Master Thesis

Virtual Field Trips based on Story Maps

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Sevilla, 30th December 2015

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Sevilla, 30th December 2015.

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Abstract:
The concept of Virtual Field Trips (VFTs) became popular with the advent of the internet in the early '90s and incorporates all kinds of simulations of real journeys and excursions. Educators who want to use VFTs in their institution face a large choice of available instances online. However, most of these are either technologically outdated or unsuited for a use in education.
Story Maps are part of ESRI's ArcGIS Online application range and intended to present multimedia content together with interactive maps. Therefore, they might be suitable as a tool for non-professionals to create and author Virtual Field Trips on their own. The application is cost free, well documented and comes with a GUI based builder, making Story Maps an easy to use tool for inexperienced and non-professional users.
The goal of this MSc. thesis is to test the application's potential for meaningful educational use scenarios based on pedagogical principles. For this evaluation, a test framework of critical factors is constructed and afterwards applied to a prototype application, featuring several sections of a field trip simulation. The evaluation of the principles of immersion, interactivity and communication shows that, while Story Maps cannot compete with highly-immersive Virtual Reality or Augmented Reality systems in terms of sensory experience, they are able to convey topics through a large variety of multimedia data types, presented in a clear way. The Story Map Journal template allows various forms of interactivity when incorporating web-applications, but is most suitable for a linear order of content with limited potential for branching or independent user navigation. Communication tools can be used in several joints of the template, if necessary. An "ideal" VFT section with the Story Map Journal consists of immersive content (overview map, panoramic pictures or virtual tours), user interactivity with the content (explanation, experiments and exercises through web applications) as well as communication tools for Questions &Answers and discussion.

Keywords: Virtual Field Trips, E-Learning, ArcGIS Online, Story Maps

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CHAPTER 1

Introduction

The concept of Virtual Field Trips (VFT) as a simulation of a real excursion or journey emerged with the advent of the internet in the early '90s. As more and more households and institutions gained access to the World Wide Web and data processing and distribution advanced through increasing hardware and software performance, immersive forms of digital education and marketing became possible. The main benefits of the VFT concept were seen in its cost-effectiveness, general logistical advantages, a larger target audience and possibilities for a global exchange of information and knowledge. Disadvantages and resentment were continuously challenged by further advancements in technology, leading to the emergence of a variety of different approaches by private, commercial, educational and scientific users with different aims and purposes.

Educators intending to use Virtual Field Trips in their course design are, however, confronted with some obstacles. The first and fundamental decision to be made is whether they want to use predefined material, or will implement an application on their own. Predefined and often commercial material from the web seems to save time and effort, especially the troubles of an implementation process, and also allows non-professionals to use appealing high end technology. By taking a closer look at the plethora of options available on the web, it will become obvious that freely available VFTs are in many cases poorly documented, of unknown origin and often outdated, either in content or by using "old technology". Furthermore, the majority of approaches is not based on a solid pedagogical framework. Often these VFTs offer only limited options to apply educational

concepts and might reduce the learning outcome.

Professional, commercial VFT programs, such as, for example, the LEARNZ project (Hovell, 2003), are a way to circumvent such hindrances but will cost the user. Adoption of the course material can prove difficult for the needs and requirements of the target group and an adoption to different levels of performance or thematic adjustments might not be conductible.

The "do-it-yourself" way of tailoring an application to the user's specific needs therefore has its advantages. An educator can use his first hand experience in the conceptualisation, as he knows the target users in their specific characteristics, needs and abilities. Designing an application to fit into the curriculum is much less of a problem than to adjust the curriculum or learning goal. On the other hand, development costs at least time and effort, potentially fees for software, training and hosting. Depending on the technology used, and this will be the largest obstacle in most cases, technological knowledge is required. Overcoming these hindrance may be the educator's responsibility (as well as that of the institution assisting in the process), but smart technology can help to reduce the critical factors of time, cost and effort.

The leading questions to ask in evaluating a product are whether the technology is mature, well understood, inexpensive and widely available. Furthermore and even more importantly: Will it be able to allow innovative and meaningful teaching? (Warren and Jones, 2014, 623). The optimal tool would therefore be cost free (or coming at a minimal price), easy to use by non-professionals, time efficient in automating redundant tasks and well documented to facilitate adjustments and experiments. In its operation, it would allow the application of educational principles by providing interfaces for pedagogical methods and techniques that are known to motivate and enhance the learning process of the target group.

ESRI's Story Map applications are freely available with a subscription to ArcGIS Online (or ArcGIS for Developers), very well documented and come with a builder application, which allows timesaving and easily accessible workflows. Thus, the product matches the criteria of cost, time and effort efficiency and can be considered to be of interest even for a non-technical target group. The combination of their build-in ability to feature map data or operations and interfaces for multimedia content, makes this tool generally suited

for the development of Virtual Field Trips. This leaves the last question open, to which extend meaningful learning activities based on educational principles can be supported by Story Maps. This master thesis is intended to investigate this potential of Story Maps for the development of educational focused Virtual Field Trips.

1.1 Goals and objectives

Story Maps are designed for "informing, educating, entertaining, and involving [...] audiences" (ESRI, 2012). The aim of this MSc. thesis is to evaluate the potential of Story Maps as a tool for development of educational Virtual Field Trips. The focus of this work is not on a demonstration of what is generally possible in creating and authoring content with the application, but rather to establish and test a principle based framework, in which a meaningful use of the application can happen. Virtual Field Trips as an umbrella term for different technologies and purposes do not provide these criteria on their own, so it is required to define these criteria over the VFT's intended use scenario.

Educational Virtual Field Trips are meant to be used in schools, universities or by any other educational institution as well as in any pedagogical project to convey a topic to an audience. As opposed to VFTs meant for entertainment and leisure, such use scenarios not only demand functionality and up to date technology, but require educational concepts to be represented in conceptualisation and design. Educators and educational designers, as the main target group, are thus not only interested in the required investment (time/effort/cost) but also in prospects of the outcome, e.g. learning effect on the audience or consequences for further teaching (Bellan and Scheurman (2001, 155),Tutwiler et al. (2013, 351). In this regard the main question of this thesis can be as:

> How can Story Maps be used to develop Virtual Field Trips on educational principles and where do limitations remain?

Following the "process of technology re-examination" by Warren and Jones (2014, 623), this question shall be answered through four steps with distinctive goals:

The first goal of this thesis is to clarify the subject area of Virtual Field Trips in establish-

ing a working definition and to illustrate prospects and constrains of the concept. This attempt can neither be universal nor exhaustive but shall aid in the decision making and evaluation process of using Story Maps for Virtual Field Trips.

The second goal is to establish a construction framework, which is grounded on transferable media based learning concepts. Instead of a specific concept, universal, elementary factors shall be deduced, which should be transferable to a wide range teaching styles. These factors address the sensory experience (immersion), activities and inquires on the content (interactivity), as well as interaction between all participants (communication).

Design and construction of a prototype VFT will be conducted in an explorative manner. Based on specific learning aims, the required resources and necessary steps of the workflow will be documented in each section of the implementation. The third goal is the simulation of a test case on which analysis can be conducted. A specific, ready to use Virtual Field Trip or Story Map is **not** the goal of this thesis.

The last and most important goal is to evaluate established pedagogical factors against the prototype to demonstrate capabilities and restrictions of the tool and to deduce which factors can be addressed by Story Maps sufficiently and which obstacles remain.

The guiding questions in this process are:

- How can multimedia contribute towards an **immersive** environment that motivates its user?
- Which forms of **interactivity** can be implemented in the application?
- Which **communication** methods can assist in using Story Maps for educational use cases?

1.2 Methodology

Resources from ArcGIS Online, ArcGIS for Developers and Arc Map were used for an implementation of a prototype VFT web application. Story Maps can be generated by a builder application available at AGOL, that guides users step-by-step through the setup

process. While this workflow does not require the user to have any programming skills, working directly on the source code allows access to the application's core functions.

The prototype uses a Map Journal template in developer version, as freely available through ESRI's GitHub account[1]. Uncompiled resources are splitted between ~700 Html, CSS, JavaScript, and resource files, containing code, styling and structure of the future application. The Eclipse IDE was used to monitor and analyse the template as well as to implement own contributions to the source code. Several test applications were compiled from the source code by using *Node.js* and *grunt* in an automated batch script. XAMPP was used to simulate an Apache webserver on localhost, to which applications were deployed. Testing was conducted for "Firefox" and "Chrome" web browsers.

To set up the general structure of the prototype's content and to experiment on various media types, ArcGIS Online's web builder application was utilized. Any modifications were saved in the cloud so that the content remained accessible through an App ID identifier to all applications and webserver instances.

While Side Panel content could not be generated outside the application and features dummy text as content, Main Stage media was created through different strategies. Web maps and related content were generated mainly in AGOL, but resources not available by the "Living Atlas" repository were created in ArcMap and published afterwards to the network. Storing map data in the network's cloud makes it accessible for web-applications through ID or URL reference.

Several sections of the prototype feature web-applications developed by using the ArcGIS for Javascript API and an ArcGIS for Developers account. These apps, composed of a single html file, containing all CSS styling, code and DOM definition, are based on code samples and widgets of the API[2]. Modifications and contributions were made by using the Sublime 2 and Notepad++ Editor. App specific workflows are documented in the respective section of the prototype (*section 5.2*).

Coding for the Side Panel contained the development of plugins for the CKEditor, using

[1]https://github.com/Esri/map-journal-storytelling-template-js
[2]https://developers.arcgis.com/javascript/jssamples/

the editor's own API. An instance of CKEditor was deployed to a browser environment to test the code, before integrating the files into the main application.

After finalization, the Story Map application was deployed together with resources and scripts to a webserver and is available at the URL storymaps.netau.net.

1.3 Structure

This thesis is divided into six chapters including the introduction. Orientated at a single cycle of the "process of technology re-examination" of Warren and Jones (2014, 623), depicted in *figure 1.1*, its structure follows the main steps of 1) identification of demands and specifics of the use case, 2) conception and design of a prototype and 3) project evaluation.

