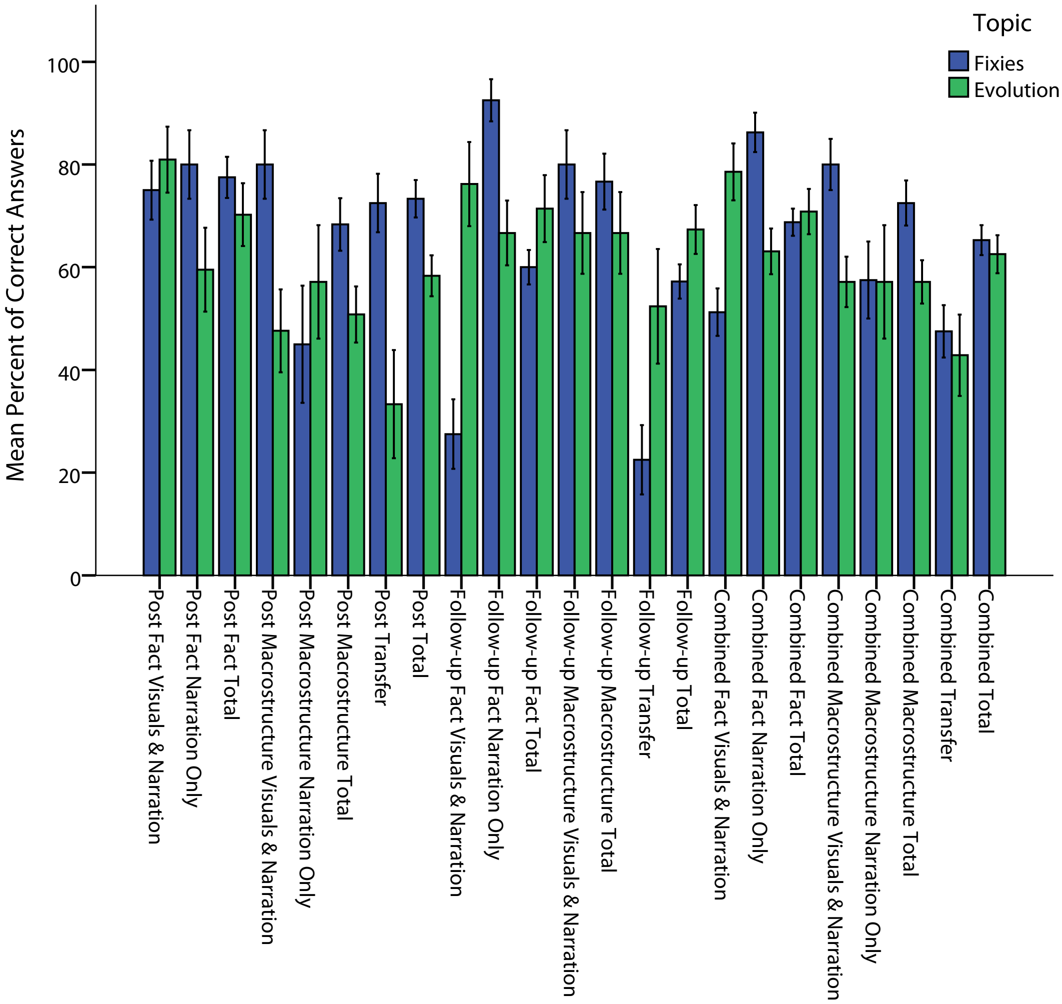

Figure 7.17: Topic Comparison: Retention and Understanding Scores of All Participants (Error Bars: $\pm 1 SE$)

greater agreement for the presentations about fixies for the two statements “I liked the presentation overall.” and “The presentation’s structure was easy to understand.” Therefore, the within groups analysis is not meaningful for these two statements.

Question/Statement	p
The presentation was interesting.	0.859
I liked the presentation's visuals.	0.204
I liked the presentation's commentary.	1.000
I liked the presentation overall.	***0.047***
The presentation was comprehensible.	0.053
The presentation did not loose me. I was never disoriented.	0.061
How was the speed of the presentation?	0.102
How was the amount of content shown at once?	0.527
The visuals distracted me from the spoken narration.	0.114
I had sufficient time to look at all the content on the screen.	0.164
The presentation's structure was easy to understand.	***0.024***
I always knew which part of the presentation was currently shown.	0.348
I always knew approximately how far advanced the presentation was.	0.683

Significances at the 0.05 level are in ***bold italics***.

Table 7.7: Wilcoxon Signed Rank Test Results for the Topic Comparison of the Answers to the Attitude and Satisfaction Questions

7.5.4 Retention and Understanding

As described before (see section 7.5.3—"Analysis Methods"), the scores to the retention and understanding questions, in percent of correct answers, were analyzed separately for the post- and follow-up-questionnaires as well as combined from both questionnaires.

Post-presentations Questionnaire

Between Groups Analysis As to be expected from the group comparison, group 2 performed better in almost all question categories for both topics. See figures 7.18 and 7.19 as well as table B.7 for the score statistics of both groups for both topics. However, an independent samples t-test showed that the difference is not significant for any question category for neither topic (see table 7.8).

The between groups analysis showed no significant differences.

Within Groups Analysis See figure 7.20, figure 7.21, and table B.7 for the score statistics for both topics/formats for the two groups. A paired samples t-test showed that in

The within groups analysis showed no significant differences.

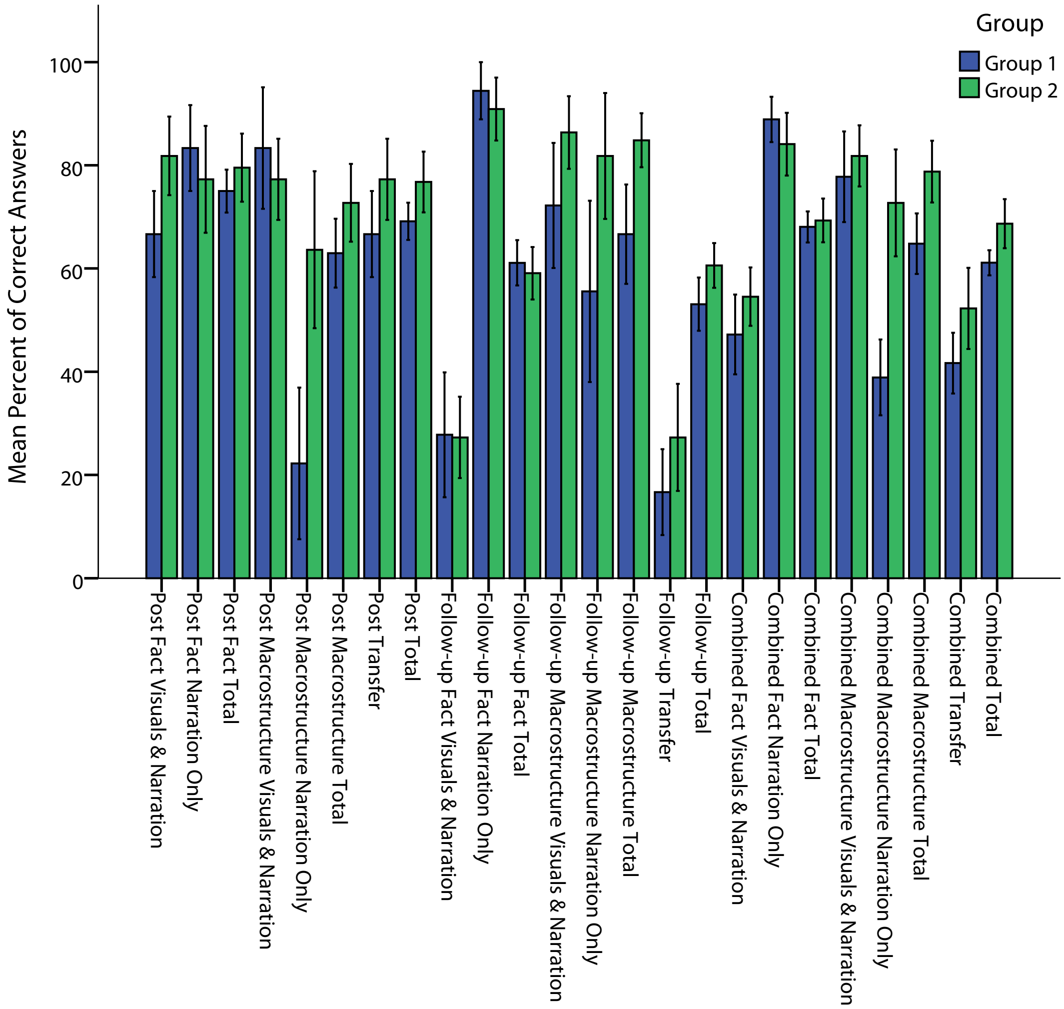

Figure 7.18: Between Groups: Retention and Understanding Scores for Fixies (Error Bars: $\pm 1SE$)

group 1 the participants scored significantly higher in the visuals and narration macrostructure questions for the Fly-supported fixies presentation. In group 2, the participants scored significantly higher in the transfer questions for the PowerPoint-supported fixies presentation. See table 7.9 for all results of the t-test. However, because the previous topic comparison has shown that for these two question categories in the post-questionnaire the topics are not comparable, no significant differences between the formats can be derived from this analysis.

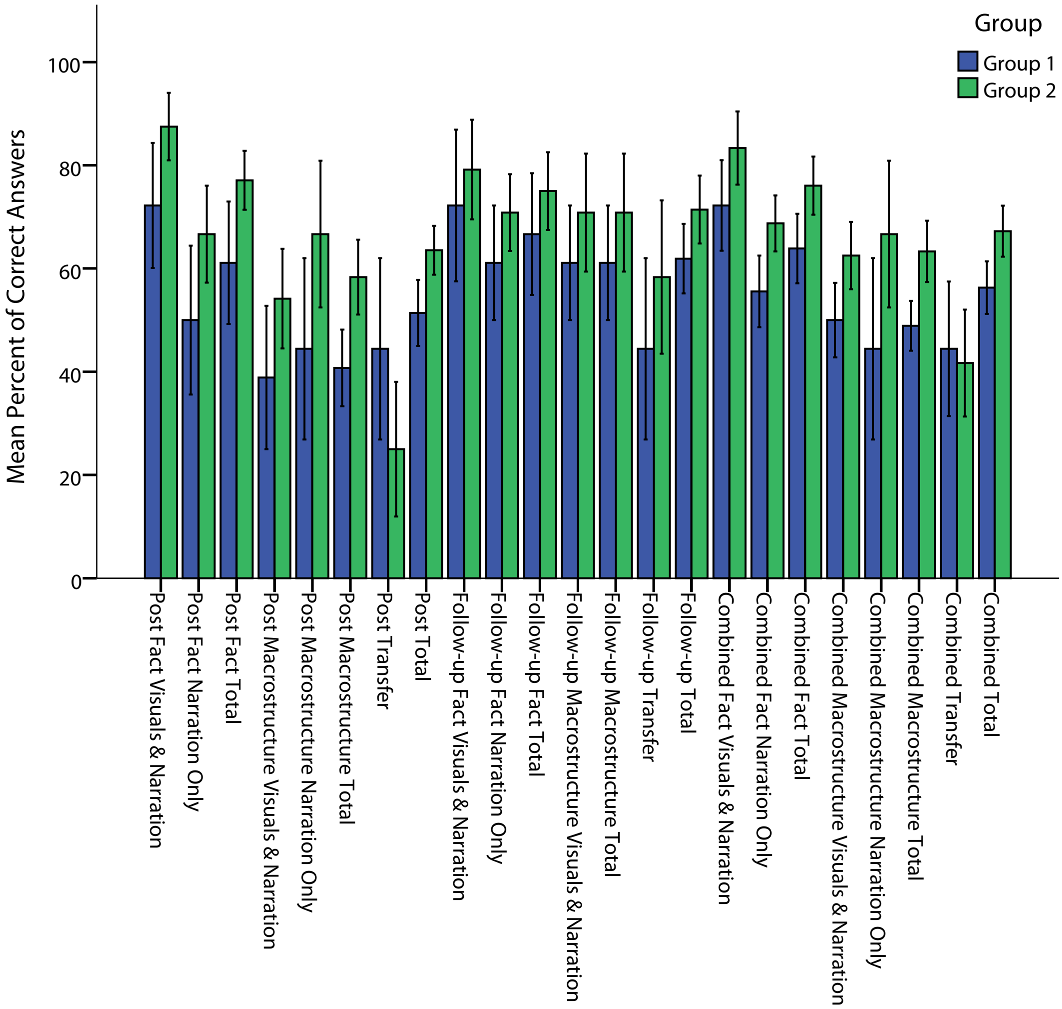

Figure 7.19: Between Groups: Retention and Understanding Scores for Convergent Evolution (Error Bars: $\pm 1 SE$)

Joined Groups Analysis See figure 7.22 and table B.10 for the statistics of the post-presentations questionnaire scores combined from both groups. A paired samples t-test showed that for transfer questions the mean score is significantly higher for the PowerPoint presentations (see table 7.10).

The joined groups analysis showed significant higher transfer question scores for the PowerPoint records.

Fixies

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	1.032	21	0.314
Fact Narration Only	0.180	21	0.859
Fact Total	0.896	21	0.380
Struct. Visuals & Narration	0.180	21	0.859
Struct. Narration Only	1.937	21	0.066
Structure Total	1.508	21	0.147
Transfer	1.454	21	0.161
Total	1.612	16.373*	0.126

Convergent Evolution

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.850	21	0.405
Fact Narration Only	0.474	21	0.640
Fact Total	0.733	15.387*	0.474
Struct. Visuals & Narration	0.822	21	0.421
Struct. Narration Only	0.573	21	0.573
Structure Total	1.186	21	0.249
Transfer	1.454	21	0.161
Total	0.671	21	0.509

* Significant different variability in the samples was taken into account.

Table 7.8: T-test Results for the Between Groups Analysis of the Post-presentations Questionnaire Retention and Understanding Scores

Follow-up-questionnaire

The between groups analysis showed no significant differences.

Between Groups Analysis As in the post-questionnaire, group 2 scored better in most question categories on both topics (see figures 7.18 and 7.19 as well as table B.8 for the score statistics). But, as for the post-questionnaire, an independent samples t-test showed that the differences are not significant (see table 7.11).

The within groups analysis showed no significant differences.

Within Groups Analysis See figure 7.20, figure 7.21, and table B.8 for the score statistics for both topics/formats for the two groups. A paired samples t-test showed that

Group 1

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.802	9	0.443
Fact Narration Only	1.342	9	0.213
Fact Total	0.557	9	0.591
Struct. Visuals & Narration	2.862	9	***0.019***
Struct. Narration Only	2.236	9	0.052
Structure Total	1.309	9	0.223
Transfer	0.000	9	1.000
Total	0.781	9	0.455

Group 2

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.363	10	0.724
Fact Narration Only	1.150	10	0.277
Fact Total	0.559	10	0.588
Struct. Visuals & Narration	1.838	10	0.096
Struct. Narration Only	0.430	10	0.676
Structure Total	1.491	10	0.167
Transfer	3.993	10	***0.003***
Total	2.125	10	0.060

Significances at the 0.05 level are in ***bold italics***.