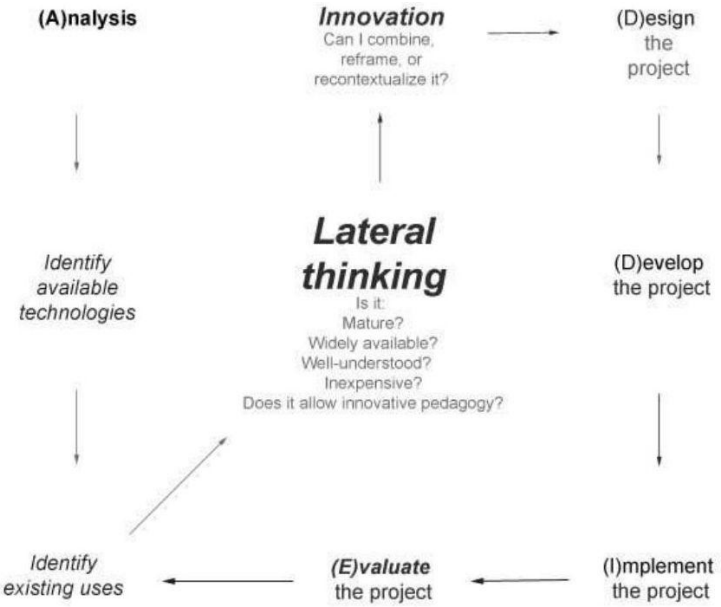

Figure 1.1: The "process of technology re-examination" by Warren and Jones (2014, 623) is used as a guideline for this thesis. "Anaylsis" is conducted in chapter 2 and 3, "innovation" with chapter 5 and "evaluation" in chapter 6. Chapter 4 contains background of Story Map "tool".

Chapter 2 provides an overview of the complex topic of VFTs as it is discussed in research literature. Similarities in preceding approaches are extracted to establish a working defi-

nition of what can be understood as the concept's core (*section 2.1*). Virtual Field Trips are distinguished by their area of application (*section 2.2*), which demonstrates the range of use cases in educational settings but also provides examples of VFTs in the tourism business. A critical review of the concept's general advantages and disadvantages (*section 2.3*) illustrates what can be expected from Virtual Field Trips and where potential limitations or obstacles can be found. Lastly, a discussion of technologies and strategies used in prior VFT implementations (*section 2.4*) shall assist in setting apart the specifics of a Story Map approach.

Chapter 3 establishes the theoretical basis on which an analysis of Story Maps for the use scenario of educational VFTs will be conducted in chapter 6. The foundation consists of the main principles of immersion (*section 3.1*), interactivity (*section 3.2*) and communication (*section 3.3*), as well as their effects on the learning process.

Chapter 4 provides background on the Story Maps as part of the ArcGIS Online product range. The first part investigates the characteristics common to the whole application range: A definition (*section 4.1.1*) characterizes distinctive properties of Story Maps, while architecture and resources (*section 4.1.2*) locate the application in the AGOL network and highlight interfaces and resources within the platform. Requirements and restrictions to development and deployment are described in the subsequent sections (*4.1.3*, *4.1.4*). The second part of the chapter briefly reviews available Story Map templates and corresponding story archetypes (*section 4.2.1*). Emphasis is laid on the Map Journal template (*section 4.2.2*), as it will be used in the construction of the master thesis prototype.

The prototype VFT constructed in **chapter 5** follows a real educational fieldtrip (*section 5.1*). Its implementation is based on an analysis of the VFT's target group, learning goals and specific requirements. A story board provides an overview of the goals to be achieved and tools and resources used in the process. The prototype construction on content level is documented in *section 5.2*. Each part is motivated by a learning goal from the original field trip and an adequate pedagogical tool is chosen. Design choices and workflow are illustrated in the implementation description. Modifications to the template on system level are presented in *section 5.3*.

The results and lessons learned of the prototype implementation are summarized in **chapter 6**. A critical review of how the educational rationale is reflected in the prototype or

can be established in a Story map application on basis of the general factors of **immersion** (*section 6.1*), **interactivity** (*section 6.2*) and **communication** (*section 6.3*). Summary and a design proposal for an "ideal" Story Map section finalizes the project.

CHAPTER 2

Virtual Field Trips

Over the years, the term "Virtual Field Trip" (VFT) has been used to address a multitude of concepts, utilizing vastly different technologies implemented by developers with diverse aims, backgrounds and skills. Generally VFTs as a teaching or communication method VFTs are relevant to all fields in which topics related to space or area based information transfer is an issue: While education is the classical domain of Virtual Field Trips and contributes the largest body of knowledge and experience on the topic, additional use cases can be found in marketing and promotion e.g. in the tourism business as well as experience-focused journalism, where geospatial information is a crucial part of the story (natural disasters, wars, spread of diseases etc.). On the other hand, many approaches that would qualify for the term VFT because of their conceptual similarities are not labelled as such, hampering efforts of definition and classification. The vast number of Virtual Field Trips and equivalents described in literature demands a reduction on core features and as far as possible, similarities. This shall be accomplished in the following sections in four steps: First by a literature review of definitions and the identification of said core elements (*section 2.1*). Second, by addressing aims and use cases, classifying VFTs by their purpose (*section 2.2*). Third, by a generalized critical review of literature analysing potential and issues of VFTs in comparison to real field trips or traditional teaching methods (*section 2.3*). Lastly, an overview of used technologies and approaches shall demonstrate how previous attempts tried to tackle these challenges from a technological point of view (*section 2.4*). Based on such assessment of existent VFTs Story Maps can be introduced to the list of approaches in subsequent chapters, allowing comparisons and

the utilization of beneficial components.

2.1 Introduction and Definitions

The term field trip describes "a planned journey through a region to illustrate some basic and specific (...) phenomena and relationships" (Hurst, 1998, 653), which is often undertaken by educational institutions or by groups of interested individuals. The group leaves its common environment for supervised first hand experience (Kent et al., 1997, 314) and activities that cannot or should not be experienced in a classroom (Boyle et al., 2007, 301). As Kent et al. (1997, 313) state field trips set themselves apart from other teaching methods by their diversity of suitable in practical and theoretical concepts as well as their potential to feature various modes of course delivery. Hence field trips have a high reputation and stable place in professions with strong ties to the visible environment like geoscience, biology, history and architecture (Dykes et al., 1999). Consequently most research on the didactics and design of field trips is carried out by teachers or professors of said disciplines.

While the concept of field trips certainly reaches back far in time, there have been notable changes in content and approaches in the last decades. For the UK Kent 1997 (Kent et al., 1997, 315-318) notes a transition from purely observational and descriptive "traditional Cook Tour's" in the 1950s to "problem-orientated, active fieldwork" with the advent of the "New Geography". Increasing the participation and responsibilities of the students, the aim of this teaching method shifted towards transferable skills whereas the role of the staff changed more to that of an assistance to the students activities rather than a lecturer. In the beginning of the 1990s two developments spurred the introduction of a virtual alternative to real field trips. First, the massive increase in student numbers brought additional stress to the already restrained budgets of many educational institutions which started to look at more cost-effective options (Boyle et al. (2007, 300), Welsh et al. (2013)). Second, the evolution of global communication and information exchange via internet opened up new possibilities. Computer aided instruction (CAI) had been used in schools at least since the 1960's (Kulik and Kulik, 1991) but mostly in form of computer labs with little to no interaction possibilities for the students. Virtual Field Trips, sometimes dubbed "electronic field trips" (EFT) presented a new

form of CAI and an alternative to often cost-intensive and logistically challenging field trips trough the use of information and communication technology (ICT) (Fauville and Lantz-Andersson, 2014). With the advent of internet technology, VFTs were no longer restricted to educational institutions but could be made by anyone for anyone, reaching new target groups with a vast range of topics all over the globe.

Historically, there is no agreement which exact event, date or invention can be seen as the first Virtual Field Trip or initial concept. Tuthill and Klemm (2002, 455) already count implementations of "teleteaching" and conference telephone calls in the 80's as "electronic field trips", whereas Hurst (1998, 654) cites Apple's Hypercard videodisc technology as a starting point in 1987. Nix and Australia (1999) on the other hand see a beginning in the TerraQuest Expedition of 1995 - a ship journey from Argentina to Antarctica featuring heavy media coverage consisting of daily media dispatches and live chat using satellite and internet technology. LEARNZ (Linking Education and Antarctic Research in New Zealand), a video based program supported by the Ministry of Education of New Zealand also started in the same year and has remained successfully running to the present day (Hovell, 2003, 75).

Certainly by the end of the millennium, Virtual Field Trips were rather popular and wide spread on the net - estimated numbers speak of ~3800 (Nix and Australia, 1999, 5) to 300.000 (Qiu and Hubble, 2002, 76) search engine hits of the term, of course depending on the specific search engine and use of applied filters. Authors like Nix and Australia (1999), Woerner (1999), Cooper and Cooper (2001) and Shroder et al. (2002) tried to record URLs and descriptions of recommendable VFTs, gathering only a small portion of private, commercial, educational and scientific programs available by then and mostly extinct by now. But contrary to the richness of available resources the body of text and level of research on the topic could not keep up with the unequally fast technological evolution. As Spicer and Stratford (2001, 346) state, "even basic evaluation of the Virtual Field Trip (...) lags far behind. Given how many of these VFTs are appearing on the web and in the market place this situation is both disappointing and unsatisfactory."

While the "early era" of Virtual Field Trips was rarely examined extensively in science and is now untraceably lost because of the volatile and short-timed nature of the world wide web, general problems arise when looking on the estimated numbers above - questions of definition and taxonomy, what has to be considered a Virtual Field Trip and what is seen

as un/related technology or derivatives. With increasing diversification of technology, tools and concepts, this is more of a recent problem than it was in the beginning.

While one does not to have to agree with CASSADY and MULLEN (2006, 150) that "there is no operational definition that is universally employed for electronic or Virtual Field Trips (EFT or VFT)", a multitude of different approaches, determined by the scientific background and educational qualification of the creators, as well as technological possibilities available and known at the time reflect in various definitions of the term. As this process is ongoing, inventions like Augmented Reality - that supplements the real world instead of replacing it (SLOCUM ET AL., 2001, 150)- challenge our understanding of the "V" in Virtual Field Trips. Nevertheless some basic principles shall be derived from statements of various authors to clarify the term and purpose of the concept.

The most basic definition is proposed by WOERNER (1999, 5):

> "A Virtual Field Trip is a journey taken without actually making a trip to the site (...) and could include slides, a set of rocks appropriately placed around the classroom, a stream table, a movie or video, a CD-ROM, or the use of the Internet and Web Sites about a particular site" (WOERNER, 1999, 5).

While the content and use of VFTs is reduced to "*making a trip without (physically) making a trip*" it is notable that with this definition the realization is not limited to computer technology at all but allowing imagination and ICT in a much wider range to host a Virtual Field Trip. Most other definitions are, however, more restrictive and limit VFTs to IT-technology specifically:

> "A VFT is an inter-related collection of images, supporting text and /or other media, delivered electronically via the world wide web, in a format that can be professionally used to relate the essence of a visit to a time or place" (NIX and AUSTRALIA, 1999, 3).

According to NIX and AUSTRALIA (1999, 3) a Virtual Field Trip is closely tied to the WWW, not counting computer based field trips distributed via CDROM, which were common at this time. Furthermore, in contrast to the definition of Virtual Field Trips as a "set of linked web-pages" (QIU and HUBBLE, 2002, 76), the definition of NIX and

AUSTRALIA (1999, 3) stresses on a "mesh-up" realization, which uses various kinds of media (multimedia). A quite similar approach was already taken by MCCARTHY (1989, after CASSADY and MULLEN (2006, 150)) to whom "a Virtual Field Trip [is] a computer-controlled multimedia product that incorporate[s] at least three of the following: text, audio, graphics, still images, and moving pictures." Concerning the content by NIX and AUSTRALIA (1999, 3) the smallest common denominator is "*the essence of a visit to a time or place*". While this definition declares all possible times and places (and multiple times and places at once) as suitable, it also introduces with "essence" some kind of generalization, not that different from what is used in cartography.

The concepts prospects are addressed in QIU and HUBBLE (2002, 75-76) definition, which considers VFTs being an instance of virtual reality.

> "VFTs can be described being an electronic exhibition of diverse natural and cultural phenomena that also provide digital simulations of the three-dimensional processes of surveying, observing, exploring and adventuring in some actual field site".

As such VFTs are (or have to be) rich in information, interactivity and design to convey specific learning concepts (QIU and HUBBLE, 2002, 75-76). Three important aspects can be deduced from this definition. First VFTs are some kind of virtual reality, defining the superset VFTs belong to. Second, this also implies that they inherit the same defining criteria to which VR are measured, namely immersion, interactivity and engagement of its audience (see TRINDADE ET AL. (2002, 2), *section 3*). Interactivity and engagement can be activities like surveying, observing, exploring and "adventuring" instead of merely reading text, viewing pictures and hearing sound (FISHER and UNWIN, 2003, 1,7-10). As such, this part can be understood both as a technological and thematic definition Lastly, QIU and HUBBLE (2002, 75) stress the need of an underlying didactic framework that distinguishes VFTs from other computer or web applications. A similar statement is given by SANCHEZ ET AL. (2005, 1):

> "Virtual Field Trips utilize state-of-the art technologies to create immersive, multi-sensory, interactive experiences with real world environments (...) [and] are designed to be an integral part of a technology-enabled educational system to teach targeted material and motivate students."

However, this "*state of the art*" is continuously changing with the development of newer technologies. SANCHEZ's (2005) concept of "interactive experiences with real world environments" is at this time already hinting towards mediated reality technologies like Augmented Reality (AR), containing not only a taxonomical problem being amplified by the more and more use of hand-held devices over traditionally home based PCs: Until now one could distinguish between a real, physical journey and its virtual simulation, going well with STEUER's (1992) definition of "presence" (unmediated reality) and "telepresence", a mediated presence experienced through any form of communication medium. AR and hand-held systems are crossing the border of this distinction and lead to questions like whether an augmented or handheld supported but otherwise "real" field trip ("blended learning", e.g. (JARVIS ET AL., 2008)) can still be considered as "virtual" or how disconnected a *Virtual* Field Trip has to be from the natural environment to qualify for the term. Here we assume that all VFTs are forms of "telepresence" (STEUER, 1992), allowing a broader definition of "virtual" than e.g. by FISHER and UNWIN (2003, 1) but delimit the term from e.g. said imaginative journeys described in WOERNER (1999). We further assume that in its traditional application and in most cases the user is not physically present in the place presented by a VFT but that the possibility exists, that said user can take the VFT with him via portable device and can use it to enhance his visit. For the sake of completeness it has to be noted that recent works (e.g. CALISKAN (2011), TUTWILER ET AL. (2013), STOTT ET AL. (2014)) mostly skip an accurate definition of the term VFT in favour of an illustration of the concept's advantages and act on the assumption that the concept is already known to the audience.

A definition of Virtual Field Trips in the context of this thesis shall be based on the key points of NIX and AUSTRALIA (1999) (1.-3.) and QIU and HUBBLE (2002) (4.-6.). as well as a statement towards of adjacent technologies (7.):

(1) A Virtual Field Trip is based on information technology, not counting non computer based approaches (imaginative journeys, white board slides).

(2) It is composed of various mediatypes (multimedia-mash-up).

(3) ...with the purpose to visit (simulate) time(s) or place(s), reduced to their "essence".

(4) VFTs are an instance of virtual reality and share their defining criteria of immersion,

interactivity and engagement.

(5) They enable user the surveying, observing, exploring and adventuring of content.

(6) The concept is (shall be) based on good design and a solid didactic framework.

(7) A Virtual Field Trip still qualifies for the term if physically taken to the time or place represented in its specific content - technologies like AR, Mobile Services and such are included in the concept despite not being strictly "virtual".

2.2 Areas of Application

From a review of the body of literature on the topic as well as from successful implementations it becomes clear that education is without doubt the main use case of VFTs. Again, it is possible that this is related to the concept of "field trips" originating from education, whereas the term "tours", like used for guided tours or city walks reflects more often in the term "Virtual Tours" used in e-tourism. In the end both concept share the similarity of a geographically located information mediation. Main use cases in both fields shall be illustrated further in the following section.

2.2.1 Educational Environment

The majority of documented Virtual Field Trips is created for learning purposes, be it schools, universities or e-learning environments. Tuthill and Klemm (2002, 456) propose a distinction in the following types:

"Travel Brochures"
Such VFTs aim to prepare the user for a real trip and give a preview of the coming experience (Stott et al., 2014, 164). The goal of this approach is to increase efficiency in learning by avoiding problems of over-stimulation and heavy cognitive load for the

study group when taking the trip later (Bellan and Scheurman (2001) or Stainfield et al. (2000)). An extensive use of "stimuli" – read images, descriptions, audio and such - is desired, as the focus lies on the creation of an immersive experience. The sector of Virtual Tours is closely related to this concept.

"Multi School Partnership"
Split in a hosting and perceiving class this concept connects different groups or institutions with each other, at least one of them at a remote location (see e.g. Robert and Lenz (2009)). The hosting students are instructed to carry out tasks set by the perceiving class. Remoteness as a motivator for ICT-based education is mostly common in the USA while less popular in smaller countries and may be outdated or at least fundamentally changed in this form by the advent of internet based technology. Obviously the approach relies heavily on communication technology and is often connected to video based programs and video-conferencing (Tuthill and Klemm, 2002, 456).

"Collaborations"
On a greater scale than "school partnerships", individuals or groups work together to create a body of knowledge, to share media and insights with each other or to carry out research in remote areas. While this idea is widespread in entities like Wikipedias and VGI, Stainfield et al. (2000, 259) remark that international collaborations on the field of VFTs are rare. Tuthill and Klemm (2002, 456) cite the "Virtual Geography Department" running from 1996-2006 and maintained by the University of Colorado as a prominent example.

"Professionally produced multi-media VFTs"
Programs produced by commercial provider like specialised companies, television stations or larger educational institutions and therefore often restricted in access for the public. As Tuthill and Klemm (2002, 456) states, these programs often contain additional infrastructure and feed-back-mechanisms like discussion groups, chats or quizzes besides the main delivery method of the content which is often video-based. A well-established representative of this kind of VFTs is LEARNZ - "Linking Education and Antarctic Research in New Zealand" (Hovell, 2003).

"Threaded VFTs"
Threaded Virtual Field Trips are defined by Tuthill and Klemm (2002, 457) as guided

tours through the web, based on a pre-sorted collection of relevant web-sites chosen by professionals as well as specific compilations of teacher resources arranged in "threads". Apparently this approach did not prevail in the form of "pre-selected web-sites" with the rapid growth and constant change of the internet. The idea of linking or merging materials from a great range of available sources and with a pedagogical profound framework has found its way in the development of sophisticated Virtual Learning Environments (VLEs).

2.2.2 Virtual Tourism

AYENI (2006 after Balogun et al. (2010, 601)) specifies three general sectors of tourism: Cultural tourism deals with in human culture and history and takes place at locations like museums, monuments, festivals and settlements. Ecological tourism centre on non-human aspects of the world and seeking interest in landscapes and biota, often condensed in national parks, heritage sites and zoos. Modern tourism is instead focused on 'modern' day life, like shopping tours, travel and visitation of modern buildings and infrastructure. All three sectors can be addressed by means of virtual tourism or "e-tourism". Guttentag (2010, 637) identifies six purposes for the use of "Virtual Reality" which could also be transferred to the implementation of VFTs in this area:

Planning and management
Realistic 3d modelling, navigation and profiling make VR suitable for planning and research purpose - e.g. to simulate different perspectives, scales and dynamics of a destination features, as an immersive visualization and presentation of tourism plans or to aid in calculating capacities, routes and user choices (Guttentag, 2010, 637). From the viewpoint of tourist needs, similar tools can assist in journey or tour planning and management, where VFTs can at least pose as an example or guide.

(Destination) marketing and promotion
As stated by Gratzer et al. (2004), tourism products have to be purchased without the opportunity of prior testing. Therefore precursory information acquirement is of great importance. Through the creation of a sensory rich experience and deliverance of destination information, potential tourists can be influenced towards the promoted

destination (Guttentag, 2010, 637) VR, and VFTs in general, are able to create and intensify the desire to visit a certain place (Buhalis and Law, 2008, 18). This can be of special importance if sites and places are yet unknown to the customer or the public (Balogun et al., 2010, 601).

Entertainment

The majority of VR applications consists of games designed for entertainment systems like PCs, video and hand held game consoles. While Guttentag (2010, 642) additionally counts VR based attractions like simulations and games at theme parks or tourist destinations as part of this category, the main ties to Virtual Field Trips can be seen in areas like geogames, treasure hunt, ralleys or geocaching (see e.g. Schlieder et al. (2006), Matyas et al. (2008),Annetta (2010)). "Entertainment" can also be understood as browsing through a VFT for recreational purposes without the aim to visit the place or achieve any learning goal.

Education

While in education pedagogically profound knowledge transfer comes first, it can be expected that in tourism the factor of entertainment and recreation takes a larger place. Nevertheless educational tourism is widespread and can be found in electronical visits to remote places or virtual tours through museums and exhibitions embedded with user information as well as tools for researchers to observe and simulate objects from different scales, perspectives and times. See e.g. Wang et al. (2002), Gontar (2013)

Accessibility

VR simulation can assist disabled persons in the visitation of a non barrier free location or by replacing the actual visit with a virtual journey. Since some potential sites might be too remote, endangered by large groups of visitors or simply not accessible at all, a virtual representation may pose a vial alternative to an actual visit for everyone (see e.g Elleven et al. (2006)).

Heritage Preservation

As a mixture of promotion, education and accessibility the preservation of objects in their digital form can be realized through VR and even enhanced by displaying uncommon perspectives and scales (see e.g. Dias et al. (2004)).

2.3 Potential and challenges of VFTs

The analysis of problems and potentials of VFTs is an ongoing discussion and takes up a lot of room in literature. The biggest influence on existing viewpoints are without doubt the technological possibilities available at the time of discussion. E.g. an author commenting on limited realism of Virtual Field Trips in the beginning of the 90's may think of webbrowser technology but was not yet familiar with the possibilities of AR and advanced VR technology 20 years later. Nevertheless a review of literature on benefits and challenges illustrates the importance of certain key factors or "best practices" and is a prerequisite to understand the context or environment in which new contributions to the topic have to be made.