Table 7.9: T-test Results for the Within Groups Analysis of the Post-presentations Questionnaire Retention and Understanding Scores

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.271	20	0.789
Fact Narration Only	0.418	20	0.680
Fact Total	0.156	20	0.877
Struct. Visuals & Narration	0.777	20	0.446
Struct. Narration Only	1.164	20	0.258
Structure Total	0.000	20	1.000
Transfer	2.358	20	***0.029***
Total	0.569	20	0.576

Significances at the 0.05 level are in ***bold italics***.

Table 7.10: T-test Results for the Joined Groups Analysis of the Post-presentations Questionnaire Retention and Understanding Scores

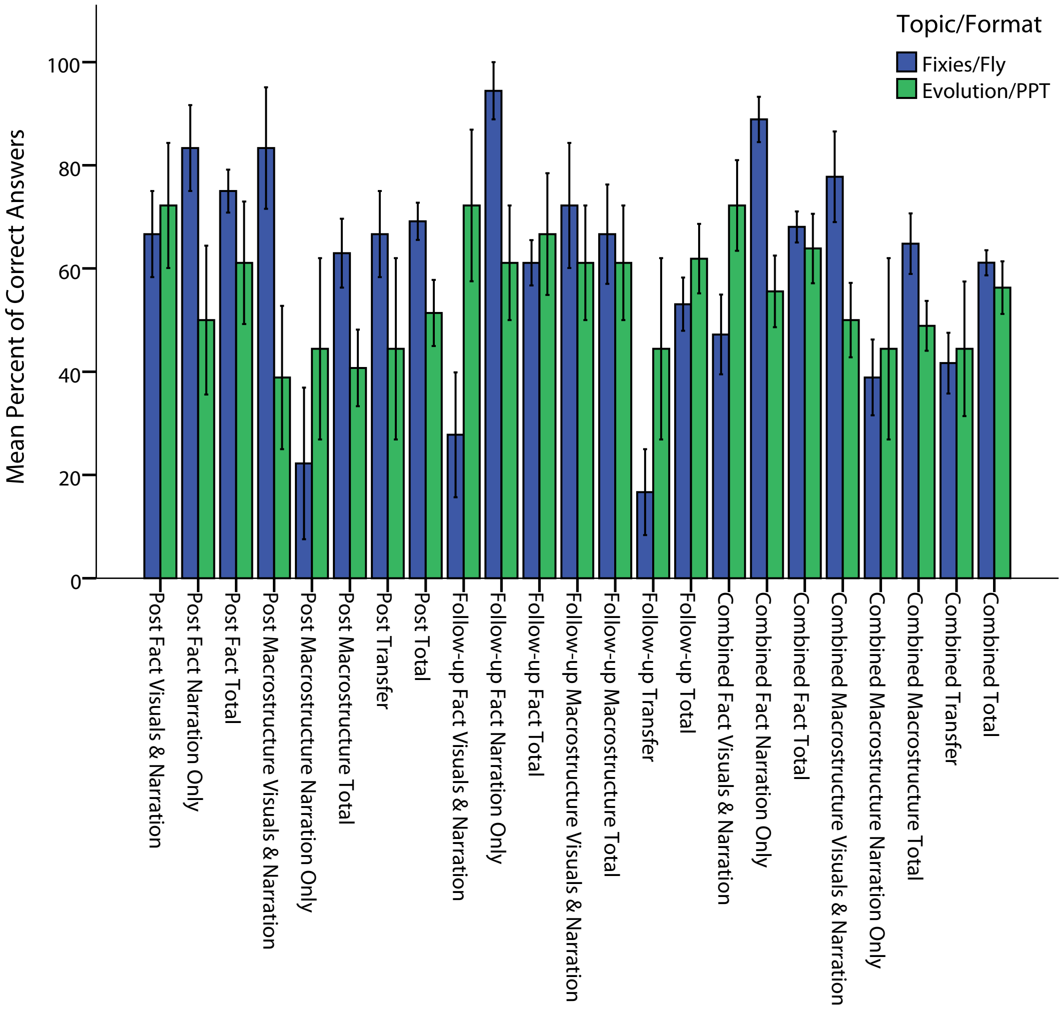

Figure 7.20: Within Groups: Retention and Understanding Scores of Group 1 (Error Bars: $\pm 1SE$)

group 1 scored significantly higher for the Fly presentation about fixies for the narration only fact questions. Group 2 scored significantly better for the Fly presentation about convergent evolution for visuals and narration fact questions and for the fixies PowerPoint presentation for narration only fact questions. See table 7.12 for all results of the t-test. However, as for the post-questionnaire, all three significant differences are in question categories for which the topics are not comparable. Therefore, no significant results between can be obtained from the within groups analysis.

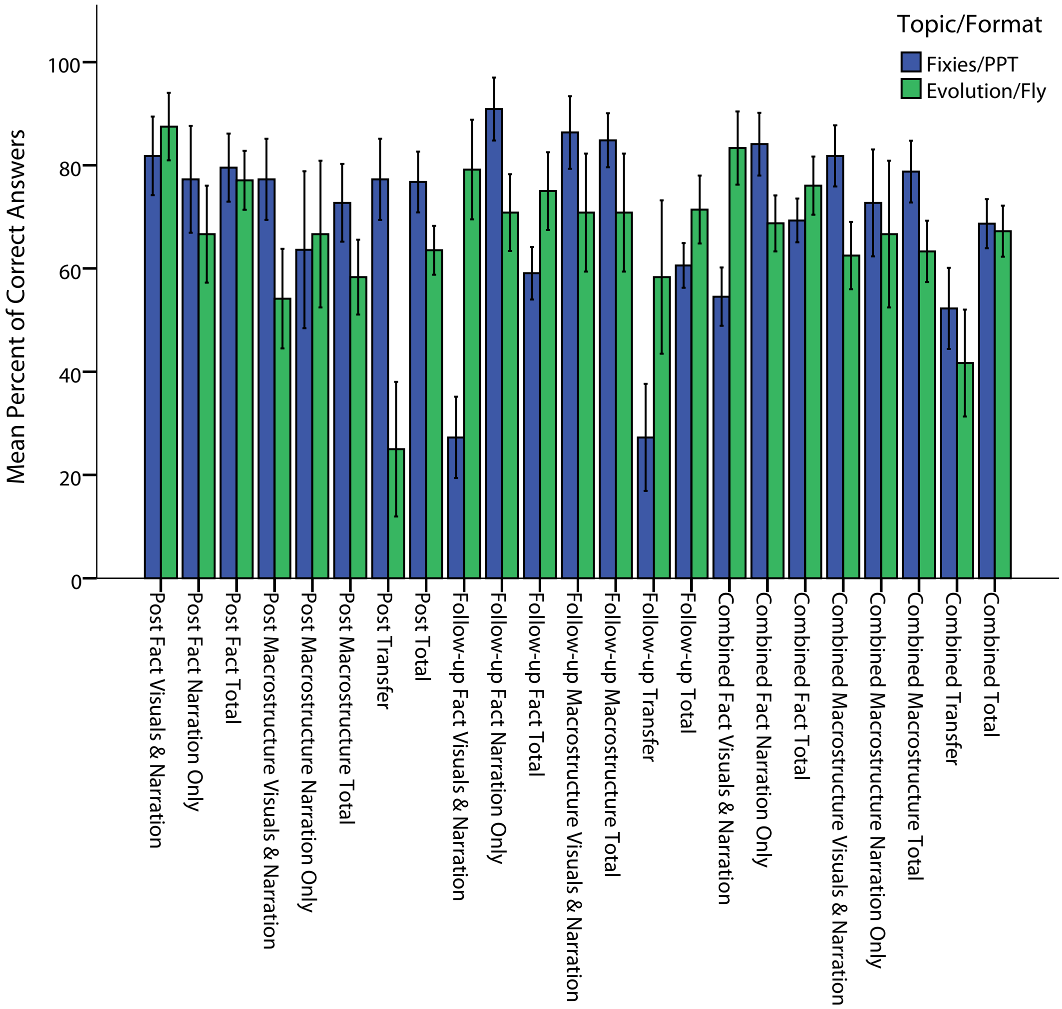

Figure 7.21: Within Groups: Retention and Understanding Scores of Group 2 (Error Bars: $\pm 1SE$)

Joined Groups Analysis Figure 7.22 and table B.11 show the score statistics of the joined groups. A paired samples t-test showed that there are no significant differences between the two formats (see table 7.13).

The joined groups analysis showed no significant differences.

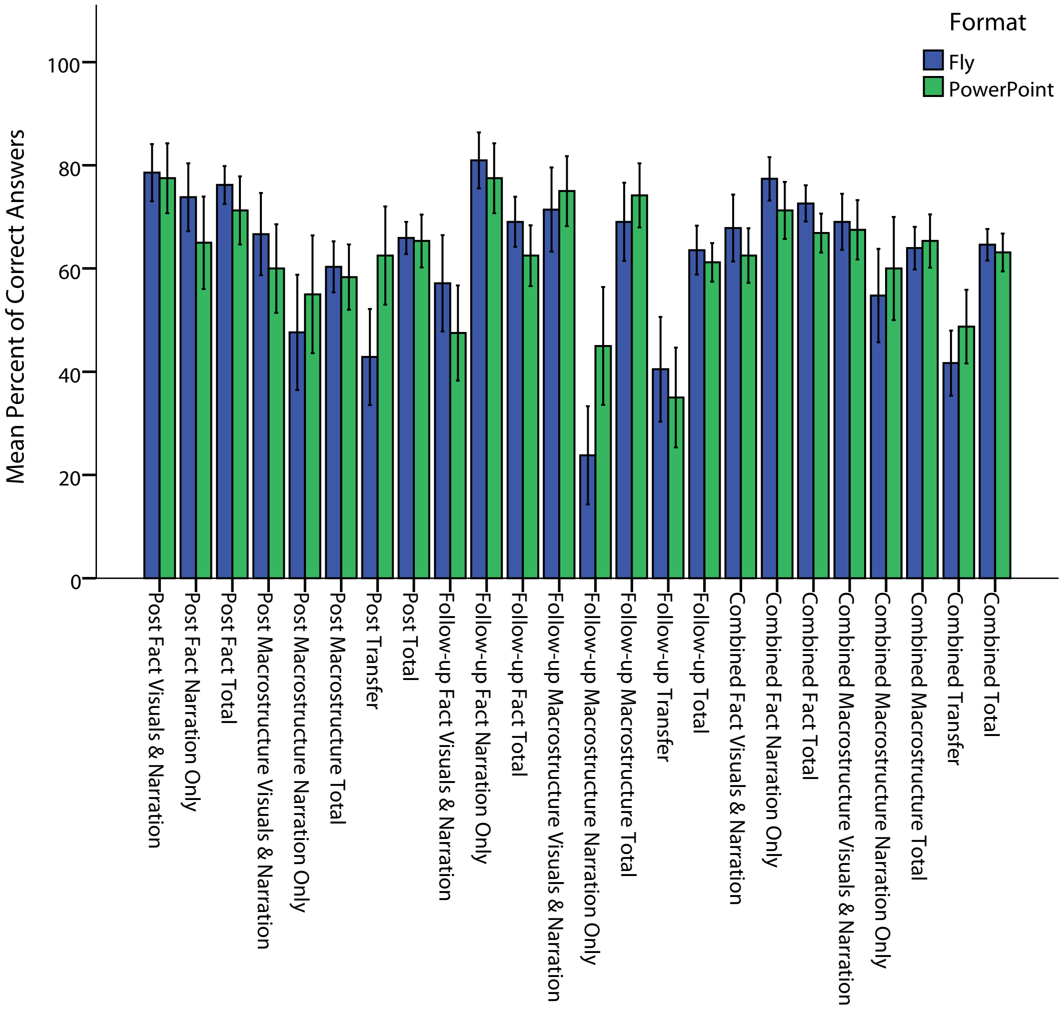

Figure 7.22: Joined Groups: Retention and Understanding Scores (Error Bars: $\pm 1SE$)

Combined Scores

The between groups analysis showed no significant differences.

Between Groups Analysis As to be expected from the separate questionnaire analyses, group 2 scored better in the majority of question categories (see figures 7.18 and 7.19 as well as table B.9 for the score statistics). An independent samples t-test showed that the difference is significant for the narration only macrostructure questions about fixies (group 2 watched this presentation with PowerPoint

Fixies

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.036	18	0.972
Fact Narration Only	0.420	18	0.679
Fact Total	0.293	18	0.773
Struct. Visuals & Narration	1.055	18	0.305
Struct. Narration Only	1.228	14.817*	0.239
Structure Total	1.743	18	0.098
Transfer	0.772	18	0.450
Total	1.124	18	0.276

* Significant different variability in the samples was taken into account.

Convergent Evolution

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.411	19	0.685
Fact Narration Only	0.756	19	0.459
Fact Total	0.623	19	0.541
Struct. Visuals & Narration	0.594	19	0.560
Struct. Narration Only		*no questions*	
Structure Total	0.594	19	0.560
Transfer	0.606	19	0.552
Total	0.993	19	0.333

Table 7.11: T-test Results for the Between Groups Analysis of the Follow-up-questionnaire Retention and Understanding Scores

support). See table 7.14 for all results of the t-test. However, the group comparison showed that the groups are not comparable for the combined narration only macrostructure scores. Therefore, no significant format differences can be derived from this analysis.

Within Groups Analysis See figure 7.20, figure 7.21, and table B.9 for the combined score statistics for both topics/formats for the two groups. A paired samples t-test showed that group 1 scored significantly better for the Fly presentation on fixies in these categories: narration only fact questions, visuals and narration macrostructure questions, and macrostructure questions in total. Group 2 scored significantly better for the Fly-supported convergent

The within groups analysis showed no significant differences.

Group 1

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	2.198	7	0.064
Fact Narration Only	2.376	7	***0.049***
Fact Total	0.424	7	0.685
Struct. Visuals & Narration	1.528	7	0.170
Struct. Narration Only	*questions only for fixies*		
Structure Total	0.882	7	0.407
Transfer	1.158	7	0.285
Total	0.783	7	0.459

Group 2

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	3.833	10	***0.003***
Fact Narration Only	2.390	10	***0.038***
Fact Total	2.185	10	0.054
Struct. Visuals & Narration	1.491	10	0.167
Struct. Narration Only	*questions only for fixies*		
Structure Total	1.354	10	0.205
Transfer	1.604	10	0.140
Total	1.481	10	0.170

Significances at the 0.05 level are in ***bold italics***.

Table 7.12: T-test Results for the Within Groups Analysis of the Follow-up-questionnaire Retention and Understanding Scores

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.815	18	0.426
Fact Narration Only	0.294	18	0.772
Fact Total	0.972	18	0.344
Struct. Visuals & Narration	0.622	18	0.542
Struct. Narration Only	1.073	18	0.297
Structure Total	0.725	18	0.478
Transfer	0.615	18	0.546
Total	0.570	18	0.576

Table 7.13: T-test Results for the Joined Groups Analysis of the Follow-up-questionnaire Retention and Understanding Scores

Fixies

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.781	18	0.445
Fact Narration Only	0.612	18	0.548
Fact Total	0.232	18	0.819
Struct. Visuals & Narration	0.393	18	0.699
Struct. Narration Only	2.549	18	***0.020***
Structure Total	1.648	18	0.117
Transfer	1.037	18	0.313
Total	1.416	14.718*	0.177

* Significant different variability in the samples was taken into account.