2.3.1 Advantages of Virtual Field Trips

While there is a great consent (see Bellan and Scheurman (2001, 1600), Qiu and Hubble (2002, 78), Stumpf et al. (2008, 388), Robert and Lenz (2009, 120)) that Virtual Field Trips can and shall not replace real excursions, VFTs add a number of advantages and possibilities to the concept, some entirely reserved to the virtual world:

VFTs are able to solve several logistical problems arising with real excursions like costs, transport, lodging, food, equipment and language barriers (Hurst, 1998, 656). This "**geographical autonomy**" (Kirchen, 2011) ranges from the simple comfort not to leave a location, over complete independency from the weather and possible dangerous situations (Robinson, 2009, 4) to the chance to visit hazardous, fragile or unreachable places - the latter especially important for students with disabilities (see Elleven et al. (2006), Stumpf et al. (2008)). The experience can also be divided into multiple units (or over several lessons), easily reproducible various times and accessible from home (or any location with network access). This massively aids students in learning at their own pace (Arrowsmith et al. (2005), McMorrow (2005, 225), Robinson (2009, 12)).

In comparison to textbooks VFTs have no size limit, cannot be lost and are easy to modify or update (Stainfield et al., 2000, 257). Depending on the institution's infrastructure or access to resources (computers, trained staff) as well as the intended program,

VFTs might have high start-up-cost but can prove cost and time efficient (Meezan and Cuffey, 2012, 5) especially as the program can be re-used by several groups or classes (Kirchen, 2011). On a greater scale, VFTs can be used internationally reaching a wider target-audience of potential users or customers and using all the accessibility benefits of the world wide web (Stainfield et al., 2000, 257). All together these factors can be summarized as "**logistical advantages**".

Perception and concentration during real field trips can prove difficult, depending on environment, class and teaching methods (Tuthill and Klemm, 2002, 454). Its virtual equivalent can solve issues of "overcrowding", as the content is directly presented on the device without hindrance in view or sound. If the experience can be paused or repeated, note-taking, discussion and problem solving no longer pose as an interfering issue. Virtual Field Trips are able to provide fundamental new experiences, as they bypass temporal, spatial and technical borders and allow for new scales and perspectives (Tuthill and Klemm (2002, 454) and Qiu and Hubble (2002, 77)): In content they can range from microscopic to planetary resolution (Hurst, 1998, 656), they can incorporate the view through a microscope, ground perspective and birds-eye-view (satellite and aerial images) at once, can overlay maps, diagrams, statistics and all kinds of multimedia as powerful mash-ups (Woerner (1999, 5), McMorrow (2005, 224)) and even visualize temporal changes, dynamics and immersive 'time-travel' topics (Jacobson et al., 2009, 572). Hurst (1998, 656-657) and others even suggest the incorporation of pre-defined experiments in a kind of "online lab", permitting complex experiments in a simple way with instant although more or less predefined test results. Links, if used, can offer multiple ways of non-linear navigation through the content and therefore support different means of problem solving or learning approaches benefiting the user in his individual choices. Links can become short cuts for sections already known or enhance further reading through the connection of external course ware and additional information, thus permitting flexible levels of learning intensity (Stainfield et al., 2000, 257). Such "**perceptual advantages**" make Virtual Field Trips the ideal medium to deliver complex topics (Nix and Australia (1999, 11), Jacobson et al. (2009, 572)).

Particularly for environmental education, Fauville and Lantz-Andersson (2014) states that VFTs meet several requirements to be an effective EE learning activity based on UNESCO 1975/77 and teaching awareness, value and feeling, problem solving skills as well as incorporating international and locale aspects (Fauville and Lantz-Andersson,

2014, 253).

2.3.2 Disadvantages of Virtual Field Trips

While there is a long list of advantages and new possibilities introduced by VFTs, bias and limitations exist not only towards their ability to fully simulation real field trips. Woerner (1999, 1-2) as well as Tuthill and Klemm (2002, 453-454) summarize the extensive body of literature on the topic of real excursions in five main pedagogical goals:

- Sensory simulation of all five senses, various physical activities possible,
- Practical experience, connection to real world topics, elevated realism,
- Support of and interaction with the actual learning topic in class,
- Enhance general or specific motivation,
- Support different learning modes, give new feedback possibilities to the teacher.

It is obvious from this list that not all points can be addressed sufficiently in a virtual environment - although depending on approach and implementation. Physical activities for instance are limited to interactions with a computer - at least in terms of "classical" Virtual Field Trips and without counting the more recent prospects of highly immersive VR, mobile technologies or AR implementations. Sensory stimulation when happening in the virtual world is mostly restricted to sight and hearing while taste, touch and smell are subject to the analogous world (Hurst (1998, 656), Stumpf et al. (2008, 388)). Stated in a sarcastic way by Qiu and Hubble (2002, 76): "If you want to examine a rock you need to pick it up and hit it with a geology hammer – this then is your experience. (...) These benefits are absent from VFTs". Another such fundamental problem in the simulation of real field trips through their virtual counterparts is referred to by Qiu and Hubble (2002, 78) the "lack [of] the serendipitous nature of discovery". While not elaborated further by the authors, the quote can be understood that this "serendipitous

nature" includes all kinds of dynamic and spontaneous developments during a field trip. A VFT in contrast is predefined and leaves room neither form unforseen events (may they be good or bad), unforeseen events or alterations nor for uncommon solving approaches, experiments and learning through failure (Hurst, 1998, 656).

Other drawbacks as listed by Qiu and Hubble (2002, 77-78) are less fundamental and more of "**technical issues**" than general disadvantages. A sense for dimension, distance, size, form, topology or spatial extend while maybe best achieved in the field, might also be taught through maps, models, images or animation (Jacobson et al. (2009, 572), Barta-Smith and Hathaway (2000, 262), McMorrow (2005, 229)). Fluid interactions with real people like lecturers or experts (Qiu and Hubble, 2002, 77) nowadays are of a lot lesser concern than in the 'early days' of the internet, but potential problems still arise: Real-time interactions require much effort and thus often generate high costs (Kaibel et al., 2006, 202), whereas written forms of communication may lack emotions, can be impersonal, delayed or misleading and may result in frustration or distraction from the topic (Stumpf et al., 2008, 388). As Stainfield et al. (2000, 260) remark "in the field, interaction is with people and places: in a VFT, interaction is with time and space".

Data retention still is a problem but has changed its nature from limited storage space on CDROMs (Qiu and Hubble, 2002, 76) to increasing data sizes and traffic costs. Quality control also includes a currentness of data as content and infrastructure (links, storage paths, hosting) changes with time (e.g. Nix and Australia (1999), Tuthill and Klemm (2002, 458)). Such concerns can be summarized as "**maintenance issues**" (Demirci, 2011, 50) which might seem absent in real field trips but in fact manifest in a different way e.g. as costs for equipment, training of the staff and filing of needed course material.

Apart from technology and content, the methodical framework and pedagogical context in which a VFT is implemented also leaves room for flaws and errors ("**framework issues**"). These, while not system inherent problems and not fully solvable by good design or maintenance practice, demonstrate that a framework has to be provided and the concept itself – like its real world counterpart - is not stand-alone or solveable with mere technology. In a comparison Bellan and Scheurman (2001, 155) illustrate that such possible pitfalls are shared between field trips and their virtual equivalent alike: If

not embedded in a solid pedagogical framework and lacking sufficient preparation (e.g. of topic and goals, introduction of used technology) on part of the teacher and students alike, field trips will not enhance learning but instead overwhelm the audience (Tutwiler et al., 2013, 351) and the effort is reduced to mere "babysitting" of students or simply saving of work for teachers (Bellan and Scheurman, 2001, 155). A similar effect can emerge out of pre-made VFTs as they may lack connection to locally relevant topics or overstrain students if inappropriate for their specific needs and learning level, reducing the advantages of globally available online field trips (Tuthill and Klemm, 2002, 458).

Cox and Su (2004) summarizes: "The bottom line is that the success of VFTs like traditional field trips, are massively dependent on preparation for the experience, engagement while on the trip and carefully planned reflection after the field trip is over." Such criticism is agreed upon by most other authors (Woerner (1999, 6), Qiu and Hubble (2002, 78), Hovell (2003, 4-5), Robert and Lenz (2009, 121), Robinson (2009, 4)). Although it is mostly the school's or institution's responsibility to choose and incorporate suitable VFTs into the instruction (Martin et al., 2014), clever design decisions can assist in doing so (Robinson, 2009, 9). As VFTs are over-abundant on the internet but rarely contain metadata for the background of their creation, their purpose, the competence of their authors and list of references, quality standards or guidelines to separate useful and non-useful content are very much needed (Robinson (2009, 10), Qiu and Hubble (2002, 78)). Lastly there are possible "**systemic issues**" (Demirci, 2011, 50) which can prevent a successful realization in the first place – e.g. lack of motivation, time issues from the teacher's side or from the school (Tuthill and Klemm, 2002, 454).

2.4 Technology

The issues illustrated above are approached with evolving technological means and a selection of approaches shall illustrate previous design choices and implementation efforts by other authors. A review like this is helpful to understand the niche for Story Maps, or web applications in general, in the context of VFTs. Because of the multitude of implementations some basic classification is needed which can neither claim to be universal nor exhaustive. Most recent approaches do not rely any more on a single tool but use a conglomerate of different methods.

2.4.1 Web-documents

This type of Virtual Field Trips is centred around several web documents or stacks associated with each other through links which shall establish logical connections, order and hierarchy of the content and allowing the user flexibility in approach and navigation (Stainfield et al., 2000, 257). These VFTs often qualify for the category "threaded VFTs" (see Tuthill and Klemm (2002, 456)) and were especially common in the 90's as the technology is relatively simple and based on HTML/CSS web documents (read pre-AJAX and pre-web applications), ubiquitously popular at that time. While most data types (media) can be supported in some way, Wang et al. (2015, 3) acknowledges severe disadvantages in this type of VFT, as e.g. spatial relationships and operations could only be poorly represented in a data storing method based on file directories and self-contained web pages.

* One of the earliest realizations using "Supercard" technology is described in (Hurst, 1998, 656-657): This development environment for MacOS was based on stacks, containing various media formats like QuickTime videos, images, audio and text while fully customizable through its own programming language. Several VFTs were developed, edited and distributed nationwide on CDROM by students and faculty members of Duke University, North Carolina. Later versions of the Virtual Field Trips featured a content framework (pages for introduction, table of contents, overview, glossary, references, user help), navigation buttons as links to different pages and a separate window for note taking and reporting results. User activity was enhanced through various experiments and tools to examine the content.

* In McMorrow (2005), a virtual tour to Dark Peak (UK) based on website technology is used to prepare students for a real field trip to the site. As shown in *figure 2.1* the concept is based on a series of linked webpages, containing text, annotations, block diagrams and all kinds of images (e.g. ground photos, aerial view, airborne images). User navigation is provided in two ways: As the user is supposed to take the tour in a logical-thematic order, a set of linear structured links is used to connect the content pages. To access POIs directly, the interactive map can be used. Popups, references and a glossary provide additional information (McMorrow, 2005, 229).

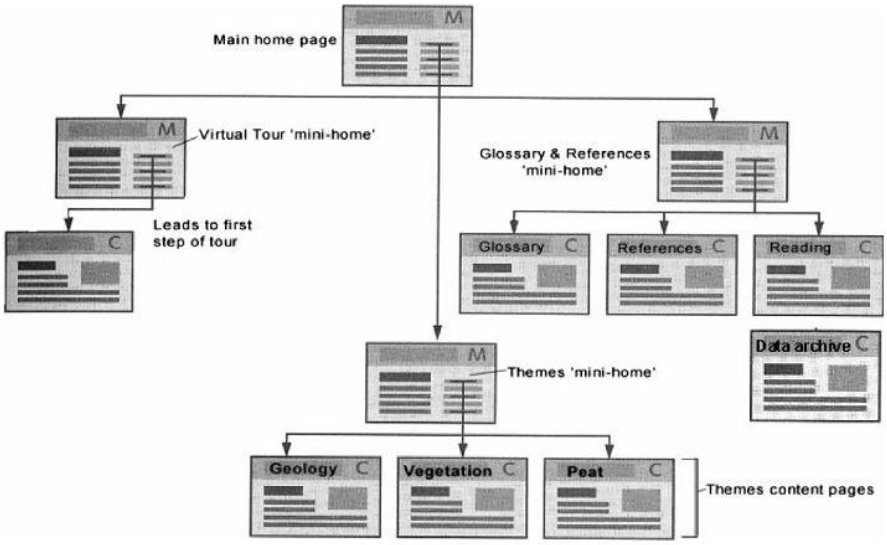

Figure 2.1: Example of a VFT structure based on a hierarchy of html web documents (McMorrow, 2005, 229).

* Another example of a html based VFT is given by Stumpf et al. (2008) and still accessible[1]. The excursion consists of a couple of stops around Tempe Butte, Arizona. POI can be viewed in order or through links displayed on an aerial photograph of the site. Each stop has text explanations, images or graphs and features a small panoramic photo with additional links to subitems with further information. User activity is restricted to navigation and perception. The VFT was designed primarily for the use at a computer lab and was embedded in a course structure where students had the opportunity to ask questions to instructors present at the lab.

* A several day spanning journey to Mexico was simulated by Jacobson et al. (2009). Visits to a museum, an Ecological Park and several other sites demonstrate the VFT concept on a larger scale (n>1 sites with several stops). Remarkably, HTML/CSS templates were deliberately chosen because of cost effectiveness and reproducibility, as "technology (...) was not a goal of the project" (Jacobson et al., 2009, 574). Instead of more evolved but also more expensive methods, resources were spent for gathering content through an actual visit of Mexico City. The team visited all places themselves, took pictures and videos and did interviews with the residents. In its final form the Virtual Field Trip

[1]http://alliance.la.asu.edu/gph111/VirtualTempeButte/intro/overview.html

consisted of the usual multimedia formats (videos, animations, slideshows, pictures, text) with a strong emphasis on maps, manipulable through a Flash-based interface. Students were able to toggle and overlay different map layers to conduct experiments and discover relationships (Fauville and Lantz-Andersson, 2014, 260-261).

2.4.2 Video based programs, Video-conferencing

Videos are widely used as they can easily be embedded in web pages or linked to maps. As such, this category contains only programs which rely mainly on videos for knowledge transfer, while other forms of media and communication are complementary or play a minor role. Most programs have in common that while they are able to present intensive visualization, they often lack interactivity (Hurst, 1998, 654), resulting in limited control over the program (Tuthill and Klemm, 2002, 455), not allowing for alterations in pace, order and extent of the presented material. As such, these VFTs do not qualify for the term "Virtual Reality", nor do they have strong ties to more spatial related VFTs in other categories. Depending on the technology used, especially if developed autonomously by the institutions rather than acquired by a professional company, high start-up and maintenance costs for equipment and staff can arise (Robert and Lenz, 2009, 129). As such these VFTs are mostly focused on whole classes rather than single individuals:

* One example is GIFT ("Guided and Interactive Factory Tour") introduced by Kaibel et al. (2006) which is based on the more complex RAFT ("Remote Accessible Field Trip") project, using solely video-conferencing (VC) to connect companies with students through the internet. A VC - experienced factory guide is using a portable camera and microphone to run a previously determined live tour through the facility while it is up to the classroom to ask questions and make requests during the conference (Kaibel et al., 2006, 202-206).

* In the predecessor "RAFT" the class was additionally split into a field team taking notes and pictures while the classroom group is coordinating the team via audio and text messaging, asking questions, reviewing results and also doing interviews with experts at the site through video-conferencing (Kaibel et al., 2006, 200).

* A similar approach was used by Robert and Lenz (2009) in "Cowboys with cameras".

By using cameras, laptops and a satellite uplink, a group of students broadcasted their field trip to the Moab desert via several video dispatches each day, while a second group of students viewed the material in the computer lab. Interaction was again established by transmitting questions and orders to the field team.

* zipTripsTM is a biology themed program that utilizes pre-recorded videos as well as live segments to connect middle school students with researchers and scientists (Adedokun et al., 2012, 607). Question and answer sessions are embedded in the show or held through the website to incorporate interactivity (Adedokun et al., 2012, 613), while experiments and live interaction were recorded in front of a studio audience. The goals of these about 45min. long show segments titled "Electronic Field Trips" were to promote interest and knowledge in science as well as to elate students to take up a career in natural science (Adedokun et al., 2012, 608).

2.4.3 Virtual Reality

While we use a broader definition of "Virtual Reality" (VR) than other authors in this thesis, some VFTs still qualify for a more strictly stated definition, eg. given by Fisher and Unwin (2003, 1, 7-10), where a user is engaged in a highly immersive artificial environment. Per definition a multitude of technical solutions ranging from panoramic image based virtual tours, responsive multimedia systems (RMS) to complete artificial virtual worlds (3-DVE, VGE) are understood as implementations of Virtual Reality. Some difficulty arises as Virtual Tours or Virtual Environments are rarely explicitly named "Virtual Field Trips" although possibly sharing some of the terms characteristics and purposes. All members of this group strongly focus on interactive graphical representations, often through 1st or 3rd person view, and in such being titled as "Avatar VFTs" following the taxonomy of Treves et al. (2015, 2). Besides the importance of interactivity, immersion and motivation can be enhanced with features adding towards realism (e.g. simulation of environmental effects)(Procter, 2012, 984).

* An example of a low-immersive VFT is given by Sanchez et al. (2005) who used panoramic photography in the creation of a virtual world for the K-12 education target group. Based on a preliminary story board which defined the pedagogical framework

(stations, learning goals, targeted vocabulary) a "natural walk" of different scenes was constructed that incorporated audio and text presentation, pre set activities and events as well as a pedagogical agent to assist the children in their tasks. The VFT was displayed on standard PCs and navigated by mouse and keyboard.

* Tutwiler et al. (2013) simulates the Hsiaoyukeng Walking Area, Taipei, Taiwan through VirtoolsTM (Dassault Systèmes), a higlyh immersive "Virtual reality Learning Environment for Field Trips (3DVLE(ft))" system. Similar to video games, the software is able to picture landscape, buildings, features and visitors in 3D, enabling the students to explore the site through first-person view, switching to third-person during conversation with NPCs. Even weather is simulated to contribute to a realistic field trip. While students have to pass several checkpoints in the visitor centre in order to meet the curriculum's goals, the outside NPCs ask them questions in form of a hidden assessment. According to the authors, the design choice to double features and learning goals both in the centre and in the park, helps to filter relevant information and thus reduce "cognitive load" (Tutwiler et al., 2013, 355).

* A highly-immersive approach and quasi VFT via RMS-based storytelling is demonstrated by Lee et al. (2005). Users visit a Buddhist temple and learn about its cultural and historical background through several events at points of interest (POIs) where the user can interact with the environment. The system is split into three parts: A multimodal tangible user interface allows for the exploration (navigation) and manipulation of the virtual environment through a set of haptic (ARtable, objects) and visional (camera tracking) controls. Reactions on this input are generated by "Unified Context-aware Application Model for Virtual Environments" (vrUCAM) that takes a previously defined user profile into account, allowing a personalization of the experienced story. The virtual environment itself is generated by a manager (VEManager) through dynamic 3D graphics and sound. In comparison to traditional VFTs the approach of Lee et al. (2005) is focused on genuine understanding through personalization (response on user action, story modification depending on user profile), sensory stimulation (sight, hearing, touch) and interaction (e.g. manipulation of objects), rather than passive story deliverance by text and picture.

* Procter (2012) uses Second Life (Linden Lab), a widely known multi-user virtual environment (MUVE), as an immersive virtual world to stage a micro-sociology focused

field trip. Student tasks include character creation and documentation of their in-world decisions. Field reports and discussions in class were used to reflect the field trip and students had to write several essays to describe their experiences and to link them to the theoretical framework of the course (social constructivism). These essays were used by the teacher to evaluate the course and to make alterations in the following years.

2.4.4 Location Based Services, Augmented Reality

Where Virtual Reality replaces the natural environment through an artificial simulation, Augmented Reality tend to enhances the former with digital content and methods McConatha et al. (2008, 1). In a strict sense, AR would therefore have no place in an assessment of *virtual* technologies. However, with the advent of handheld devices and smartphones, an exclusion of the latter would seem questionable, as such technologies already compete with purely "virtual" approaches. In context of computer aided instruction and e-learning, location based services can enhance VR in the form of blended learning (Sharples et al., 2009). Two examples shall be provided:

* Jarvis et al. (2008) proposes an AR system to field learning in geomorphology where the visualization (imagination) of landscape-processes plays an important role and is often difficult for students. In its first instance the application runs on a PDA with the aim to transfer it to a head-mounted display (HMD). In previous years, students were prepared for the field trip to experiment with photographs, topographic maps and DEMs in the computer lab. The benefit of hand-held systems like PDAs is that such background information can be directly displayed at waypoints in the field if needed - e.g. to visualize a pleistocene glacier which melted afterwards. It is notable that the system evolved from a traditional VFT-like approach where the scenes were prepared in advance in the lab and the students were asked to navigate with on screen support of their PDAs to a certain waypoint and to compare prepared scenes with the real view on the site (Priestnall and Polmear, 2006). A sketch function and audio explanation regarding the visible features were also supported. The proposed successor by Jarvis et al. (2008) transfers vision from the PDA screen to head mounted display to dynamically merge the visible reality with artificial layers, localized by GPS and motion sensors.