Convergent Evolution

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.993	19	0.333
Fact Narration Only	1.518	19	0.145
Fact Total	1.390	19	0.181
Struct. Visuals & Narration	1.276	19	0.217
Struct. Narration Only	0.993	19	0.333
Structure Total	1.791	19	0.089
Transfer	0.169	19	0.868
Total	1.510	19	0.148

Significances at the 0.05 level are in ***bold italics***.

Table 7.14: T-test Results for the Between Groups Analysis of the Combined Retention and Understanding Scores

evolution presentation for the visuals and narration fact questions and significantly better for the fixies PowerPoint presentation in these categories: narration only fact questions, visuals and narration macrostructure questions, and macrostructure questions in total. See table 7.15 for the t-test results. But, as in the separate analyses of the questionnaires, for all question categories with significant differences the topics are not comparable. Consequently, this analysis could not show a significant difference between the formats.

Group 1

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	1.673	7	0.138
Fact Narration Only	7.937	7	$<$ ***0.001***
Fact Total	0.683	7	0.516
Struct. Visuals & Narration	4.245	7	***0.004***
Struct. Narration Only	0.607	7	0.563
Structure Total	3.911	7	***0.006***
Transfer	0.205	7	0.844
Total	1.099	7	0.308

Group 2

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	2.550	10	***0.029***
Fact Narration Only	2.609	10	***0.026***
Fact Total	0.944	10	0.367
Struct. Visuals & Narration	3.105	10	***0.011***
Struct. Narration Only	0.000	10	1.000
Structure Total	2.271	10	***0.046***
Transfer	1.550	10	0.152
Total	0.339	10	0.741

Significances at the 0.05 level are in ***bold italics***.

Table 7.15: T-test Results for the Within Groups Analysis of the Combined Retention and Understanding Scores

The joined groups analysis showed no significant differences.

Joined Groups Analysis See figure 7.22 and table B.12 for the combined score statistics of the joined groups. As for the follow-up-questionnaire, a paired samples t-test showed no significant differences between the two formats for any question category (see table 7.16 for the t-test results).

Questionnaire Comparison

To determine the relationship between the short- and long-term achievements, the total scores of the post- and follow-up-questionnaires were compared. Naturally, it is to be expected that the participants will score lower after four days than immediately after the presentations. However, since

Question Category	t	df	p (2-tailed)
Fact Visuals & Narration	0.600	18	0.556
Fact Narration Only	0.893	18	0.384
Fact Total	1.191	18	0.249
Struct. Visuals & Narration	0.325	18	0.749
Struct. Narration Only	0.383	18	0.706
Structure Total	0.151	18	0.881
Transfer	1.222	18	0.238
Total	0.381	18	0.708

Table 7.16: T-test Results for the Joined Groups Analysis of the Combined Retention and Understanding Scores

the post- and follow-up-questionnaires contained distinct test sets, the individual questions strongly influenced the performances for the different questionnaires.

Separate Groups Analysis See figure 7.23 for the comparison of the total scores of the questionnaires for the two topics. For the fixies presentations, the scores of the follow-up-questionnaire were lower than the scores of the post-questionnaire in both groups. Whereas, for the presentations about convergent evolution the scores of the follow-up-questionnaire were higher than the scores of the post-questionnaire in both groups. However, a paired samples t-test showed that the difference between the questionnaires is only significant for the fixies presentation of group 2 (see table 7.17).

For fixies the follow-up-performance was lower than the post-performance; for convergent evolution it was the other way round.

Joined Groups Analysis Figure 7.23 shows the means of the total scores of all post- and follow-up-questionnaire records combined from both groups and topics. There is no significant difference between the questionnaires for neither PowerPoint nor Fly.

In neither of the two formats the scores of the questionnaires differed significantly.

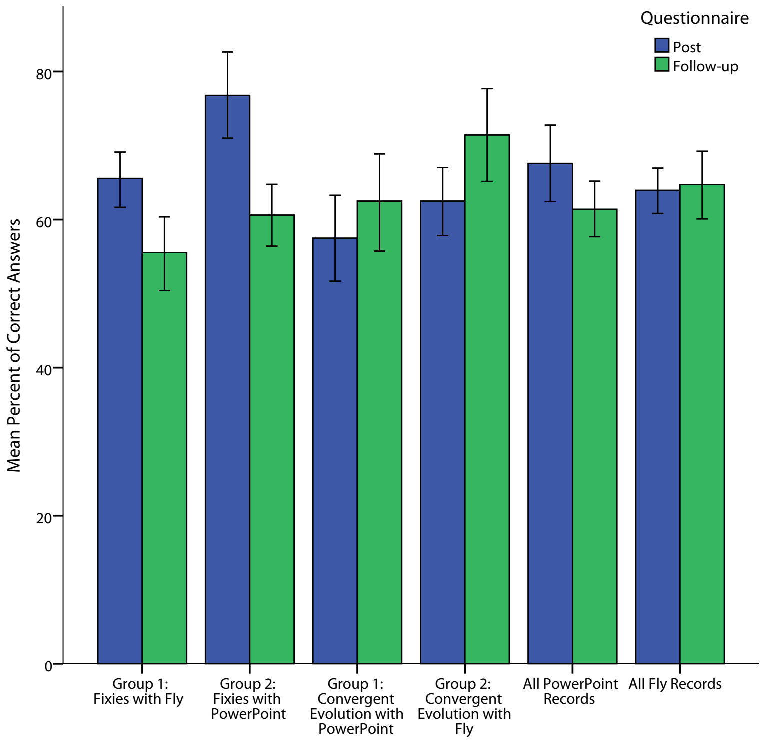

Figure 7.23: Retention and Understanding Questionnaire Comparison (Error Bars: $\pm 1SE$)

Group 1

Topic (Format)	t	df	p (2-tailed)
Fixies (Fly)	2.159	8	0.63
Evolution (PowerPoint)	1.274	8	0.239

Group 2

Topic (Format)	t	df	p (2-tailed)
Fixies (PowerPoint)	3.975	10	***0.003***
Evolution (Fly)	1.428	11	0.181

Significances at the 0.05 level are in ***bold italics***.

Table 7.17: T-test Results for the Separate Groups Comparison of the Retention and Understanding Scores of Both Questionnaires

7.5.5 Attitude and Satisfaction

See the tables B.15 and B.16 for the statistics of the answers to the attitude and satisfaction questions for the two groups and table B.17 for all participants. To test for significant differences between the formats, the distribution of answers in the between groups analysis was compared with independent samples Mann-Whitney U tests (see table 7.18 for the results) and related samples Wilcoxon Signed Rank tests were used for the within groups (see table 7.19 for the results) and joined groups (see table 7.20 for the results) analyses.

For four statements there were significant differences in favor of Fly. The were no significant differences in favor of PowerPoint. The significant results are described in the following sections.

There were multiple significant differences in favor of Fly.

"I liked the presentation overall."

There was significant greater agreement to this statement in the between groups analysis in favor of Fly for the convergent evolution presentations. Also in the joined groups analysis the agreement was significantly greater for the Fly records.

The participants liked the Fly presentations better.

Moreover, also in the within groups analysis for group 1 there was significant greater agreement for the Fly presentation. However, the topic comparison (see section 7.5.3—"Topic Comparison") had shown that for this statement the topics are not comparable.

"The presentation's structure was easy to understand."

The joined groups analysis showed a significant higher agreement to this statement for the Fly records. Also the within groups analysis for group 1 showed a significant higher agreement for the Fly presentation. But, also for this statement the two topics are not comparable.

The structure of Fly presentations was easier to understand.

"I always knew which part of the presentation was currently shown."

The participants had a better contentual orientation in the Fly presentations.

There was significant higher agreement to this statement in favor of Fly in the between groups analysis of the convergent evolution presentations, in the within groups analysis of group 1, and in the joined groups analysis.

"I always knew approximately how far advanced the presentation was."

The Fly presentations provided a better orientation about progress.

For this statement there was significant higher agreement in favor of Fly in all analyses: in the between groups analysis for both topics, in the within groups analysis of both groups, and in the joined groups analysis.

7.5.6 Format Preference

Half of the participants preferred Fly; one fifth preferred PowerPoint.

There were more participants that preferred Fly than participants that preferred PowerPoint. The preferences are distributed differently in the two groups. Whereas in group 1 eight students preferred Fly and no one preferred PowerPoint, in group 2 five students each preferred PowerPoint respectively Fly. See table B.18 for the answer frequencies for all participants and separately for the two groups. A one sample chi-square test showed that there is no significant format preference for neither any of the two groups (group 1: $p = 0.581$, group 2: $p = 0.735$) nor for all participants ($p = 0.152$).

7.5.7 Correlations to Spatial Cognitive Ability

To test if individuals were affected differently by the visual aids because of their spatial cognitive abilities, the data was analyzed with Pearson correlation tests to detect possible effects.

Retention and Understanding

There were no significant correlations between the participants' spatial cognitive abilities and neither the total scores of both questionnaires nor the combined scores for none of the formats, topics, or groups.

Attitude and Satisfaction

The only question for which the answers significantly correlated to the participants' spatial abilities in more than one group-topic/format-combination was "How was the amount of content shown at once?". This correlation, however, was significant for both groups, both formats, all fixies records, and all records. See table 7.21 for the results of the Pearson correlation test. The higher the spatial cognitive ability was, the more the individuals perceived the amount of content on the screen as too much.

The higher the spatial ability, the more the content chunk size was perceived as too big.

In order to test if this correlation was the same for both formats, the participants were classified into verbal and visual learners. The 10 students that scored below the mean in the cognition test formed the group of verbal learners and the nine students that scored above the mean formed the group of spatial learners. Independent samples Mann-Whitney U tests showed that the difference in the perception of the content chunk size between the two learner types was only significant for the PowerPoint presentations (PowerPoint: $p = 0.011$; Fly: $p = 0.125$). See table 7.22 for the answer frequencies of both learner types for the two formats. One should note, however, that this division into learner types is not robust since the distribution of the scores for spatial ability was normal and not bimodal.

The bad chunk size perception by visual learners occured only for the PowerPoint presentations.

Format Preference

There were no significant correlations between spatial cognitive ability and the expressed format preference.

7.5.8 Participants' Comments

In the comments about the individual presentations, the reasons for the format preference, and the study altogether, the participants expressed the following opinions.

Fly Approval

Many participants liked the good visibility of the structures, the good provided orientation, and the concentrated focus.

Among the comments was a wide approval of Fly. The participants described the visuals as "more dynamic" and "more colorful".

The comments of 13 students expressed satisfaction with the Fly presentations' structures. They mentioned the integration of the content sections into global layouts: "The partitioning of the topics and how they fit into the big picture was good."; "Good transitions from overview to detail."; "Better overview of the whole presentation and of the topics."; "I liked that the overall structure was easy to see."; "One presentation, not separate slides." (this corresponds to the argument in section 6.2.4—"Less Content Fragmentation").

The comments also described how the visuals helped for orientation: "One always has the overview, knows where one currently is, and how long sections will take. Because one knows the complexity beforehand."; "The presentation's end is better foreseeable. Therefore, one can divide up one's concentration and attention better."

Three comments were in favor of the focus on single aspects: "Highlighting of individual elements, by zooming in, allowed for concentrated listening." (confirming the argument of section 6.1.6—"Less Text on the Screen"); "The aspect that is currently talked about is always in the center, which makes concentration easier."

Two other noteworthy comments mentioned how the visuals helped to remember ("It is possible to associate the content with spatial position and color.") and that content was recapitulated ("Information is repeated, but it does not feel artificial and does not interrupt the presentation flow.") (in accordance to the argument of section 6.2.3—"More Diachronic Redundancy").

Fly Criticism

There were two main points of criticism about Fly. Six students wrote that the transition animations distracted from the content: "Sometimes too much animation. Distracted from the content."; "Animated transitions were a little distracting."; "The transition animations of Fly were irritating."

Some perceived the animations as distracting and the truncations as messy.

Five students did not like that text got truncated in Fly. They perceived this as distracting and as making the visuals look "messy": "Pictures, slides, and boxes did not fit completely into the viewport and were truncated. Appears wrong, uncomfortable, and unclean."; "I did not like that there were a lot of truncated sentences and words. This was distracting."

Furthermore, three comments dismissed the spatial arrangement and the animations as "eye-candy" and "gimmicks".

PowerPoint Criticism

Some comments explicitly criticized the "colorless" PowerPoint presentations. Three participants described problems related to the poorly provided orientation about presentation progress: "One could not see how far advanced the presentation was. It ended surprisingly."

Comments stated that the slides gave poor orientation about the progress and distracted from the commentary.

Two comments complained about the amount of content on the slides: "Sometimes there was too much text. Then it was difficult to read and listen."; "There was not enough time to read the slides completely when one wanted to listen to the commentary."

Bias Accusations

Some participants presumed that deliberately bad slides were used.

Three participants expressed the opinion that the presentations were deliberately biased, on the one hand, by using more text in the slides than in the Fly visuals (“There was ‘extra’ much text in the PowerPoint presentation.”) and, on the other hand, by using more interesting graphics in the Fly visuals (“Interesting graphics do not depend on the format.”; “Both formats can be used good and bad. Especially the PowerPoint presentation was a real bad example. This can be done better.”).

It was wrongly perceived that the slides contained more text than the Fly visuals.

Since the students saw two presentations on different topics, they did not have a clear comparison. However, the perception that the PowerPoint visuals contained more text than the Fly visuals is interesting. Since, in fact, it was the other way round (see section 7.2.4—“Presentation Visuals”). It may, therefore, be the case that text does not appear as prominent in the Fly format as on slides. Probably because of the smaller resolution of the Fly detail viewports. As described in section 7.2.4—“Presentation Visuals”, whenever the Fly visuals contained more or different graphics, this was because of the distinct possibilities of the canvas format.

7.6 Study Results

7.6.1 Retention and Understanding

Overall, no significant effect could be shown.

The only significant difference for retention and understanding between the formats was for the transfer questions in the joined groups analysis of the post-questionnaire scores. Here the scores in the records for the PowerPoint-supported presentations were significantly higher than in the records for the Fly-supported presentations. This finding, however, could not been confirmed neither with the other analysis methods of the post-questionnaire data nor in the analyses of the follow-up-questionnaire data or the combined scores. Therefore, this must be regarded as an anomaly caused by the big difference in the scores of the two presentations in group 2.

Consequently, the result of this study is that there is no significant effect for retention and understanding. Therefore, it can be said that Fly is as suited as PowerPoint for conveying information to a presentation audience. The hypothesis H1 was proven; the hypothesis H2 was disproven.

Fly is as good as PowerPoint for conveying information.

7.6.2 Attitude and Satisfaction

The perception of Fly, as revealed by the attitude and satisfaction questions, was positive in many respects. There were multiple significant results in favor of Fly, whereas, the PowerPoint presentations were not perceived as significantly better in any regard.

All but one hypotheses about the advantages of Fly could be proven.

Hypothesis H3 has been proven by this study. The students liked the Fly presentations significantly better. This may be partially caused by the novelty effect but also be rooted in Fly's more engaging nature.

Hypothesis H4 has also been proven. There was no significant difference for the answers to the question about comprehensibility, but the participants found the Fly presentations' structures significantly easier to understand. Also the numerous comments that emphasized this aspect (see section 7.5.8—"Fly Approval") support this finding. The results confirmed the argument made in section 6.2.2—"Better Orientation".

Hypothesis H5 could not be proven. There were no significant differences for the questions that asked about the content chunk size, if there was enough time to look at the content, and if the visuals distracted from the commentary. But, as described in section 7.5.8—"PowerPoint Criticism", there were comments that explicitly mentioned these problems for the PowerPoint presentations.