* In the context of nature conservation and protected areas Dias et al. (2004) developed an application for mobile devices providing tourists with a wide range of information about conservation sites in the Netherlands and Switzerland. The content is twofold: First tourists are aided in their visit by tools for navigation and spatial queries (e.g. distance, directions, projected arrival time, picnic places) based on location data. The second part consists of environmental research data (e.g. probability and density maps of wildlife) as well as information and commentary on biota encountered in the park. Data is requested via UMTS or GPRS from several data bases and web-services (WMS, WFS), cached on the device and filtered by user preferences, location and time (Dias et al., 2004, 5). The project was part of "Web Park" funded by the European Commission.

2.4.5 Web maps and WebGIS

According to Wang et al. (2015), most approaches to the topic of VFT lack in "content presentation, data organization and (...) representation of spatial information", meaning spatial operations, localization and relationships (Wang et al., 2015, 4). Such shortcomings can be solved by maps and the use of Geoinformation Systems. Proficiency in GIS is however much less common than e.g. basic HTML scripting or recording videos, hindering attempts of easy-to-use VFTs for inexperienced users. This might be the reason that GIS based VFTs are rather sparse and instead more often realized by Google technology lacking many functions of a fully developed GIS (Patterson, 2007).

* Tong and Dong (2010) demonstrate immersion and interactivity in Virtual Tours for tourism industry through the application of a navigation and query system. Based on a WebGIS, this system provides information on attractions (POIs), does distance or best route calculation and allows for sorting functions by name, tourist rating and type. Annotations and hot links provide multimedia content (descriptions with text, images, video) on various spots whereas service functions assist the users in the usage of the application. The "virt. conclusions tour function" is a routing system for mobile systems, where preselected tours are stored as a line layer with landmarks created by Google Earth. In doing so the system unites characteristics of both a virtual tour (or field trip) and a navigation system.

* Meezan and Cuffey (2012) use Google Maps technology in Virtual Field Trips to teach Geomorphology to Community College students. The .kml based map layers of satellite images, topographic and thematic content were merged as mash-ups and ultimately incorporated into websites, thus bearing high resemblance to Story Maps were multimedia overlays are also created on top of an existing base map. In contrast to these, the system is based on webpages and uses "traditional" hypertext links to navigate through the content instead of a map foundation to access the media content.

* More an information system than a Virtual Field Trip, Martin et al. (2014) use the Google Map API to represent the results of an assessment of geoheritage site inventories in Switzerland. Features of the site are either stored in a MySQL database or as .kml files and are displayed on a Google base map. Various tools were implemented to navigate through the content, to add custom or additional layers as well as to alter the map type and display (query builder, navigation tools, interactive legend). Point, line and polygon features are selectable, to access images, profiles and text explanation via popup.

* A "teaching assistant system for geography field practice (TASGFP)" is introduced by Wang et al. (2015), utilizing a variety of different spatial information technologies like WebGIS, web services and remote sensing. In resemblance to Story Maps, the front-end contains a base map to which geo-referenced multimedia files are connected through coordinates. Organized in POIs called "practice locale" these stations further contain several subtopics ("knowledge points") to which teaching resources are linked. POIs can be accessed by their tabular listing in a side bar, by selection on the map or by following a route, allowing different forms of access. Last mode also includes a "roaming function" that displays a video showing the corresponding walk or car drive with exact coordinates along the route. The back-end design utilizes ArcSDE (ESRI) as spatial data engine as well as a relational data base for storage and management purposes. Function modules provide interoperability between data server (data storage), GIS server (spatial operations) and Web server (visualization) (Wang et al., 2015, 12).

* As part of an experiment to track student movement and behaviour, Treves et al. (2015) prepared a simple VFT through the Google Earth API. The students took two voice narrated tours to get familiar with the navigation tools and to get an introduction to the topic of palaeo-landscape identification in Geomorphology. Following up was an assignment to identify previously explained landforms by themselves and a closing test on

the subject. While the VFT does seem simple in comparison to other Virtual Field Trips, it demonstrates the utilization of user movement profiles and their usefulness as feedback to evaluate and improve a course.

CHAPTER 3

Educational Rationale and Concepts

The necessity for education focused Virtual Field Trips to be based on fundamental didactic principles has been stressed in definitions and the review of challenges for virtual excursions (*section 2.3*). Specifically this group of VFTs can be seen as part of the bigger concept of "Virtual Learning Environments" (VLE) and have to be measured to the same educational principles if designed for this purpose (Fauville and Lantz-Andersson, 2014). As several authors note, this is currently not the case for the majority of available VFTs, where the demonstration of technological possibilities precede a profound didactic framework and not vice versa (Masoumi, 2010, 4). It can be assumed that even VFTs with a more general goal to inform an audience somehow will benefit from being based on principles concerning learning strategies, user engagement and general motivation. Criteria shall be developed for both, the more strict and the more general educational use case, in this chapter.

The Joint Research Centre (Bocconi et al., 2012, 9-12) defines the main dimensions for creative learning concepts based on ICT technology as content and curricula, assessment, learning practices, teaching practices, organization, leadership and values, connectedness (social & emotional values) and infrastructure. As the authors state, most if not all components have to be addressed accordingly to implement a successful educational project.

In a tripartite scheme of institution/teacher and learner characteristics (SELIM(2005) after Masoumi (2010, 6)), VFTs represent the third, technological factor. While primarily managing the *content*, they do have an influence on *teaching <-> learning practice* as well

as on the level of *connectedness* and are in general responsible for providing circuit points and interfaces that enable a smooth integration into holistic educational concepts. The latter is especially important as the role of the teacher is transformed from a lecturer to a facilitator in modern learning concepts (e.g. KLEIN(2003) after KRAKOWKA (2012, 237), BOCCONI ET AL. (2012, 8)), but also because multiple learning styles and different forms of interactivity should be supported (MASOUMI (2010, 7-8), BOCCONI ET AL. (2012, 8)).

According to FELDER(1988, after (TRINDADE ET AL., 2002, 2)), most common lectures are based on *verbal, deductive and passive* teaching, while the majority of learners favours *sensory, visual, inductive, and active* strategies, and show a prominent preference towards visual-spatial thinking. Further studies discussed in TRINDADE ET AL. (2002) also illustrate the importance of a visual-spatial aptitude, especially towards an academic level of science, including physics and chemistry. While these result indicate a mismatch between common teaching methods and student needs, they play into the hand of virtual environments (and the majority of VFTs), as they natively incorporate high amounts of sensory and visual content.

A summary of "critical elements for online teaching" by REUSHLE ET AL. (1999) (*figure 3.1*) reflects the demands in design to meet a learner focused virtual education:

	Criterion	Method or tool	Reference
Study skills for online learning	Online study aids	Tips, examples, interactive practice	
Cognitive skills	Cognitive tools Reflective tools Multiple channels Multiple paths and solutions	Multimedia, tools, databases Learning diaries, journalling activities	*Thorpe 1995* *Hiemstra 1994*
Content structure	Manageable sized 'chunks' Overview over content, goals Different learning pathways available	Concept maps, graphic organisers	*Taylor 1994*
Meaningful activities and learner motivation	„Situated" learning, relevant context User choice on content level, detail Feedback on learning progress		*Reeves 1992*
Learner control and interactivity (navigation)	Various sources of information Active participation possible Intuitive interface design Consistent content structure Navigation and orientation tools		*Vazquez-Abad &Winer 1992* *Krause in Donnelly 1996, Conklin 1987, Heller 1990* *McDonald & Stevenson 1996*
Embedded activities – interactive learning objects	Quizzes, exercises, experiments Collaborative learning, group communication (synchronous and asynchronous)	Label quizzes, numeric exercises Online discussion groups, chat	*Roschelle & Teasley 1995, Askew & Carnell 1998, Jonassen 1998*
Social relations and social presence	Live interaction Tools to reach lecturer individually		
Assessment	Clarification of assessment purpose Authentic assessment tasks Collaborative or reflective assignment Traditional assessments	Creative, productive tasks Discussion and critique tasks Multiple choice, essay, exams	*Brown, Collins and Duguid 1989*
Student feedback	Immediate ,frequent, detailed Focus on positive and further improvement Intrinsic, attention focusing		*Waldrop, Justen & Adams 1986.Ference and Vockell 1994* *Spitzer 1996* *Laurillard 1996*
Course feedback	Reflection of successes, concerns and problems	Online evaluation	

Figure 3.1: Critical elements for online teaching, modified after Reushle (1999)

It becomes obvious from the assessment that a strong coupling between didactic demands and design choices (or tools) exists: The former require the implementation of tools to meet the educational goals, while in return the tools have a critical impact on how successfully these goals can be met. Quality in this context is understood by Masoumi (2010, 3) as "quality in design, contextualization [...] and evidence of the outcome".

With the goal of *sensory*, *visual*, *inductive*, and *active* education, we will follow a tripartite approach based on the concept of Trindade et al. (2002, 2), but with greater emphasis on communicational interactivity than on the more applied factor of engagement:

- **Immersion**(sensory, visual) - as a factor for the representation of phenomenons, concepts and forms, partly not possible to experience in the real world - also adding towards user motivation and perception through telepresence (Trindade et al., 2002, 2).
- **Interactivity**(active, inductive) - defined as interaction with the (virtual) environment (human<->computer) in content and structure, resulting in meaningful responses and feedback (Trindade et al., 2002, 2).
- **Communication**(sensory, active) - as interactivity between humans, mediated through a virtual environment (human<-computer->human). This includes instruction, feedback, evaluation, assessment as well as peer activities and collaboration (Reushle et al., 1999, 4).

3.1 Immersion/Sensory experience

Steuer (1992, 5) defines presence as the subjective sensory and mental perception of our surroundings - in a field trip, this is the environment in which the excursion happens. If an individual is uses forms of telecommunication, his perception is split between the physical environment around him and the mediated environment, which is created by the communication medium. Sensory-mental experience is labelled "*telepresence*", and while virtuality is generally not mistaken for reality, similar reactions to stimuli can be encountered (Steuer, 1992, 6), leading to a sensation of "being there". Such a feeling of being actually in the virtual environment is called "*immersion*", while the "scale of immersion" (Fisher and Unwin, 2003, 7-10) is an indicator for the "fidelity" of a virtual simulation (MacEachren et al., 1999, 36). Sheridan (1992) after (Steuer, 1992, 10) identifies the three technological determinants of telepresence for the feeling of immersion as "extent of sensory information, control of sensors relative to environment and the ability to modify the physical environment". While the latter two are summarized as "interactivity" and discussed later, the extent of sensory information labelled "vividness" is directly influenced by the quality ("depth") and quantity ("width") of sensory stimulation (Steuer, 1992, 11).

Quantity is a result of simultaneous stimuli, where redundant information (e.g. by multimedia) input leads to a higher feeling of reality than a discrete sensation of hearing, sight,

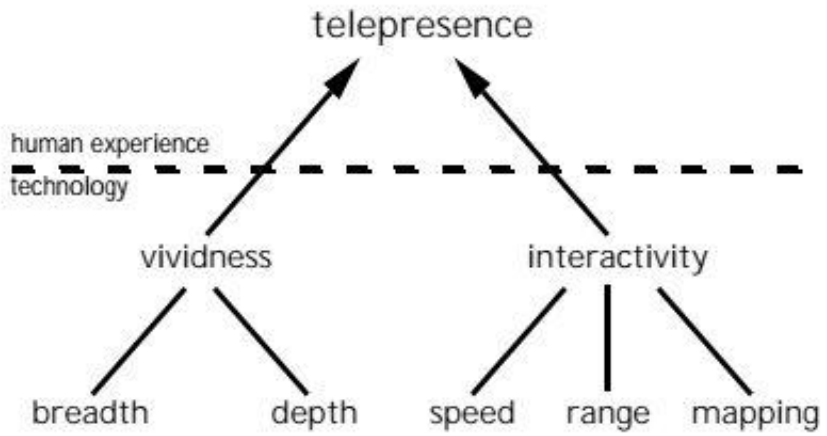

Figure 3.2: Technological factors for telepresence by Steuer (1992). Immersion is determined by breadth and width of vividness.

smell, taste and touch (Steuer, 1992, 12). Quality is measured by detail or amount per bandwidth and it affects the information density, having an impact on what is perceived (or expected) as "natural" (MacEachren et al., 1999, 36). It is important to note that the highest standard, being real-world perception, can never be achieved by simulation (Steuer, 1992, 12), but also that not realism but authenticity is truly desired in design of a virtual system, with the difference lying in the omission of unnecessary intricacies (SLATOR et al. (2006) after Granshaw (2011, 21)).

For virtual learning, it is known that sensory stimulation influences the affective domain, which in Bloom's Taxonomy (see: Forehand (2010, 2)) interplays with the cognitive and pyschomotor domains to enhance deep learning effects (Meezan and Cuffey, 2012, 34). Furthermore, a simulation of reality permits the application of "real-world cognitive processing strategies", while the learner is also less distracted by the background noise of his actual environment (Slocum et al., 2001, 63).

MacEachren et al. (1999, 36) pose as key research question how immersion can be experienced in geographical VLEs (meaning not fully developed, high quality 3D-VRs) and how the impact on learning can be assessed. We will address this problem through the quantity aspect of immersion, namely sensory experience by the use of multimedia.

According to Giordano and Wisniewski (2008, 222), multimedia resources along active

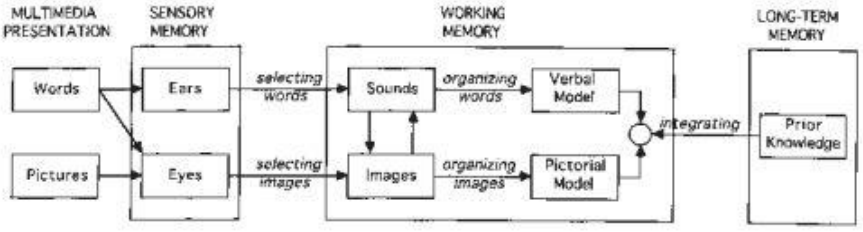

Figure 3.3: "Cognitive theory of multimedia learning" by MAYER and MORENO (2003, 44) Arrows indicate cognitive processing, labelled arrows active processes.

learning stimulate the cognitive categories of analysis, problem-solving and reflection, while also permitting different learning styles and modes of perception. In cognitive theory, this is done for the domain of words (video, audio) and images (video) through two separate cognitive channels, each processing one type of information while being of limited capacity for input processing (MAYER and MORENO, 2003, 44-45).

This results in the "multimedia principle", stating that learners benefit more from learning with different sources than with single channels alone. In the research of cognitive load versus information processing, (NELSON and ERLANDSON, 2008, 623) deduced further related principles and their effect on learning:

Such principles help in the reduction of cognitive load as well as the optimal utilization of short term memory in learning NELSON and ERLANDSON (2008, 624). A such, these criteria can also act as "best practice" guidelines for the construction of VFTs.

3.2 Interactivity with objects

STEUER (1992, 14) defines interactivity as "the extent to which users can participate in **modifying** the form and content of a mediated environment in real time" and also as a factor influencing telepresence. As the author states, reading a book is not considered interactive, although various reading paths might lead to different experiences (STEUER, 1992, 14). The determining factor is whether and how the medium itself (or its con-

Principle	Definition	Pragmatics
Multimedia	People learn better from words and pictures together than from words alone	
Coherence	People learn more deeply when extraneous material is excluded	Use few rather than many extraneous words and pictures
Signaling	People learn more deeply when cues highlight the organization of essential material	Guiding the learner in selection, organization, and integration of explanatory information
Redundancy	People learn more deeply when multiple forms of identical information are NOT presented simultaneously	People will learn better from a combination of graphics and narration than from graphics, narration, and on-screen text
Modality	People learn more deeply from a multimedia message when the words are spoken rather than printed	Dual-coding can take place, allowing for more information to be processed in working memory
Spatial contiguity	People learn more deeply when corresponding words and pictures are closer to each other	Graphic element referenced on a page of text should appear within a certain distance of the referencing text
Temporal contiguity	People learn more deeply when corresponding animation and narration are presented simultaneously rather than successively	Animation and descriptive narration should be synchronized based on content
Segmenting	People learn more deeply when a multimedia message is presented in learner-paced segments, rather than as a continuous unit	Learner controls the pacing, he or she has the option to repeat any step in the lesson as many times as necessary
Pre-training	People learn more deeply from a multimedia message when they know the names and characteristics of main concepts	Having a list of previously-explained terms "in hand" can considerably help the learner to grasp the overarching concepts within the lesson

Figure 3.4: Multimedia learning principles by Nelson and Erlandson (2008, 623)

tent) can be accessed, changed and navigated through user action (Sims, 1997, 4). A classification by Roussou et al. (2008, 142) distinguishes between the activity types navigation (explorative), manipulation (manipulative) and construction (contributive). These actions follow a three-stage model consisting of the stage's initiation, response, and feedback. Both actors, the system or the user can initiate the interaction resulting in an exchange of information (Evans and Gibbons, 2007, 1148). The classification of Sims (1997) demonstrates various types of interactivity for traditional computer based, learner centred tasks and also distinguishes between navigation (generalized: program control) and manipulative/constructive (here: "instructional") interactivity:

The degree of interactivity can be identified by measuring the quantity of modifiable attributes of content or structure and the degree to which they can be manipulated (quality) in the mediated environment (Steuer, 1992, 16). Krygier et al. (1997) distinguish interactivity on a scale from "static, animated, sequential, hierarchical [to] conditional" based on the complexity of tasks (Crampton, 2002, 88). This leads to a "more is more"

* Interactivity	Function	Control	Engagement
Object	Activation (e.g. by click) of an object leads to a audio - visual response.	Program	Instructional
Linearity	Refers to linear navigation through sequenced content (e.g. by scrolling).	Both	Navigational
Hierarchy	Vertical navigation, e.g the access of sub-content or menus.	Both	Navigational
Support	Display of general or context-specific support.	Learner	Both
Update	Application of a problem or task, user action is evaluated and responded to.	Both	Instructional
Construct	Activity that leads to the creation or manipulation of an object.	Both	Instructional
Reflective	System responses to user action by the display of text or results.	Learner	Instructional
Simulation	Definition of starting parameters determining the systems respond.	Learner	Instructional
(Hyper)linked	*Here:* Independent way finding through rich content.	Learner	Navigational
Non-immersive, contextual	Non-immersive VR environment for meaningful user experiments.	Learner	Instructional
Immersive, virtual	*Here:* Highly immersive and responsive VR setting.	Learner	Instructional

Figure 3.5: Interactivity types (for learning) after Sims (1997). Control is referring to who is responsible for making the decisions, instructional or navigational determines the type of engagement.

assumption of a positive correlation between interactivity and the development of cognitive skills in a successful learning environment (Sims, 1997, 3). Rhodes and Azbell (1985) distinguish between three learning modes on a scale from low to high states of interactivity:

- Reactive - the course is determined by the program, the user has little influence on content or structure
- Coactive - user has navigational control over the structure (e.g pace, style) but not over content
- Proactive - user is in full control of both.

However, later studies weight external (read: not system inherent) factors stronger in having a major effect on the learning outcome, rejecting a linear correlation between the amount of applied technological means and educational success (Spector, 1995). A coupling of mental engagement and interactivity was already demonstrated in the discussion of "telepresence" (*figure 3.2*).

In a constructivist approach supporting the active learning hypothesis, a learner is understood as starting from a personal level, with individual needs and specific prior knowledge (Katterfeld and Paelke, 2007, 3). As such, he can benefit from a corresponding environment supporting individualistic approaches and active engagement with the study material through the control of *when* (structure) and *what* (content) information is displayed

(Evans and Gibbons, 2007, 1149). An example of a *proactive* simulation-interactivity approach is e.g. presented by Ramasundaram et al. (2005, 22), demonstrating that advanced test suites for experiments can lead to sophisticated learning activities. The student is able to create his individual "phenomena of interest" and test hypotheses against it.

Such environments do indeed have very little in common with a mere *reactive* or passive reception by books or television (Evans and Gibbons, 2007, 1148) and match the demands proposed by Cox and Su (2004, 113) to incorporate "interaction (...) through participation, exploration and analysis" into Virtual Field Trips.

In the specific context of Geovisualisation, Crampton (2002, 88)(see: *figure 3.6*) defines interactivity as the coupling of visual data display with response to user input, allowing for different levels of complexity in geographic information systems. Ranging from "viewing and browsing activities" to content control of databases and information layers, complexity is increasing towards the highest level of "management, manipulation and analysis" of internal content as well as related external resources (Katterfeld and Paelke, 2007, 4).

Interaction	Description of Interaction	Impact on the Learning Process
Interaction with the Data Representation		
Lighting	Illumination changes	low
Viewpoint ("camera")	Perspective changes	medium
Orientation of Data	Perspective changes	medium
Zoom-in/ Zoom-out & Rescaling	Level of Detail of data changes	high
Remapping Symbols	Clarification of quantitative and qualitative information as well as semantics	low
Interaction with Geometric and Textual Dimensions		
Navigation	Free movement to any perspective/ attribute data is enabled	high
Fly-Throughs	Bird's eye view is applied to have different perspectives	medium
Toggling	Views on data may be changed	medium
Sorting or Re-expression	Inter-Relationship of values is made clear	high
Interaction with the aim of Comparison		
Multiple Views	Comparison of different areas and/ or different representations	high
Combining Data Layers	Synopsis of different data	high
Window Juxtaposition	Synopsis of different data	medium
Linking	Synopsis of different data	high
Interaction with the Data		
Database Querying & Data Mining	Data Analysis by different techniques	high
Filtering	Data Analysis: Excluding data	high
Highlighting	Data Analysis: Including data	high
Computer-Based Mapping comprising analytical capabilities	Data Analysis: Manipulation, Management, Analysis, Linking of selected Data with external Information, Graphic Redesign	high

Figure 3.6: CRAMPTON's (2002) "Taxonomy of Interactivity" establishes different "classes" of Geovisualisation tasks. The modified figure from KATTERFELD and PAELKE (2007, 4) shows a weighting of these forms of interactivity with regard to their impact on the learning process and with ascending complexity.