Hypothesis H6 has been proven in this study. While there was no significant difference for the answer to the statement "The presentation did not loose me. I was never disoriented.", there were significant differences in favor of Fly for the answers to the statements about the contentual and temporal orientation. The participants knew better which parts of the presentations were currently shown and how far advanced the presentations were. The results confirmed the argument of section 6.2.2—"Better Orientation".

7.6.3 Format Preference

Half of the participants preferred Fly over PowerPoint, but since the preference is not significant, the hypothesis H7 could not been proven.

7.7 Conclusion and Discussion

There are many related studies that failed to show a significant effect on learning achievement.

The fact that this study could not show a significant difference for learning outcome between the two conditions does not come as a surprise. This evaluation is in line with the vast body of past studies that could not show significant differences for learning achievement between alternate technologies and formats of learning support. Russell [1999] summarized these studies; they are listed on the book's companion website.[3]

Instructions cannot compromise learning unless they have serious defects.

Students seem to be able to deal with the shortcomings of suboptimal instructions. Unless the instructions have major flaws that prevent the processing of information, such as burying content or causing cognitive overload, the content will be comparably remembered and understood. In this study the visuals of both formats were designed well enough to assure that all information could be apprehended.

Students know how to deal with slide-based support.

Two further reasons might have contributed to the results of this study. On the one hand, students are used to the PowerPoint format and have learned to deal with it. For example, when confronted with a text-loaded slide, they know that they would not be able to follow the speaker if they immediately read the slide completely. Instead, they

[3] http://www.nosignificantdifference.wcet.info

either read it in chunks or wait until there is a pause in the commentary.

On the other hand, the commentary might have had an equalizing effect, since it covered all the content. There were no aspects that were only mentioned in the visuals, therefore, the students could learn everything from the commentary alone. In future studies, it may, therefore, be useful to show visuals without oral commentary or at least with a commentary that does not cover all the content. Of course, such a setup would be more dissimilar to a live presentation.

The commentary may have equalized the conditions.

Despite the lack of differences in the learning outcome, alternative formats can still provide support of different qualities with regard to how easy they make it for the learners to take in and understand the information. With a poor support the necessary cognitive effort is higher than with a good aid.

The results for attitude and satisfaction showed that Fly made it easier to understand and to follow the presentations. The integrating global layout, the animated transitions, the spatial more numerous overviews, and the colorful topic emphases conveyed the presentation structures better and provided better information about current context and presentation progress.

Fly made it easier for the students to understand and follow the presentations.

The failure to show a significant preference for the Fly format might have been because of the two aspects of the Fly visuals that the participants criticized in the comments: the animations and the content truncations. Both aspects need to be refined and improved. The quality of the animations in the records was not optimal; there were some jerking movements. Also, the use of many small path stops may have resulted in too many animations. There was too much movement and the times in which the visuals stood still were too short. The right balance between the content chunk size and the amount of animation must be found. Further refinement of the viewports could reduce the amount of truncation. With somewhat greater chunk sizes, less content will be truncated.

Specific shortcomings of the Fly visuals may have kept the students from expressing a preference in favor of Fly.

The primarily textual content might have been the reason why visual learners perceived the chunk size as inadequate.

A potential explanation for the strong correlation between spatial cognitive ability and the perception of the content chunk size may be that the highly visual learners are not as good in processing textual content. Since the visuals of both formats contained primarily textual content, they were harder for them to process. Consequently they preferred smaller amounts of content at a time. The Fly visuals had smaller chunk sizes and, therefore, the highly visual learners did not perceive them as too big. Too much text at once on the screen hurts especially individuals with a high spatial ability. By allowing for viewports of smaller resolution, the Fly format supports spatial learners better.

The results are not directly applicable to live presentations.

An important restriction of the results is that they cannot be directly applied to live presentations. There are differences between the study's recorded setup and face-to-face presentations. The most important one for the evaluation of the visual support is that viewers can pay constant attention to the visuals, whereas in a live presentation they have to switch between looking at the presenter and the visuals.

Fixies

Question/Statement	p
The presentation was interesting.	0.586
I liked the presentation's visuals.	0.322
I liked the presentation's commentary.	0.612
I liked the presentation overall.	0.238
The presentation was comprehensible.	0.326
The presentation did not loose me. I was never disoriented.	0.512
How was the speed of the presentation?	0.579
How was the amount of content shown at once?	0.143
The visuals distracted me from the spoken narration.	0.149
I had sufficient time to look at all the content on the screen.	0.608
The presentation's structure was easy to understand.	0.126
I always knew which part of the presentation was currently shown.	0.269
I always knew approximately how far advanced the presentation was.	***0.014***

Convergent Evolution

Question/Statement	p
The presentation was interesting.	0.263
I liked the presentation's visuals.	0.322
I liked the presentation's commentary.	0.914
I liked the presentation overall.	***0.029***
The presentation was comprehensible.	0.349
The presentation did not loose me. I was never disoriented.	0.329
How was the speed of the presentation?	0.695
How was the amount of content shown at once?	0.164
The visuals distracted me from the spoken narration.	0.158
I had sufficient time to look at all the content on the screen.	0.222
The presentation's structure was easy to understand.	0.079
I always knew which part of the presentation was currently shown.	***0.003***
I always knew approximately how far advanced the presentation was.	***0.006***

Significances at the 0.05 level are in ***bold italics***.

Table 7.18: Mann-Whitney U Test Results for the Between Groups Analysis of the Answers to the Attitude and Satisfaction Questions

Group 1

Question/Statement	p
The presentation was interesting.	0.878
I liked the presentation's visuals.	0.162
I liked the presentation's commentary.	0.480
I liked the presentation overall.	***0.034***
The presentation was comprehensible.	0.089
The presentation did not loose me. I was never disoriented.	0.107
How was the speed of the presentation?	0.317
How was the amount of content shown at once?	0.102
The visuals distracted me from the spoken narration.	0.388
I had sufficient time to look at all the content on the screen.	0.165
The presentation's structure was easy to understand.	***0.010***
I always knew which part of the presentation was currently shown.	***0.016***
I always knew approximately how far advanced the presentation was.	***0.026***

Group 2

Question/Statement	p
The presentation was interesting.	0.480
I liked the presentation's visuals.	1.000
I liked the presentation's commentary.	0.317
I liked the presentation overall.	1.000
The presentation was comprehensible.	0.257
The presentation did not loose me. I was never disoriented.	0.280
How was the speed of the presentation?	0.157
How was the amount of content shown at once?	0.317
The visuals distracted me from the spoken narration.	0.198
I had sufficient time to look at all the content on the screen.	0.465
The presentation's structure was easy to understand.	0.863
I always knew which part of the presentation was currently shown.	0.154
I always knew approximately how far advanced the presentation was.	***0.012***

Significances at the 0.05 level are in ***bold italics***.

Table 7.19: Wilcoxon Signed Rank Test Results for the Within Groups Analysis of the Answers to the Attitude and Satisfaction Questions

Question/Statement	p
The presentation was interesting.	0.756
I liked the presentation's visuals.	0.204
I liked the presentation's commentary.	0.248
I liked the presentation overall.	***0.047***
The presentation was comprehensible.	0.293
The presentation did not loose me. I was never disoriented.	0.612
How was the speed of the presentation?	1.000
How was the amount of content shown at once?	0.058
The visuals distracted me from the spoken narration.	0.755
I had sufficient time to look at all the content on the screen.	0.805
The presentation's structure was easy to understand.	***0.048***
I always knew which part of the presentation was currently shown.	***0.006***
I always knew approximately how far advanced the presentation was.	0.001

Significances at the 0.05 level are in ***bold italics***.

Table 7.20: Wilcoxon Signed Rank Test Results for the Joined Groups Analysis of the Answers to the Attitude and Satisfaction Questions

		Pearson's r	p (2-tailed)	N
Grp. 1	Fixies (Fly)	0.554	0.122	9
	Evolution (PPT)	0.489	0.182	9
	Total	0.469	***0.050***	18
Grp. 2	Fixies (PPT)	0.602	0.065	10
	Evolution (Fly)	0.362	0.304	10
	Total	0.481	***0.032***	20
All	Fixies	0.566	***0.011***	19
	Evolution	0.399	0.091	19
	Fly	0.456	***0.050***	19
	PowerPoint	0.527	***0.020***	19
	Total	0.469	***0.003***	38

Significances at the 0.05 level are in ***bold italics***.

Table 7.21: Pearson Test Results for the Correlation Between Spatial Ability and Answers to the Question "How was the amount of content shown at once?"

PowerPoint

	Verbal Learners		Visual Learners	
	Frequency	Percent	Frequency	Percent
too little	1	10.0	0	0.0
about right	8	80.0	3	33.3
too much	1	10.0	6	66.7

Fly

	Verbal Learners		Visual Learners	
	Frequency	Percent	Frequency	Percent
too little	0	0.0	0	0.0
about right	10	100.0	7	77.8
too much	0	0.0	2	22.2

Table 7.22: Answer Frequencies to the Question “How was the amount of content shown at once?” by Learner Types

Chapter 8

Summary and Future Work

8.1 Summary and Contributions

First, related systems for alternative presentation visuals were analyzed and their specific benefits and drawbacks were identified. In addition, 50 publicly available Prezi documents were evaluated with regard to how authors use a canvas-based presentation format. As a result, the features of Prezi that led to shortcomings in the created documents were identified. The evaluation confirmed results of the previous authoring evaluations of Fly, in particular, the creation of meaningful layouts and the use of zooming and overviews in the presentation paths.

Related alternative systems and a sample of canvas-based presentation documents were analyzed.

The Prezi authors created meaningful as well as decorative layouts. Most of the meaningful layouts were structured into topic areas. In the majority of documents the content was classified into one to three hierarchy levels. The authors used viewports of variable sizes in their presentation paths. The majority of presentation paths incorporated overviews and all presentations drew attention to single content elements. The authors used element rotation primarily for decorative purposes, such as decorative canvas layouts and dramatic viewport transitions. Orientation manipulation, however, is harmful to the conveyance

Most authors created well structured meaningful layouts.

Some authors misused element rotation and frame elements.

of the spatial structure to the audience. This consequence was probably not considered by the authors. Prezi's rectangular frame elements can resemble slide frames and they where in fact use like slide frames in nine documents.

Based on a design rationale, the Fly concept was refined and extended.

Second, the concept and design for the next Fly version was developed. A design rationale was derived from the results of the previous version's evaluation and from the analyses of the related systems.

The usability issues of the previous version were addressed.

The developed concept addresses the usability issues that occurred in the prior authoring evaluation. The canvas navigation controls of the previous Fly version were hard to discover and understand by users. They were replaced with interactions that are established by other document handling applications. Also the association of element types with zoom levels caused usability problems. The concept of topic elements on dedicated zoom levels was dismissed and instead semantic topics were introduced as a means for classifying the content and structuring the canvas.

Fly's capabilities were extended with new features.

The new design also extends Fly's capabilities. Features that exist in slideware applications but that were missing in Fly were adapted to the canvas format. These are the support for animated builds, video elements, and presenter notes and the possibility for a private presenter screen. Moreover, the Fly format was extended by path alternatives, editing capabilities for existing paths and path stops, path stop clean/dirty states, and a varying content display depending on the presentation progress.

A software prototype was implemented.

Third, a software prototype of the new Fly version was developed. Not the complete design was realized; instead, primarily the functionalities that were used in the audience study have been implemented. These are, on the one hand, the features that are relevant for presentation authoring and, on the other hand, the display of the visuals during presentation delivery. The prototype was implemented based on a maintainable and extensible software architecture that allows for future continued development.

Last, the Fly format was evaluated in an experimental audience study against the baseline PowerPoint. In a mixed between and within groups design, recorded informative presentations were shown to groups of university students. Presentation recordings were used instead of live presentations to prevent the speaker's equalizing influence and to achieve a more controlled setup. The videos showed the visual aid together with a spoken commentary. The participants were tested for fact and macrostructure retention as well as content understanding directly after the presentations and after four days. The students were also asked about their attitude towards and satisfaction with the presentations and their format preference.

Fly's effectiveness for knowledge transfer and the perception of Fly visuals by audiences were evaluated.

No significant difference for learning achievement between the conditions could be found, but the students liked the Fly visuals better, could understand the structures of the Fly presentations more easily, and were better informed about the current contentual context and the presentation progress during the Fly presentations. Half of the participants preferred Fly and one fifth preferred PowerPoint, but the preference was not statistically significant. The evaluation also examined if the two formats affect verbal and visual learners differently. There was no correlation to learning achievement, but individuals with a high spatial ability perceived the amount of content on the slides as too much. This was not the case for the viewports of the Fly presentations. The study could show that Fly is as suited as PowerPoint for conveying information to audiences. Moreover, Fly made it easier for viewers to understanding and follow the presentations.

There was no significant effect on learning outcome, but Fly made it easier to understand and follow the presentations.

Feedback from study participants showed that special attention must be paid to the amount of animation and content truncation in the Fly visuals. Too much of both can distract the viewers. The right balance must be found between content chunk size and the focus on single content elements.

Study participants identified shortcomings in the Fly visuals.

For the study, an experienced PowerPoint author created the PowerPoint and Fly visuals. The fixed low resolution of slides made it difficult to partition the content, to fit the content onto slides, and to integrate texts with images. In Fly, the available space was not limited which led to less

Qualitative observations of the authoring process with PowerPoint and Fly were made.

abbreviated texts, the use of more images, and a tighter integration of images and texts. In the presentation path the author used much more path stops than there were slides in the corresponding PowerPoint documents. The viewports had variable resolutions; many stops focused on single aspects; and overlapping viewports were used to incrementally reveal content. The author found overviews effortless to create and used them to preview and recapitulate content. The act of arranging the content on the canvas led to additional reasoning about the relationships between content sections. As a consequence, the presentation sequences were refined. These improvements were adopted in the prior created PowerPoint documents. On the Fly canvases, unique large-scale layouts were created that could not be adapted in slides, for example, horizontal timeline layouts for historic content. The qualitative observations of the authoring process confirmed results of the previous authoring evaluation of Fly, such as the use of top-down authoring strategies, Fly's advantage for capturing topic structures, the utilization of more content, and the use of zooming and overviews in the presentation paths.

8.2 Future Work

The Fly application is in an early and incomplete state.

The Fly application can be developed further towards a ready-to-use application. The features that were designed but not realized in this thesis should be integrated into the application.

Fly can be extended further with features for authors and presenters.

There are also further functionalities that could improve Fly, for example, a search function within Fly documents. Search should not only be possible during authoring, but also during presentation delivery. To facilitate the adaption of Fly, there could be an import function that would allow to import existing slide decks. The authoring capabilities could be extended with assistances for element alignment. The private presenter screen could not only be accessible on a computer screen, but may also be implemented as a remote application for large screen mobile devices such as the *iPhone* or the *iPad*. The new features that have been added to Fly in this thesis as well as those that may be added in the future need to be evaluated with regard to how good they work for users.

Best practices for Fly documents should be specified.

The shortcomings of the Fly visuals that the audience study identified, the amount and quality of the animations and the amount of content truncation, should be examined and addressed. Future work should investigate what document designs work best for the viewers.

Future work should evaluate how Fly can assist presenters.

Since the Fly format has now been evaluated with regard to presentation authoring and with regard to perception by the audience, the third perspective that should be evaluated is presentation delivery. It should be examined how well the Fly format supports the presenter, in particular, during improvisation. Is it easier to react to the audience, adapt the presentation, and access specific content? Can presentation delivery be less scripted and more flexible? The argument for Fly in this regard was made in section 6.2.6—"Greater Support for Adaptation".

Appendix A

Audience Study Questionnaires

A.1 Pre-presentations Questionnaire

See table A.1 for the original German questionnaire and table A.2 for an English translation.

A.2 Post-presentations Questionnaire

A.2.1 Retention and Understanding Questions

Fixies—Single Speed/Fixed Gear Bikes

See table A.3 for the original German questions and table A.4 for an English translation. Correct answers are in *italics*.

Convergent Evolution—Marsupials and Placentals

See table A.5 for the original German questions and table A.6 for an English translation. Correct answers are in *italics*.

A.2.2 Attitude and Satisfaction Questions

See table A.7 for the original German questions and table A.8 for an English translation. The post-questionnaire contained these questions twice—once for each presentation/topic.

A.2.3 Format Preference Questions

See table A.9 for the original German questions and table A.10 for an English translation.

A.3 Follow-up-questionnaire

A.3.1 Fixies—Single Speed/Fixed Gear Bikes

See tables A.11 and A.12 for the original German questions and tables A.13 and A.14 for an English translation. Correct answers are in *italics*.

A.3.2 Convergent Evolution—Marsupials and Placentals

See table A.15 for the original German questions and table A.16 for an English translation. Correct answers are in *italics*.

Demografische Daten
Was ist dein Geburtsjahr?
Was ist dein Geschlecht? männlich, weiblich
Was ist deine Muttersprache?
Was ist dein Studiengang?
Dein wievieltes Semester ist dies? *(Bei Zweit-/Aufbaustudium inklusive der Semester aus dem vorherigen Studium.)*

Selbsteinschätzung
Ich interessiere mich für das Thema Single-Speed/Fixie Fahrräder und Fahrradtechnik. 1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)
Wie würdest du dein Wissen über Single-Speed/Fixie Fahrräder und Fahrradtechnik einschätzen? 1 (Thema ist komplett unbekannt), 2, 3, 4, 5 (Thema ist ausführlich bekannt)
Ich interessiere mich für das Thema Evolution der Säugetiere und Parallelevolution von höheren Säugetieren und Beutelsäuger. 1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)
Wie würdest du dein Wissen über Evolution der Säugetiere und Parallelevolution von höheren Säugetieren und Beutelsäuger einschätzen? 1 (Thema ist komplett unbekannt), 2, 3, 4, 5 (Thema ist ausführlich bekannt)
Wenn deutsch nicht deine Muttersprache ist, wie würdest du deine Deutschkenntnisse einschätzen? 1 (keine Kenntnisse), 2, 3, 4, 5 (sehr gute Kenntnisse)

Präferenz
Welche Form von visueller Unterstützung von Präsentationen bevorzugst du als Zuseher? computerbasierte Darstellung, analoge Overhead-Folien, Tafel/Whiteboard, keine visuelle Unterstützung, keine Präferenz

Table A.1: Original German Pre-presentations Questions

Demographic Information

In what year were you born?
What is your gender?
  male, female
What is your native language?
What is your course of studies?
How many semester did you study so far?

Self-assessment

I am interested in single speed/fixed gear bikes and bicycle technology.
  1 (completely agree), 2, 3, 4, 5 (completely disagree)
How would you assess your knowledge about single speed/fixed gear bikes and bicycle technology?
  1 (poor), 2, 3, 4, 5 (excellent)
I am interested in evolution of mammals and parallel evolution of placentals and marsupials.
  1 (completely agree), 2, 3, 4, 5 (completely disagree)
How would you assess your knowledge about evolution of mammals and parallel evolution of placentals and marsupials?
  1 (poor), 2, 3, 4, 5 (excellent)
If German is not your native language, how would you assess your knowledge of the German language?
  1 (poor), 2, 3, 4, 5 (excellent)

Preference

What kind of visual support for presentations do you prefer?
  computer visuals, overhead transparencies, black-/whiteboard, no visual support, do not care

Table A.2: English Translations of the Pre-presentations Questions

Fact Questions (In Visuals and Narration)
Wann gab es die erste Kettenschaltung?
1924, *1940*, 1950
Welche Übersetzung ist beim Kunstradfahren gebräuchlich?
1:1, 1:2, 2:1

Fact Questions (Only in Narration)
Bei einem ungleichmäßigen Trittstil wird…
…*hauptsächlich während der Abwärtsbewegung der Füße Kraft ausgeübt.*
…beim bergab fahren die Pedalbewegung gebremst.
…der Hinterreifen einseitig abgenutzt.
Was ist die richtige Reihenfolge der Radtypen nach gängiger Übersetzung (von klein zu groß)?
Kunstrad, Bike Polo, Mountain Bike
Bahnrad, Bike Polo, Kunstrad
Strasse, Mountain Bike, Bahnrad

Macrostructure Questions (In Visuals and Narration)
Warum verlagert man beim Skid Stop das Körpergewicht nach vorne?
Für ein besseres Gefühl für den Grip des Hinterrades.
Um Skid Patches zu verhindern.
Um den Antrieb des Hinterrades zu reduzieren.
Warum sind vertikale Ausfallenden an der Hinterradaufhängung schlechter für Fixies geeignet?
Sie machen das Spannen der Kette schwieriger.
Sie verhindern die Montage eines Lockringes.
Sie machen eine gerade Kettenlinie schwieriger.

Macrostructure Questions (Only in Narration)
Warum sind mit dem "runden Tritt" höhere Trittfrequenzen möglich?
Es liegt mehr Gewicht auf dem Hinterrad.
Der Körperschwerpunkt bleibt mittig.
Man hat ein direkteres Fahrgefühl.

Transfer Questions
Warum kann man sich mit einem Fixie nicht so stark in die Kurve legen?
Weil der Körperschwerpunkt mittig gehalten werden muss.
Wegen den schmalen Lenkern kann man die Balance schlechter halten.
Weil die Pedale nicht auf horizontaler Position gehalten werden können.
Wovon ist die Anzahl der Skid Patches am Hinterreifen abhängig?
der Übersetzung, der Laufradgröße, der Kurbellänge

Table A.3: Original German Post-presentations Retention and Understanding Questions About Fixies

Fact Questions (In Visuals and Narration)
When were the first derailleur gears invented?
1924, *1940*, 1950
Which gear ratio is used for trick cycling?
1:1, 1:2, 2:1

Fact Questions (Only in Narration)
When pedaling unevenly…
…force is exerted primarily during the downward movement of the feet.
…the pedal movement is slowed down when driving downhill.
…the rear tire is worn off unevenly.
What is the correct order of bicycle types ordered by usual gear ratio (from small to large)?
trick bike, bike polo, mountain bike
track bike, bike polo, trick bike
street bike, mountain bike, track bike

Macrostructure Questions (In Visuals and Narration)
Why do drivers shift their weight to the front during a skid stop?
For a better sense of the rear wheel's grip.
To avoid skid patches.
To reduce the rear wheel's drive.
Why are vertical dropouts at the rear suspension ill-suited for Fixies?
They make it harder to tighten the chain.
They make it impossible to mount a lock ring.
They make it harder to achieve a straight chain line.

Macrostructure Questions (Only in Narration)
Why is it possible to achieve greater cadences with the "round stroke"?
More weight is shifted to the rear wheel.
The body's mass center stays centered.
The driving experience is more direct.

Transfer Questions
Why is it not possible to lean as steep into the curves with a Fixie?
Because the body's mass center must be kept centered.
Because of the narrower handlebars, it is harder to keep the balance.
Because the pedals cannot be kept in a horizontal position.
What influences the number of skid patches on the rear tire?
the gear ration, the wheel size, the crank length

Table A.4: English Translations of the Post-presentations Retention and Understanding Questions About Fixies

Fact Questions (In Visuals and Narration)
Wie hoch ist der Anteil der höheren Säugetieren an den heute lebenden Säugetierarten?
72%, 86%, *94%*
Wie schwer ist der Wurf von Beuteltieren anteilig zum Gewicht der Mutter?
< 1%, 1–5%, 5–10%

Fact Questions (Only in Narration)
Wie viele Arten der eierlegenden Ursäuger/Kloakentiere leben heute noch?
2, *5*, 10
Was führte zum Aussterben des Beutelwolfs?
Bejagung durch den Menschen, Verdrängung durch höhere Säugetiere, Eingeschleppte Parasiten

Macrostructure Questions (In Visuals and Narration)
Was ist die richtige Reihenfolge der Erdzeitalter (von ältestem zu neuestem)?
Neogen, Kreidezeit, Paläozän
Paläozän, Kreidezeit, Neogen
Kreidezeit, Paläozän, Neogen
Wodurch starben die Beutelsäuger Ende der Kreidezeit in Nordamerika aus?
Einwanderung höherer Säugetiere aus Asien
Einwanderung höherer Säugetiere aus Südamerika
Klimatische Veränderungen durch die Eiszeit und Bejagung durch den Menschen

Macrostructure Questions (Only in Narration)
Welche beiden Faktoren werden für das weltweite Aussterben der meisten großen Säugetierarten im Zeitraum von vor 51—38 Tsd. Jahren verantwortlich gemacht?
Kontinentalverschiebung und klimatische Veränderungen durch die Eiszeit.
Bejagung durch den Menschen und klimatische Veränderungen durch die Eiszeit.
Verdrängung durch den Menschen und Verwaldung der offenen Grasflächen.

Transfer Questions
Was war für den Aufbau der inneren Systematik der Beutelsäuger maßgeblich?
Die Abtrennung Australiens von den anderen Kontinenten.
Die Besetzung gleicher ökologischer Nischen wie die höheren Säugetiere.
Die Bejagung durch den Menschen.

Table A.5: Original German Post-presentations Retention and Understanding Questions About Convergent Evolution

Fact Questions (In Visuals and Narration)

How large is the placentals' share of the mammals living today?
  72%, 86%, *94%*
How heavy is the litter of marsupials proportional to the mother's weight?
  < 1%, 1–5%, 5–10%

Fact Questions (Only in Narration)

How many species of monotremes are still living today?
  2, *5*, 10
What caused the extinction of the Tasmanian tiger?
  hunting by man, crowding out by placentals, introduced parasites

Macrostructure Questions (In Visuals and Narration)

What is the correct sequence of the geologic eras (from oldest to newest)?
  Neogene, Cretaceous, Paleocene
  Paleocene, Cretaceous, Neogene
  Cretaceous, Paleocene, Neogene
What caused the extinction of the marsupials in North America at the end of the Cretaceous?
  Immigration of placentals from Asia
  Immigration of placentals from South America
  Climatic changes caused by the ice age and hunting by man

Macrostructure Questions (Only in Narration)

To which two factors is the worldwide extinction of most big mammal species in the period 51–38 thousand years ago attributed to?
  Continental drift and climatic changes caused by the ice age
  Hunting by man and climatic changes caused by the ice age
  Crowding out by man and overgrowth of open grass areas

Transfer Questions

What was constitutive for the structure of the marsupials' inner systematics?
  The separation of Australia from the other continents
  The occupation of the same ecological niches as the placentals
  Hunting by man

Table A.6: English Translations of the Post-presentations Retention and Understanding Questions About Convergent Evolution

Attitude Questions
Die Präsentation war interessant.
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)
Mir gefielen die gezeigten Darstellungen.
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)
Mir gefiel die gesprochene Narration.
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)
Mir gefiel die Präsentation insgesamt.
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)

Satisfaction Questions
Die Präsentation war verständlich.
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)
Ich konnte der Präsentation immer folgen. Ich habe nie die Orientierung verloren.
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)
Wie war die Geschwindigkeit der Präsentation?
1 (zu langsam), 2 (ungefähr richtig), 3 (zu schnell)
Wie war die Menge an Inhalt die auf einmal gezeigt wurde?
1 (zu wenig), 2 (ungefähr richtig), 3 (zu viel)
Die Darstellungen haben mich von der gesprochenen Narration abgelenkt.
1 (sehr oft), 2, 3, 4, 5 (nie)
Ich hatte genügend Zeit alle gezeigten Inhalte anzusehen.
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)
Die Struktur der Präsentation war einfach zu verstehen.
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)
Ich wußte immer welcher inhaltliche Teil der Präsentation gerade gezeigt wird.
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)
Ich wußte immer wie weit die Präsentation inhaltlich fortgeschritten ist.
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)

Learning Questions
Woher hast du die meisten Information erhalten?
1 (von den gezeigten Darstellungen), 2 (von der gesprochenen Narration), 3 (ungefähr gleich viel von beiden)
Ich habe mir Informationen aufgrund ihrer räumlichen Position gemerkt. *(Nur wenn du diese Präsentation im Fly-Format gesehen hast.)*
1 (stimme voll zu), 2, 3, 4, 5 (stimme gar nicht zu)

Open Questions
Was hat dir an der Präsentation gefallen oder nicht gefallen?

Table A.7: Original German Post-presentations Attitude and Satisfaction Questions

Attitude Questions
The presentation was interesting.   1 (completely agree), 2, 3, 4, 5 (completely disagree)
I liked the presentation's visuals.   1 (completely agree), 2, 3, 4, 5 (completely disagree)
I liked the presentation's commentary.   1 (completely agree), 2, 3, 4, 5 (completely disagree)
I liked the presentation overall.   1 (completely agree), 2, 3, 4, 5 (completely disagree)
Satisfaction Questions
The presentation was comprehensible.   1 (completely agree), 2, 3, 4, 5 (completely disagree)
The presentation did not loose me. I was never disoriented.   1 (completely agree), 2, 3, 4, 5 (completely disagree)
How was the speed of the presentation?   1 (too slow), 2 (about right), 3 (too fast)
How was the amount of content shown at once?   1 (too little), 2 (about right), 3 (too much)
The visuals distracted me from the spoken narration.   1 (very often), 2, 3, 4, 5 (never)
I had sufficient time to look at all the content on the screen.   1 (completely agree), 2, 3, 4, 5 (completely disagree)
The presentation's structure was easy to understand.   1 (completely agree), 2, 3, 4, 5 (completely disagree)
I always knew which part of the presentation was currently shown.   1 (completely agree), 2, 3, 4, 5 (completely disagree)
I always knew approximately how far advanced the presentation was.   1 (completely agree), 2, 3, 4, 5 (completely disagree)
Learning Questions
Where did you get most of the information from?   1 (the visuals), 2 (the narration), 3 (about equal from both)
I remembered information based on its spatial location. *(Only for the Fly presentation.)*   1 (completely agree), 2, 3, 4, 5 (completely disagree)
Open Questions
What did you like/dislike about the presentation?

Table A.8: English Translations of the Post-presentations Attitude and Satisfaction Questions

Welches Darstellungsformat hat dir besser gefallen?
PowerPoint, Fly, keine Präferenz
Was sind Gründe für deine Präferenz?
Weitere Anmerkungen

Table A.9: Original German Post-presentations Format Preference and Comments Questions

Which format do you prefer?
PowerPoint, Fly, no preference
What are reasons for your preference?
Anything else?

Table A.10: English Translations of the Post-presentations Format Preference and Comments Questions

Fact Questions (In Visuals and Narration)

Wann wurde die erste Freilaufnabe erfunden?
  1900, 1902, 1940
Die Übersetzung eines Fahrrades wird größer und damit schwerer zu treten, je…
  …größer die Kurbel und je kleiner das Ritzel.
  …kleiner das Kettenblatt und je größer das Ritzel.
  …größer das Kettenblatt und je kleiner das Ritzel.

Fact Questions (Only in Narration)

Warum sind Kettenspanner an Fixies nicht beliebt?
  Sie führen zu einer schnelleren Abnutzung der Kette.
  Mit ihnen wird zusätzliche Technik am Fahrrad angebracht.
  Sie verändern das Übersetzungsverhältnis.
Mit einem schmalen Lenker…
  …ist es leichter die Balance zu halten.
  …müssen die Arme für eine Lenkbewegung weniger bewegt werden.
  …kann man sich stärker in die Kurve legen.

Macrostructure Questions (In Visuals and Narration)

Warum muss beim Fixie das Ritzel mit einem Lockring blockiert werden?
  Beim Pedalkontern wirken Kräfte gegen die Laufrichtung.
  Bei hohen Übersetzungen wirken beim Anfahren starke Kräfte.
  Damit die Kette beim Pedalkontern nicht abspringt.
Die Übersetzung ist ein Kompromiss aus…
  …der maximalen Geschwindigkeit auf ebener Strecke und bergab und der ergonomisch sinnvollen Kurbellänge.
  …der ergonomisch sinnvollen Kurbellänge und der maximal tretbaren Steigung bergauf.
  …der maximalen Geschwindigkeit auf ebener Strecke und bergab und der maximal tretbaren Steigung bergauf.

Macrostructure Questions (Only in Narration)

Was ist Voraussetzung für eine Rücktrittbremse?
  Freilauf, Vertikale Ausfallenden, Nabenschaltung

continued in table A.12

Table A.11: Original German Follow-up Retention and Understanding Questions About Fixies (Part 1/2)

continued from table A.11

Transfer Questions
Die Übersetzung eines Fahrrades wird durch das Verhältnis der Zähne an Kettenblatt und Ritzel angegeben.
Das ist eine Vereinfachung. Eigentlich sollten das Größenverhältnis von Kettenblatt und Ritzel verwendet werden da die Zahngröße variieren kann.
Das ist sinnvoll, da die Zahngröße an Kettenblatt und Ritzel gleich groß sein muss.
Das ist eine Vereinfachung. Eigentlich sollte das Größenverhältnis von Kurbel und Ritzel verwendet werden.
Wenn man ein Fahrrad mit Kettenschaltung zu einem Fixie umbaut ist es nicht einfach eine gerade Kettenlinie zu erreichen, weil…
…die Hinterradaufhängung zu breit ist.
…die Hinterradaufhängung meist vertikale Ausfallenden hat.
…die Hinterradaufhängung kein gegenläufiges Gewinde für einen Lockring hat.

Table A.12: Original German Follow-up Retention and Understanding Questions About Fixies (Part 2/2)

Fact Questions (In Visuals and Narration)

When was the first freehub invented?
1900, 1902, 1940
The gear ratio of a bicycle is larger and harder to pedal the...
...bigger the crank and the smaller the sprocket wheel.
...smaller the chain wheel and the bigger the sprocket wheel.
...bigger the chain wheel and the smaller the sprocket wheel.

Fact Questions (Only in Narration)

Why are chain tighteners for Fixies not popular?
Because they increase the wearing of the chain.
Because with them additional technology is mounted onto the bike.
Because they change the gear ratio.
With a narrow handlebar...
...it is easier to keep the balance.
...the arms need to be moved less for a steering movement.
...it is possible to lean stronger into the curve.

Macrostructure Questions (In Visuals and Narration)

Why is it necessary to block the sprocket wheel of a Fixie with a lock ring?
When backpedaling forces exert against the rolling direction.
With high gear ratios strong forces exert when starting.
To prevent the chain from coming off when backpedaling.
The gear ratio is a compromise between...
...the maximum speed on level ground and downhill and the ergonomically reasonable crank length.
...the ergonomically reasonable crank length and the maximum possible uphill incline.
...the maximum speed on level ground and downhill and the maximum possible uphill incline.

Macrostructure Questions (Only in Narration)

What is the prerequisite for a coaster brake?
a freehub, vertical dropouts, hub gears

continued in table A.14

Table A.13: English Translations of the Follow-up Retention and Understanding Questions About Fixies (Part 1/2)

continued from table A.13

Transfer Questions
The gear ratio of a bicycle is specified by the number of sprockets at the chain wheel and the sprocket wheel.
This is a simplification. Actually the sizes of the chain wheel and the sprocket wheel should be used.
This is meaningful, as the sprocket size at chain and sprocket wheel need to be equal.
This is a simplification. Actually the sizes of the crank and the sprocket wheel should be used.
When converting a bicycle with derailleur gears to a Fixie, it is not easy to achieve a straight chain line, because…
…the rear suspension is to wide.
…the rear suspension usually has vertical dropouts.
…the rear suspension has no oppositely directed thread for a lock ring.

Table A.14: English Translations of the Follow-up Retention and Understanding Questions About Fixies (Part 2/2)

Fact Questions (In Visuals and Narration)
Was versteht man unter Konvergenz in der Evolution?
Die Ausbildung gleicher Merkmale bei verwandten Arten.
Die Ausbildung gleicher Merkmale bei nicht-verwandten Arten.
Die Trennung von Evolutionslinien (z.Bsp. durch Kontinentalverschiebung).
Welche Art der höheren Säugetiere ist das konvergente Pendant des Koalabären?
Der Braunbär, Der Schwarzbär, *Der Koala hat keinen Pendant bei den höheren Säugetieren.*

Fact Questions (Only in Narration)
Was versteht man unter Homologie in der Evolution?
Die Ausbildung ähnlicher Gattungen in getrennten Evolutionslinien.
Ähnlichkeiten zwischen Arten aufgrund ihrer Verwandschaft.
Die Trennung von Evolutionslinien (z.Bsp. durch Kontinentalverschiebung).
Was ist bei Beutesäugern bei der Geburt bereits gut entwickelt?
die Vordergliedmaßen, die Augen, das Fell

Macrostructure Questions (In Visuals and Narration)
Warum ist bei den meisten Beutelsäugerarten biologisch keine längere Trächtigkeitszeit möglich?
Weil sonst das Immunsystem des Jungtieres aktiv werden würde.
Weil sie keine separaten Geschlechtsöffnungen haben.
Weil sie keine Plazenta entwickeln.
Was führte zum Aussterben vieler Beutelsäugerarten in Südamerika?
Einwanderung von Arten aus der Antarktis.
Einwanderung von Arten aus Nordamerika.
Einwanderung von Arten aus Asien.

Transfer Questions
Wie nützt den Arten der höheren Säugetiere der ungleich verteilte Energieaufwand während der Tragezeit?
Sie können Territorien bevölkern in denen es eine wechselnd gute Nahrungsversorgung gibt.
Sie können schneller ein neues Junge zur Welt bringen wenn das erste Junge stirbt.
Sie können mehrere Junge pro Wurf zur Welt bringen.

Table A.15: Original German Follow-up Retention and Understanding Questions About Convergent Evolution

Fact Questions (In Visuals and Narration)

What is meant by convergence in evolution?
- The formation of equal features in related species.
- *The formation of equal features in unrelated species.*
- The separation of evolutionary lines (e.g., because of continental drift).

Which species is the convergent placental counterpart of the koala?
- the brown bear, the black bear, *the koala has no placental counterpart*

Fact Questions (Only in Narration)

What is homology in evolution?
- The formation of similar species in separated evolutionary lines.
- *Similarities between species because of their relationship.*
- The separation of evolutionary lines (e.g., because of continental drift).

What is already well developed with marsupials at the time of birth?
- *the front limbs*, the eyes, the fur

Macrostructure Questions (In Visuals and Narration)

Why is with the most marsupial species a longer pregnancy not possible?
- Because else the immune system of the young would become active.
- Because they have no separate reproduction opening.
- *Because they develop no placenta.*

What lead to the extinction of many marsupial species in South America?
- The immigration of species from the Antarctica.
- *The immigration of species from North America.*
- The immigration of species from Asia.

Transfer Questions

How do placental species benefit from the unequally distributed energy demand during the pregnancy?
- *They can populate areas with changing food supply.*
- They can give birth to a new young faster if the first young dies.
- They can give birth to multiple young with one litter.

Table A.16: English Translations of the Follow-up Retention and Understanding Questions About Convergent Evolution

Appendix B

Audience Study Statistics

B.1 Pre-presentations Questionnaire

See table B.1 for the statistics of demographic data and table B.2 for the statistics of interest and prior knowledge. Questions had a five-point Likert scale format, from one (completely agree) to five (completely disagree) for interest and from one (poor) to five (excellent) for prior knowledge. Table B.3 lists the frequencies of presentation support preference. Table B.4 contains the statistics for spatial ability.

		All	Group 1	Group 2
N	Male	23	10	13
	Female	3	3	0
	Total	26	13	13
Year of Birth	Mean	1984.65	1984.46	1984.85
	SD	3.752	4.196	3.412
	Minimum	1976	1976	1977
	Maximum	1988	1988	1988
Semesters	Mean	9.27	9.15	9.38
	SD	4.813	5.257	4.538
	Minimum	5	5	5
	Maximum	21	21	18

Table B.1: Statistics of the Study Participants' Gender, Year of Birth, and Semesters Studied

Group 1

		Fixies		Evolution	
		Interest	Prior Knowl.	Interest	Prior Knowl.
N	Valid	12	12	11	11
	Excluded	1	1	2	2
Median		4.5	1	4	2
Mode		5	1	4	2
Range		4	2	3	2

Group 2

		Fixies		Evolution	
		Interest	Prior Knowl.	Interest	Prior Knowl.
N	Valid	11	11	12	12
	Excluded	2	2	1	1
Median		4	1	3	2
Mode		4	1	3	2
Range		4	1	3	2

All Participants

		Fixies		Evolution	
		Interest	Prior Knowl.	Interest	Prior Knowl.
N	Valid	23	23	23	23
	Excluded	3	3	3	3
Median		4	1	3	2
Mode		5	1	2*	2
Range		4	2	3	2

* Multiple modes exist. The smallest value is shown.

Table B.2: Statistics of the Interest in and Prior Knowledge About the Topics

Group 1

	Frequency	Percent	Valid Percent
Computer-based	9	69.2	75.0
Black-/Whiteboard	2	15.4	16.7
No Preference	1	7.7	8.3
Missing	1	7.7	

Group 2

	Frequency	Percent	Valid Percent
Computer-based	10	76.9	83.3
Black-/Whiteboard	2	15.4	16.7
No Preference	0	0.0	0.0
Missing	1	7.7	

All Participants

	Frequency	Percent	Valid Percent
Computer-based	19	73.1	79.2
Black-/Whiteboard	4	15.4	16.7
No Preference	1	3.8	4.2
Missing	2	7.7	

Table B.3: Answer Frequencies to the Question About Presentation Support Preference

		All	Group 1	Group 2
N	Valid	19	9	10
	Missing	7	4	3
Mean		127.32	126.22	128.30
Std. Deviation		21.011	22.191	21.045
Minimum		86	86	100
Maximum		160	159	160

Table B.4: Statistics of the Spatial Cognitive Ability Test Scores

B.2 Retention and Understanding

B.2.1 Group Comparison

See table B.5 for the statistics for both groups.

B.2.2 Topic Comparison

See table B.6 for the statistics for both topics.

B.2.3 Separate Groups

See the tables B.7, B.8, and B.9 for the statistics of both questionnaires separately and for the combined scores.

B.2.4 Joined Groups

See the tables B.10, B.11, and B.12 for the statistics of both questionnaires separately and for the combined scores.

Post-questionnaire

Question Category	Group 1			Group 2		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	23	73.913	29.6555	23	84.783	23.5236
Fact Narration Only	23	67.391	35.7030	23	71.739	33.1185
Fact Total	23	70.652	25.7304	23	78.261	20.3720
Struct. Visuals & Narration	23	58.696	41.7029	23	65.217	31.7475
Struct. Narration Only	23	39.130	49.9011	23	65.217	48.6985
Structure Total	23	52.174	24.2610	23	65.218	25.5821
Transfer	23	58.696	38.8826	23	50.000	45.2267
Total	23	62.018	18.2665	23	69.868	18.8000

Follow-up-questionnaire

Question Category	Group 1			Group 2		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	18	50.000	45.3743	23	54.348	39.6377
Fact Narration Only	18	77.778	30.7849	23	80.435	24.9505
Fact Total	18	63.889	26.0404	23	67.391	23.1531
Struct. Visuals & Narration	18	66.667	34.2997	23	78.261	33.1185
Struct. Narration Only	18	27.778	46.0889	23	39.130	49.9011
Structure Total	18	63.889	30.3849	23	77.537	31.2242
Transfer	18	30.556	42.4918	23	43.478	45.9850
Total	18	57.496	18.0466	23	66.252	19.6004

Combined Scores

Question Category	Group 1			Group 2		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	18	59.722	27.3040	23	69.565	26.0643
Fact Narration Only	18	72.222	24.0845	23	76.087	20.6131
Fact Total	18	65.972	15.3426	23	72.826	17.1276
Struct. Visuals & Narration	18	63.889	27.4159	23	71.739	22.9925
Struct. Narration Only	18	41.667	39.2953	23	69.565	41.9392
Structure Total	18	56.852	17.6555	23	70.725	21.2951
Transfer	18	43.056	29.4628	23	46.739	31.3560
Total	18	58.706	11.9133	23	67.923	16.1508

Table B.5: Statistics of the Retention and Understanding Scores of Both Groups

Post-questionnaire

Question Category	Fixies			Evolution		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	21	73.810	25.5883	21	80.952	29.4796
Fact Narration Only	21	78.571	29.8807	21	59.524	37.4802
Fact Total	21	76.190	18.5003	21	70.238	28.0836
Struct. Visuals & Narration	21	80.952	24.8807	21	47.619	40.2374
Struct. Narration Only	21	38.095	49.7613	21	66.667	48.3046
Structure Total	21	66.668	23.5714	21	53.968	26.8267
Transfer	21	69.048	24.8807	21	38.095	49.7613
Total	21	71.430	17.4168	21	60.119	20.3942

Follow-up-questionnaire

Question Category	Fixies			Evolution		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	19	28.947	30.3488	19	73.684	42.0596
Fact Narration Only	19	92.105	18.7317	19	63.158	32.6688
Fact Total	19	60.526	15.1744	19	68.421	34.1993
Struct. Visuals & Narration	19	81.579	29.8632	19	63.158	40.2841
Struct. Narration Only	*questions only for fixies*					
Structure Total	19	78.948	22.7995	19	63.158	40.2841
Transfer	19	23.684	30.5888	19	47.368	51.2989
Total	19	58.480	14.2715	19	63.908	27.5068

Combined Scores

Question Category	Fixies			Evolution		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	19	51.316	21.2029	19	75.000	32.2749
Fact Narration Only	19	86.842	17.4173	19	57.895	25.0730
Fact Total	19	69.079	12.0534	19	66.447	26.6968
Struct. Visuals & Narration	19	82.895	18.7317	19	52.632	26.2133
Struct. Narration Only	19	57.895	34.4124	19	63.158	49.5595
Structure Total	19	74.562	17.8880	19	54.737	23.8906
Transfer	19	47.368	23.4146	19	36.842	36.6746
Total	19	66.084	12.8155	19	58.597	22.6155

Table B.6: Statistics of the Retention and Understanding Scores of Both Topics

Group 1

Question Category	Evolution/PPT			Fixies/Fly		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	10	75.000	35.3553	10	65.000	24.1523
Fact Narration Only	10	55.000	43.7798	10	80.000	25.8199
Fact Total	10	65.000	35.7460	10	72.500	14.1912
Struct. Visuals & Narration	10	40.000	45.9468	10	85.000	24.1523
Struct. Narration Only	10	60.000	51.6398	10	10.000	31.6228
Structure Total	10	46.666	28.1108	10	60.001	21.0840
Transfer	10	60.000	51.6398	10	60.000	21.0819
Total	10	57.500	24.4381	10	65.558	13.3029

Group 2

Question Category	Fixies/PPT			Evolution/Fly		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	11	81.818	25.2262	11	86.364	23.3550
Fact Narration Only	11	77.273	34.3776	11	63.636	32.3335
Fact Total	11	79.545	21.8466	11	75.000	19.3649
Struct. Visuals & Narration	11	77.273	26.1116	11	54.545	35.0325
Struct. Narration Only	11	63.636	50.4525	11	72.727	46.7099
Structure Total	11	72.728	25.0259	11	60.606	25.0271
Transfer	11	77.273	26.1116	11	18.182	40.4520
Total	11	76.769	19.5341	11	62.500	16.7705

Table B.7: Statistics of the Post-presentations Questionnaire Retention and Understanding Scores for Both Groups Separately

Group 1

Question Category	Evolution/PPT			Fixies/Fly		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	8	75.000	46.2910	8	31.250	37.2012
Fact Narration Only	8	62.500	35.3553	8	93.750	17.6777
Fact Total	8	68.750	37.2012	8	62.500	13.3631
Struct. Visuals & Narration	8	62.500	35.3553	8	75.000	37.7964
Struct. Narration Only	*questions only for fixies*					
Structure Total	8	62.500	35.3553	8	70.834	27.8185
Transfer	8	37.500	51.7549	8	18.750	25.8775
Total	8	62.500	21.5138	8	55.556	14.5508

Group 2

Question Category	Fixies/PPT			Evolution/Fly		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	11	27.273	26.1116	11	81.818	33.7100
Fact Narration Only	11	90.909	20.2260	11	72.727	26.1116
Fact Total	11	59.091	16.8550	11	77.273	26.1116
Struct. Visuals & Narration	11	86.364	23.3550	11	68.182	40.4520
Struct. Narration Only	*questions only for fixies*					
Structure Total	11	84.850	17.4060	11	68.182	40.4520
Transfer	11	27.273	34.3776	11	54.545	52.2233
Total	11	60.606	14.3735	11	71.426	23.9040

Table B.8: Statistics of the Follow-up-presentations Questionnaire Retention and Understanding Scores for Both Groups Separately

Group 1

Question Category	Evolution/PPT			Fixies/Fly		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	8	71.875	28.1498	8	46.875	24.7758
Fact Narration Only	8	53.125	20.8631	8	90.625	12.9387
Fact Total	8	62.500	21.1289	8	68.750	9.4491
Struct. Visuals & Narration	8	50.000	23.1455	8	84.375	18.6006
Struct. Narration Only	8	50.000	53.4522	8	37.500	23.1455
Structure Total	8	50.000	15.1186	8	68.750	13.9070
Transfer	8	43.750	41.7261	8	40.625	18.6006
Total	8	55.835	16.3049	8	62.503	6.4705

Group 2

Question Category	Fixies/PPT			Evolution/Fly		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	11	54.545	18.7689	11	84.091	25.6728
Fact Narration Only	11	84.091	20.2260	11	68.182	19.6561
Fact Total	11	69.318	14.1019	11	76.136	20.5050
Struct. Visuals & Narration	11	81.818	19.6561	11	61.364	23.3550
Struct. Narration Only	11	72.727	34.3776	11	72.727	46.7099
Structure Total	11	78.788	19.8471	11	63.636	21.5744
Transfer	11	52.273	26.1116	11	36.364	32.3335
Total	11	68.688	15.7671	11	66.666	17.8874

Table B.9: Statistics of the Combined Retention and Understanding Scores for Both Groups Separately

Question Category	PowerPoint			Fly		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	21	78.571	29.8807	21	76.190	25.5883
Fact Narration Only	21	66.667	39.7911	21	71.429	29.8807
Fact Total	21	72.619	29.4796	21	73.810	16.7261
Struct. Visuals & Narration	21	59.524	40.6788	21	69.048	33.4522
Struct. Narration Only	21	61.905	49.7613	21	42.857	50.7093
Structure Total	21	60.318	29.0971	21	60.318	22.6564
Transfer	21	69.048	40.2374	21	38.095	38.4212
Total	21	67.593	23.5963	21	63.956	14.9234

Table B.10: Statistics of the Post-presentations Questionnaire Retention and Understanding Scores for All Participants

Question Category	PowerPoint			Fly		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	19	47.368	42.4057	19	60.526	42.7491
Fact Narration Only	19	78.947	30.3488	19	81.579	24.7797
Fact Total	19	63.158	26.8334	19	71.053	22.4585
Struct. Visuals & Narration	19	76.316	30.5888	19	71.053	38.4267
Struct. Narration Only	19	47.368	51.2989	19	26.316	45.2414
Structure Total	19	75.439	27.9814	19	69.298	34.8116
Transfer	19	31.579	41.5349	19	39.474	45.8831
Total	19	61.404	17.1958	19	64.744	21.5543

Table B.11: Statistics of the Follow-up-presentations Questionnaire Retention and Understanding Scores for All Participants

Question Category	PowerPoint			Fly		
	N	Mean	SD	N	Mean	SD
Fact Visuals & Narration	19	61.842	24.1069	19	68.421	31.0041
Fact Narration Only	19	71.053	25.3629	19	77.632	20.2326
Fact Total	19	66.447	17.2062	19	73.026	16.8032
Struct. Visuals & Narration	19	68.421	26.1434	19	71.053	23.9548
Struct. Narration Only	19	63.158	43.5957	19	57.895	41.7105
Structure Total	19	66.667	22.8249	19	65.789	18.4534
Transfer	19	48.684	32.7805	19	38.158	26.8334
Total	19	63.276	16.8525	19	64.913	14.0889

Table B.12: Statistics of the Combined Retention and Understanding Scores for All Participants

B.3 Attitude and Satisfaction

In the tables below, the questions and statements are labelled with IDs. The questions with the IDs S3, S4, and L1 had a multiple-choice format with three answer options. All other questions had a five-point Likert scale format, from one (very often) to five (never) for question S5 and from one (completely agree) to five (completely disagree) for the others. See A.2.2—"Attitude and Satisfaction Questions" for the detailed questions and the associations between numbers and answer options.

B.3.1 Group Comparison

See table B.13 for the statistics for both groups.

B.3.2 Topic Comparison

See table B.14 for the statistics for both topics.

B.3.3 Separate Groups

See tables B.15 and B.16 for the statistics for both groups.

B.3.4 Joined Groups

See table B.17 for the statistics of the records joined from both groups.

Group 1

	N	Median	Mode	Range
A1: The presentation was interesting.	26	2.00	2	4
A2: I liked the presentation's visuals.	26	2.00	2	4
A3: I liked the presentation's commentary.	26	2.00	2	3
A4: I liked the presentation overall.	25	2.00	2	4
S1 : The presentation was comprehensible.	25	2.00	2	4
S2 : The presentation did not loose me.	25	2.00	2	4
S3 : How was the speed of the presentation?	25	2.00	2	2
S4 : How was the amount of content shown?	25	2.00	2	2
S5 : The visuals distracted from the narration.	25	4.00	4	3
S6 : I had sufficient time to look at all content.	25	3.00	2	4
S7 : The structure was easy to understand.	26	2.00	1	4
S8 : I always knew which part was shown.	26	2.00	1	4
S9 : I always knew about the talk's advance.	26	2.00	1*	4
L1 : Where did you get most information from?	26	3.00	3	2
L2 : I remembered information by its location.	13	3.00	4	3

Group 2

	N	Median	Mode	Range
A1: The presentation was interesting.	26	2.00	2	3
A2: I liked the presentation's visuals.	26	2.00	2	3
A3: I liked the presentation's commentary.	26	2.00	1*	4
A4: I liked the presentation overall.	26	2.00	2	2
S1 : The presentation was comprehensible.	26	2.00	2	3
S2 : The presentation did not loose me.	26	2.00	1	3
S3 : How was the speed of the presentation?	26	2.00	2	1
S4 : How was the amount of content shown?	26	2.00	2	1
S5 : The visuals distracted from the narration.	26	3.00	2	4
S6 : I had sufficient time to look at all content.	26	2.00	2	3
S7 : The structure was easy to understand.	26	2.00	1*	3
S8 : I always knew which part was shown.	26	1.00	1	3
S9 : I always knew about the talk's advance.	26	2.00	1	3
L1 : Where did you get most information from?	26	2.00	3	2
L2 : I remembered information by its location.	13	2.00	2	3

* Multiple modes exist. The smallest value is shown.

Table B.13: Statistics of the Answers to the Attention and Satisfaction Questions of Both Groups

Fixies

	N	Median	Mode	Range
A1: The presentation was interesting.	26	2.00	2	4
A2: I liked the presentation's visuals.	26	2.00	2	3
A3: I liked the presentation's commentary.	26	2.00	2	4
A4: I liked the presentation overall.	26	2.00	2	3
S1 : The presentation was comprehensible.	26	2.00	2	3
S2 : The presentation did not loose me.	26	2.00	2	3
S3 : How was the speed of the presentation?	26	2.00	2	2
S4 : How was the amount of content shown?	26	2.00	2	1
S5 : The visuals distracted from the narration.	26	4.00	4	3
S6 : I had sufficient time to look at all content.	26	2.00	2	3
S7 : The structure was easy to understand.	26	1.50	1	2
S8 : I always knew which part was shown.	26	1.00	1	2
S9 : I always knew about the talk's advance.	26	2.00	1*	3
L1 : Where did you get most information from?	26	3.00	3	2
L2 : I remembered information by its location.	13	3.00	4	3

Convergent Evolution

	N	Median	Mode	Range
A1: The presentation was interesting.	26	2.00	2	4
A2: I liked the presentation's visuals.	26	2.00	2	4
A3: I liked the presentation's commentary.	26	2.00	2	4
A4: I liked the presentation overall.	25	3.00	2*	3
S1 : The presentation was comprehensible.	25	2.00	2	4
S2 : The presentation did not loose me.	25	3.00	2	4
S3 : How was the speed of the presentation?	25	2.00	2	1
S4 : How was the amount of content shown?	25	2.00	2	2
S5 : The visuals distracted from the narration.	25	3.00	2	4
S6 : I had sufficient time to look at all content.	25	3.00	2	3
S7 : The structure was easy to understand.	26	2.00	2	4
S8 : I always knew which part was shown.	26	1.00	1	4
S9 : I always knew about the talk's advance.	26	2.00	1	4
L1 : Where did you get most information from?	26	2.00	3	2
L2 : I remembered information by its location.	13	2.00	2	3

* Multiple modes exist. The smallest value is shown.

Table B.14: Statistics of the Answers to the Attention and Satisfaction Questions for Both Topics

Convergent Evolution (PowerPoint)

	N	Median	Mode	Range
A1: The presentation was interesting.	13	2.00	2	4
A2: I liked the presentation's visuals.	13	3.00	2	4
A3: I liked the presentation's commentary.	13	2.00	2*	2
A4: I liked the presentation overall.	12	3.00	3	3
S1 : The presentation was comprehensible.	12	2.50	2	4
S2 : The presentation did not loose me.	12	3.00	2*	4
S3 : How was the speed of the presentation?	12	2.00	2	1
S4 : How was the amount of content shown?	12	2.50	3	2
S5 : The visuals distracted from the narration.	12	4.00	2*	3
S6 : I had sufficient time to look at all content.	12	3.00	2*	3
S7 : The structure was easy to understand.	13	3.00	2*	4
S8 : I always knew which part was shown.	13	3.00	3	4
S9 : I always knew about the talk's advance.	13	3.00	2*	4
L1 : Where did you get most information from?	13	3.00	3	2
L2 : I remembered information by its location.	*question only for Fly*			

* Multiple modes exist. The smallest value is shown.

Fixies (Fly)

	N	Median	Mode	Range
A1: The presentation was interesting.	13	2.00	2	4
A2: I liked the presentation's visuals.	13	2.00	2	3
A3: I liked the presentation's commentary.	13	2.00	2	3
A4: I liked the presentation overall.	13	2.00	2	3
S1 : The presentation was comprehensible.	13	2.00	1	2
S2 : The presentation did not loose me.	13	2.00	2	2
S3 : How was the speed of the presentation?	13	2.00	2	2
S4 : How was the amount of content shown?	13	2.00	2	1
S5 : The visuals distracted from the narration.	13	4.00	4	3
S6 : I had sufficient time to look at all content.	13	2.00	2	3
S7 : The structure was easy to understand.	13	1.00	1	1
S8 : I always knew which part was shown.	13	1.00	1	2
S9 : I always knew about the talk's advance.	13	2.00	1	2
L1 : Where did you get most information from?	13	3.00	3	2
L2 : I remembered information by its location.	13	3.00	4	3

Table B.15: Statistics of the Answers to the Attention and Satisfaction Questions for Group 1

Fixies (PowerPoint)

	N	Median	Mode	Range
A1: The presentation was interesting.	13	2.00	2	2
A2: I liked the presentation's visuals.	13	2.00	2	2
A3: I liked the presentation's commentary.	13	2.00	1*	4
A4: I liked the presentation overall.	13	2.00	2	2
S1 : The presentation was comprehensible.	13	2.00	2	3
S2 : The presentation did not loose me.	13	2.00	1	3
S3 : How was the speed of the presentation?	13	2.00	2	1
S4 : How was the amount of content shown?	13	2.00	2	1
S5 : The visuals distracted from the narration.	13	3.00	3*	3
S6 : I had sufficient time to look at all content.	13	2.00	1*	3
S7 : The structure was easy to understand.	13	2.00	1*	2
S8 : I always knew which part was shown.	13	2.00	1	2
S9 : I always knew about the talk's advance.	13	3.00	3	3
L1 : Where did you get most information from?	13	3.00	3	2
L2 : I remembered information by its location.	*question only for Fly*			

Convergent Evolution (Fly)

	N	Median	Mode	Range
A1: The presentation was interesting.	13	2.00	2	3
A2: I liked the presentation's visuals.	13	2.00	2	3
A3: I liked the presentation's commentary.	13	2.00	2	4
A4: I liked the presentation overall.	13	2.00	2	1
S1 : The presentation was comprehensible.	13	2.00	2	1
S2 : The presentation did not loose me.	13	2.00	2	3
S3 : How was the speed of the presentation?	13	2.00	2	1
S4 : How was the amount of content shown?	13	2.00	2	1
S5 : The visuals distracted from the narration.	13	3.00	2	4
S6 : I had sufficient time to look at all content.	13	2.00	2	2
S7 : The structure was easy to understand.	13	2.00	1*	3
S8 : I always knew which part was shown.	13	1.00	1	3
S9 : I always knew about the talk's advance.	13	1.00	1	3
L1 : Where did you get most information from?	13	2.00	1*	2
L2 : I remembered information by its location.	13	2.00	2	3

* Multiple modes exist. The smallest value is shown.

Table B.16: Statistics of the Answers to the Attention and Satisfaction Questions for Group 2

PowerPoint

	N	Median	Mode	Range
A1: The presentation was interesting.	26	2.00	2	4
A2: I liked the presentation's visuals.	26	2.00	2	4
A3: I liked the presentation's commentary.	26	2.00	3	4
A4: I liked the presentation overall.	25	3.00	2	3
S1 : The presentation was comprehensible.	25	2.00	2	4
S2 : The presentation did not loose me.	25	2.00	1	4
S3 : How was the speed of the presentation?	25	2.00	2	1
S4 : How was the amount of content shown?	25	2.00	2	2
S5 : The visuals distracted from the narration.	25	4.00	2*	3
S6 : I had sufficient time to look at all content.	25	3.00	2	4
S7 : The structure was easy to understand.	26	2.00	2	4
S8 : I always knew which part was shown.	26	2.00	3	4
S9 : I always knew about the talk's advance.	26	3.00	3	4
L1 : Where did you get most information from?	26	3.00	3	2
L2 : I remembered information by its location.	*question only for Fly*			

* Multiple modes exist. The smallest value is shown.

Fly

	N	Median	Mode	Range
A1: The presentation was interesting.	26	2.00	2	4
A2: I liked the presentation's visuals.	26	2.00	2	3
A3: I liked the presentation's commentary.	26	2.00	2	4
A4: I liked the presentation overall.	26	2.00	2	3
S1 : The presentation was comprehensible.	26	2.00	2	2
S2 : The presentation did not loose me.	26	2.00	2	3
S3 : How was the speed of the presentation?	26	2.00	2	2
S4 : How was the amount of content shown?	26	2.00	2	1
S5 : The visuals distracted from the narration.	26	4.00	4	4
S6 : I had sufficient time to look at all content.	26	2.00	2	3
S7 : The structure was easy to understand.	26	1.50	1	3
S8 : I always knew which part was shown.	26	1.00	1	3
S9 : I always knew about the talk's advance.	26	1.00	1	3
L1 : Where did you get most information from?	26	2.50	3	2
L2 : I remembered information by its location.	26	3.00	2	3

Table B.17: Statistics of the Answers to the Attention and Satisfaction Questions for All Participants

B.4 Format Preference

See table B.18 for the frequencies of format preference.

Group 1

	Frequency	Percent
PowerPoint	0	0.0
Fly	8	61.5
No Preference	5	38.5

Group 2

	Frequency	Percent
PowerPoint	5	38.5
Fly	5	38.5
No Preference	3	23.1

All Participants

	Frequency	Percent
PowerPoint	5	19.2
Fly	13	50.0
No Preference	8	30.8

Table B.18: Answer Frequencies to the Question About Format Preference

Appendix C

CD-ROM Contents

The enclosed CD-ROM contains:

- The PDF version of the thesis.
- The compiled software prototype (for Mac OS X 10.6).
- The source code of the software prototype, including a Git[1] repository with the complete development history.
- The PowerPoint and Fly documents used in the audience study.
- Transcripts of the spoken commentary on both topics.
- Video files of the presentation recordings that were shown in the audience study.
- The raw data of the audience study and the Prezi document evaluation.

[1] http://git-scm.com

Bibliography

B Allen. Information space representation in interactive systems: relationship to spatial abilities. In *Proceedings of the third ACM conference on Digital libraries*, pages 1–10. ACM, 1998.

M Alley and KA Neeley. Discovering the power of powerpoint: rethinking the design of presentation slides from a skillful user's perspective. In *Proceedings of the 2005 American society of engineering education annual conference and exposition*, pages 12–15, 2005.

Apple Human Interface Guidelines. Apple Inc., 2009.

C Atkinson. Beyond bullet points: Using microsoft powerpoint to create presentations that inform, motivate, and inspire. *Microsoft Press*, 2008.

AD Baddeley. *Working Memory*. Oxford University Press, 1987.

BB Bederson. The promise of zoomable user interfaces. In *Proceedings of the 3rd International Symposium on Visual Information Communication*. ACM, 2010.

BB Bederson and JD Hollan. Pad++: A zooming graphical interface for exploring alternate interface physics. In *Proceedings of the 7th annual ACM symposium on User interface software and technology*, pages 17–26. ACM, 1994.

BB Bederson, J Meyer, and L Good. Jazz: an extensible zoomable user interface graphics toolkit in java. In *Proceedings of the 13th annual ACM symposium on User interface software and technology*, pages 171–180. ACM, 2000.

W Blokzijl and B Andeweg. The effects of text slide format and presentational quality on learning in college lectures.

In *Proceedings of the 2005 International Professional Communication Conference*, pages 288–299. IEEE, 2005.

E Bumiller. We have met the enemy and he is powerpoint. *New York Times*, 2010.

JB Carroll. *Human cognitive abilities: A survey of factor-analytic studies*. Cambridge University Press, 1993.

RE Clark. Media will never influence learning. *Educational Technology Research and Development*, 42(2):21–29, 1994.

A Cockburn, A Karlson, and BB Bederson. A review of overview+detail, zooming, and focus+context interfaces. *ACM Computing Surveys*, 41, 2008.

RJ Craig and JH Amernic. Powerpoint presentation technology and the dynamics of teaching. *Innovative Higher Education*, 31(3):147–160, 2006.

JLM de la Iglesia and JEL Gayo. Doing business by selling free services. *Web 2.0: The Business Model*, 2009.

A Dillon, C McKnight, and J Richardson. Space—the final chapter or why physical representations are not semantic intentions. *Hypertext: A psychological perspective*, pages 169–191, 1993.

A Dillon, RJ Spiro, JT Levonen, and JF Rouet. *Hypertext and cognition*. Lawrence Erlbaum Associates, 1996.

JL Doumont. The cognitive style of powerpoint: Slides are not all evil. *Technical communication*, 52(1):64–70, 2005.

RB Ekstrom, JW French, and HH Harman. Cognitive factors: Their identification and replication. *Multivariate Behavioral Research Monographs*, 1979.

L Ellis and D Mathis. College student learning from televised versus conventional classroom lectures: A controlled experiment. *Higher Education*, 14(2):165–173, 1985.

DK Farkas. A heuristic for reasoning about powerpoint deck design. In *Proceedings of the 2008 International Professional Communication Conference*. IEEE, 2008.

DK Farkas. Managing three mediation effects that influence powerpoint deck authoring. *Technical communication*, 56 (1):28–38, 2009.

F Fowler. *Improving survey questions: Design and evaluation*. Sage Publications, Inc, 1995.

M Goldstein. It's alive! the audience, that is, but some presenters do not seem to know it. *Successful Meetings*, 52(2), 2003.

L Gomes. Powerpoint turns 20, as its creators ponder a dark side to success. *Wall Street Journal*, 2007.

L Good. *Zoomable User Interfaces for the Authoring and Delivery of Slide Presentations*. PhD thesis, University of Maryland, 2003.

L Good and BB Bederson. Counterpoint: Creating jazzy interactive presentations. Technical report, Computer Science Department, University of Maryland, 2001.

L Good and BB Bederson. Zoomable user interfaces as a medium for slide show presentations. *Information Visualization*, 1(1):35–49, 2002.

T Hays. Spatial abilities and the effects of computer animation on short-term and long-term comprehension. *Journal of Educational Computing Research*, 14(2):139–155, 1996.

D Holman, P Stojadinović, T Karrer, and J Borchers. Fly: an organic presentation tool. In *CHI '06 extended abstracts on Human factors in computing systems*, pages 863–868. ACM, 2006.

R House, A Watt, and J Williams. Work in progress—what is powerpoint? educating engineering students in its use and abuse. volume 35. IEEE, 2006.

T Hümmer. International openoffice market shares. http://www.webmasterpro.de/portal/news/2010/02/05/international-openoffice-market-shares.html (accessed on 2010-05-10), 2010.

S Jul and GW Furnas. *Critical zones in desert fog: aids to multiscale navigation*. North Carolina State University Raleigh, 1999.

S Kalyuga, P Chandler, and J Sweller. Managing split-attention and redundancy in multimedia instruction. *Applied Cognitive Psychology*, 13(4):351–371, 1999.

V Kaptelinin and BA Nardi. *Acting with technology: Activity theory and interaction design*. The MIT Press, 2006.

PA Kirschner. Cognitive load theory: Implications of cognitive load theory on the design of learning. *Learning and instruction*, 12(1):1–10, 2002.

JE Kjeldsen. The rhetoric of powerpoint. *Seminar.net—International journal of media, technology and lifelong learning*, 2(1), 2006.

RB Kozma. Will media influence learning? reframing the debate. *Educational Technology Research and Development*, 42(2):7–19, 1994.

RW Kulhavy, JB Lee, and LC Caterino. Conjoint retention of maps and related discourse. *Contemporary Educational Psychology*, 10(1):28–37, 1985.

L Lichtschlag. Fly: an organic authoring tool for presentations. Master's thesis, RWTH Aachen University, 2008.

L Lichtschlag, T Karrer, and J Borchers. Fly: a tool to author planar presentations. In *Proceedings of the CHI 2009 Conference on Human Factors in Computing Systems*. ACM Press, 2009.

Bride Mallon and Brian Webb. Structure, causality, visibility and interaction: propositions for evaluating engagement in narrative multimedia. *International Journal of Human-Computer Studies*, 53(2):269–287, 2000.

RE Mayer. Multimedia learning: Are we asking the right questions? *Educational psychologist*, 32(1):1–19, 1997.

RE Mayer and LJ Massa. Three facets of visual and verbal learners: Cognitive ability, cognitive style, and learning preference. *Journal of Educational Psychology*, 95:833–841, 2003.

RE Mayer and R Moreno. Aids to computer-based multimedia learning. *Learning and instruction*, 12(1):107–119, 2002.

RE Mayer and R Moreno. Nine ways to reduce cognitive load in multimedia learning. *Educational psychologist*, 38 (1):43–52, 2003.

RE Mayer and VK Sims. For whom is a picture worth a thousand words? extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology*, 86 (3):389–401, 1994.

RE Mayer, J Heiser, and S Lonn. Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology*, 93(1):187–198, 2001.

R Moreno and RE Mayer. A learner-centered approach to multimedia explanations: Deriving instructional design principles from cognitive theory. *Interactive Multimedia Electronic Journal of Computer-Enhanced Learning*, 2 (2):2004–2007, 2000.

R Moreno and JL Plass. Individual differences in learning with verbal and visual representations. In *Proceedings of the NYU Symposium on Technology and Learning*, volume 2, 2006.

T Moscovich, K Scholz, JF Hughes, and D Salesin. Customizable presentations. Technical report, Computer Science Department, Brown University, 2004.

SY Mousavi, R Low, and J Sweller. Reducing cognitive load by mixing auditory and visual presentation modes. *Journal of Educational Psychology*, 87(2):319–334, 1995.

D Norman. In defense of powerpoint. http://www.jnd.org/dn.mss/in_defense_of_powerp.html (accessed on 2010-03-02), 2004.

AM O'Donnell, DF Dansereau, and RH Hall. Knowledge maps as scaffolds for cognitive processing. *Educational psychology review*, 14(1):71–86, 2002.

A Paivio. *Mental representations: A dual coding approach*. Oxford University Press, 1990.

I Parker. Absolute powerpoint: Can a software package edit our thoughts. *The New Yorker*, 77(13):76–87, 2001.

ME Patterson, DF Dansereau, and DA Wiegmann. Receiving information during a cooperative episode: effects of communication aids and verbal ability. *Learning and Individual Differences*, 5(1):1–11, 1993.

K Perlin and D Fox. Pad: An alternative approach to the computer interface. In *Proceedings of the 20th annual conference on Computer graphics and interactive techniques*, pages 57–64. ACM Press, 1993.

G Reynolds. The "lessig method" of presentation. http://presentationzen.blogs.com/presentationzen/2005/10/the_lessig_meth.html (accessed on 2010-05-18), 2005.

G Reynolds. *Presentation zen: simple ideas on presentation design and delivery*. New Riders Press, 2007.

G Robertson, M Czerwinski, K Larson, DC Robbins, D Thiel, and M Van Dantzich. Data mountain: using spatial memory for document management. In *Proceedings of the 11th annual ACM symposium on User interface software and technology*, pages 153–162. ACM, 1998.

GG Robertson, JD Mackinlay, and SK Card. Cone trees: animated 3d visualizations of hierarchical information. In *Proceedings of the SIGCHI conference on Human factors in computing systems: Reaching through technology*, pages 189–194. ACM, 1991.

DH Robinson, AD Katayama, and AC Fan. Evidence for conjoint retention of information encoded from spatial adjunct displays. *Contemporary Educational Psychology*, 21:221–239, 1996.

DH Robinson, SL Robinson, and AD Katayama. When words are represented in memory like pictures: Evidence for spatial encoding of study materials. *Contemporary Educational Psychology*, 24(1):38–54, 1999.

DL Schacter and L Nadel. Varieties of spatial memory: A problem for cognitive neuroscience. *Perspectives on cognitive neuroscience*, pages 165–185, 1991.

M Sjölinder. Spatial cognition and environmental descriptions. *Exploring Navigation: Towards a Framework for Design and Evaluation of Navigation in Electronic Spaces*, 1998.

DA Slykhuis, EN Wiebe, and LA Annetta. Eye-tracking students' attention to powerpoint photographs in a science education setting. *Journal of Science Education and Technology*, 14(5):509–520, 2005.

R Spicer and A Kelliher. Nextslideplease: designing tools for creating flexible presentations. In *Proceedings of the NSF Workshop on Media Arts, Science, and Technology (MAST)*, 2009a.

RP Spicer and A Kelliher. Nextslideplease: navigation and time management for hyperpresentations. In *Proceedings of the 27th international conference extended abstracts on Human factors in computing systems*, pages 3883–3888. ACM, 2009b.

RP Spicer, YR Lin, A Kelliher, and H Sundaram. A slideware application to support discursive presentations. In *Proceedings of the seventeen ACM international conference on Multimedia*, pages 971–972. ACM, 2009.

M Sprenger. *Learning and memory: The brain in action*. Association for Supervision and Curriculum Development, 1999.

J Sweller. Cognitive load during problem solving: Effects on learning. *Cognitive Science: A multidisciplinary journal*, 12(2):257–285, 1988.

J Sweller. Cognitive load theory, learning difficulty, and instructional design. *Learning and instruction*, 4(4):295–312, 1994.

M Thüring, J Hannemann, and J Haake. Hypermedia and cognition: Designing for comprehension. *Communications of the ACM*, 38:57–66, 1995.

ER Tufte. *The Cognitive style of PowerPoint*. Graphics Press LLC, 2003.

EJ Ullmer. Media and learning: Are there two kinds of truth? *Educational Technology Research and Development*, 42(1):21–32, 1994.

D Vile. Office suite wars. http://www.it-director.com/business/change/content.php?cid=9453 (accessed on 2010-05-10), 2007.

DA Wiegmann, DF Dansereau, EC McCagg, KL Rewey, and U Pitre. Effects of knowledge map characteristics on information processing. *Contemporary Educational Psychology*, 17(2):136–155, 1992.

DE Zongker and DH Salesin. On creating animated presentations. In *Proceedings of the 2003 ACM SIGGRAPH/Eurographics symposium on Computer animation*, pages 298–308. Eurographics Association, 2003.

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