It can also be seen from *figure 3.6* that the impact on the learning process is supposed to be correlated with the complexity of the task. While navigational tasks are regarded as straightforward, an important addition is also made by CRAMPTON (2002, 87) with the inclusion of a time factor - with past user activities affecting future interactions - leading towards a *temporal* and *spatial* context dependency of (map) interactivity. This e.g. allows for "branching" in the program's course, breaking with the linearity paradigm of other media and resulting in "conditional" interactivity (KRYGIER ET AL., 1997). As REUSHLE ET AL. (1999, 4) note, the design of conditional complexity has to be weighted against the cognitive load applied to the user, with higher complexity allowing greater freedom but also resulting in higher demands towards orientation.

3.3 Communication

Verbal communication between peer members and educator happens naturally in a field trip, as all participants meet face to face. In a virtual environment, this component has to be enabled by a set of tools, covering various aspects of communication. The necessity of a social component enabling a truly "populated" learning environment is stressed

by Dillenbourg et al. (2002, 5). Experiments by Robert and Lenz (2009, 121) hint towards a high demand for communication methods that might not be so obvious in traditional teaching. This includes the student's desire to communicate with the study group, the teacher or external experts as well as to understand social behaviour, signals and signs and to actively engage in peer dynamics (Adedokun et al., 2012, 613). The latter is especially challenging, as in difference to real world person-to-person communication, fundamental signals of verbal (e.g. accent, tone) and non-verbal clues (e.g. body language, face expression) are clouded or missing in electronic communication, posing an obstacle for vivid or realistic interactivity (Andrade and Huang, 2014, 66).

Bocconi et al. (2012, 12) address these factors under the term of "connectedness" and attest that diversity in social interaction through communication with multiple actors and on different levels has a major impact on learner's motivation and engagement. Connectedness as dimension of social and emotional factors (Bocconi et al., 2012, 12) is in return linked to the concept of "*social presence*" introduced by Short et al. (1976). Social presence is defined by Richardson and Swan (2003, 70) not only as the "degree to which a person is perceived as "real" in mediated communication" but also as "a factor of both the medium and the communicators' perceptions of presence in a sequence of interactions." As studies show, the intensity of social presence has an effect on how students perceive learning intensity - and, stated in a wider sense, the study outcome from interaction with others is greater than from the course material alone (Richardson and Swan, 2003, 77).

Among social factors such as the relationship to the teacher, group composition or peer characteristics, technology affects "connectedness" and "social presence" in a major way. Short et al. (1976) indicate that involvement is also influenced by the chosen medium, as people e.g. adapt their behaviour and degree of commitment according to the possibilities of the communication technique. Following the distinction of Dillenbourg et al. (2002, 5) and Adedokun et al. (2012, 613), the technological aspects of social interaction can therefore be characterised as:

- Communication medium - focussing on different senses through text, audio, video, verbal vs. non-verbal communication.
- Synchronous vs. asynchronous communication - meaning immediate (voice or video conferencing, chats) or delayed response (mail, message boards, recordings).

- Cardinality - covering the quantitative aspects ranging from 1:1, 1:n to n:n connection.
- Content - indicating qualitative aspects and whether bits of information or objects are exchanged.

Although some studies argue with the impact of "face-to-face" communication - speaking in favour of a specific *communication medium* like video-conferencing - Richardson and Swan (2003, 69-70) note that certain elements can be sufficiently substituted or paralleled by other tools. Furthermore, social presence can be "cultured" by users, leading towards an adaptation process (Gunawardena and Zittle, 1997). In conclusion, not a specific medium has to be seen as most beneficial towards social presence but a combination of the technological features and participant attributes (Richardson and Swan, 2003, 70).

The same holds true for *synchronicity* in communication, as both types prove beneficial for different situations and purposes:
According to Cox and Su (2004, 192) and Hrastinski (2008a, 52-53) synchronous communication, which was first seen as a general advancement over delayed communication via e-mail, proves useful in "personal participation". Benefits are seen in overcoming isolation, developing peer cohesion, mobilising collaborated engagement, or asking questions, especially if these are an imminent obstacle in forthcoming and individual progress (Cox and Su, 2004, 192). Drawbacks are seen in the fast pace of such interaction, leaving only a short time window for processing information and response (Hrastinski, 2008b, 505) as well as a high potential for off-task activity (Cox and Su, 2004, 192). Asynchronous communication, on the other hand, seems to be generally more content and progress-orientated, e.g. as the delayed responses ideally leave more time to deliberate the topic and refine a contribution. As Hrastinski (2008a, 52) remarks, asynchronism is explicitly chosen because of its flexible nature, allowing participation anytime, anywhere without the dependency of the contact person's (online) presence.

An important aspect in this context and touching the subject of *cardinality* is the area of team learning or "collaboration". The pedagogical aim is to initiate a coordinated activity in an "attempt to construct and maintain a shared conception of a problem" (Reushle et al., 1999, 5). According to Andrade and Huang (2014, 65) and others, team learning has a verifiable influence on knowledge gain, increasing performance as well as social dynamics like e.g. team building and the articulation of thoughts and

	Asynchronous E-Learning	Synchronous E-Learning
When?	■ Reflecting on complex issues ■ When synchronous meetings cannot be scheduled because of work, family, and other commitments	■ Discussing less complex issues ■ Getting acquainted ■ Planning tasks
Why?	■ Students have more time to reflect because the sender does not expect an immediate answer.	■ Students become more committed and motivated because a quick response is expected.
How?	■ Use asynchronous means such as e-mail, discussion boards, and blogs.	■ Use synchronous means such as videoconferencing, instant messaging and chat, and complement with face-to-face meetings.
Examples	■ Students expected to reflect individually on course topics may be asked to maintain a blog. ■ Students expected to share reflections regarding course topics and critically assess their peers' ideas may be asked to participate in online discussions on a discussion board.	■ Students expected to work in groups may be advised to use instant messaging as support for getting to know each other, exchanging ideas, and planning tasks. ■ A teacher who wants to present concepts from the literature in a simplified way might give an online lecture by videoconferencing.

Figure 3.7: "Asynchronous vs. Synchronous E-Learning" (Hrastinski, 2008a, 54).

ideas (Bocconi et al., 2012, 11). From a design perspective, Dillenbourg et al. (2002, 24) argue that collaborative learning is no recipe and does rely on the efficiency in which group members can interact. The task is to integrate collaboration into VLEs through "semi-structured communication interfaces", allowing for task structuring as well as appropriate communication channels for the participants (Dillenbourg et al., 2002, 24).

Lastly, communication can be classified by its purpose and *content*. HAYTHORNTHWAITE (2002) after Hrastinski (2008a, 54) distinguishes between content-related exchange (e.g. questions, expressions), the planning of tasks and social support (e.g. answer to problems, emotions, off-topic). In student-teacher interaction, this list has to be further extended by feedback and assessment: Reushle et al. (1999, 6) distinguish between intrinsic feedback, which is the (more or less) immediate result of user action e.g in the completion of tasks (see: interactivity with objects) and extrinsic feedback which has the traditional form of assessments, exams or presentations and which is less often realised within the program. In return, not only the students should be assessed, as their feedback is valuable for the benchmarking of the program's success and further developments or modifications. This could be achieved e.g. through comments, analysis of content-related questions and online-evaluation (Reushle et al., 1999, 6). In either case, a high qualitative program should allow appropriate means of "summative" assessment, regarding the learner's perception of effectiveness and impact as well as a formative evaluation that supports quality management and modifications to the program (Adedokun et al., 2012, 615).

CHAPTER 4

Story Maps

According to Caquard (2013) maps and narratives have a mutual history and are entangled in a complex relationship with each other. Both share the commonality that they provide information - the former through graphical illustration and annotations, the latter through textual descriptions - and both can be further classified by their properties and purpose. From a narrative and non-scientific viewpoint Macfarlane (2007) is distinguishing spatial depictions in "grid maps", serving as an accurate, all-comprehensive and detailed catalogue for spatial data and "story maps" that are object to narrative cartography, allowing room for personal perspectives and individual topics. From a narrative point of view the latter can be understood as a "storytelling stimulator rather than storytelling limiter" (Caquard, 2013, 140).

While Geographic Information Systems have been developed and used mainly in the domain of *quantitative* data analysis, storage and cartography ("grid maps"), several attempts were made to incorporate *qualitative* data, like images and text into these systems to widen their purpose and functionality (Kwan and Ding, 2008, 444). "Story Maps" are the recent outcome of this development enabling a coexistence of digital, interactive maps with additional informative content made of multimedia data and descriptive elements (Strachan, 2014, V). A "story" in this context is not necessarily restricted to narratives, but can be applied in a broader sense to all kinds of messages, information and concepts ranging from personal and subjective to informative and educational information (ESRI (2012, 1,3), Probst et al. (2014, 5)).

Three major software projects are currently addressing the concept of Story Maps through web-mapping applications:

StoryMapJS is developed by Knight Lab at the Nothwestern University and part of the "publishers toolbox" a collection of prototypes for media makers. The aim as defined by the mission statement is to "help make information meaningful, promoting quality journalism, storytelling and content on the Internet"[1].

MapStory is a "community driven effort" by the MapStoryFoundation that "seeks to let everyone share their unique knowledge about how the world evolves over time"[2]. As such the project is well documented by several videos and a large Wikipedia as well as 1000+ avialabe datasets which can be added as layers to all kinds of mash-up maps.

Story Maps is part of the application range for ArcGIS Online, a cloud based, online cartography and GIS service by ESRI (Kouyoumjian, 2010, 5) which itself is based on the ArcGIS product line. As opposed to the Desktop and Server solutions ArcGIS Online is accessible for everyone through a cost-free online subscription, with advanced services reserved for users with a commercial license. Functionality can be added through interfaces with the product line (ArcGIS for Desktop/Server) and various available APIs, like the ArcGIS for JavaScript API. As ESRI's solution is the most extensive and best documented project, this thesis will focus on the Story Maps application range.

[1]Source: http://knightlab.northwestern.edu/about/ (4/2015)
[2]Source: *http://wiki.mapstory.org/* (4/2015)

4.1 Story Map applications

4.1.1 Definition

ESRI[3] characterizes Story Maps as

> *"lightweight, open-source web apps [which] combine web maps (...) with multimedia content — text, photos, video, and audio — to let you tell stories about the world."*

This definitions contains the following implications, characterizing the applications properties and purposes:

- The product's purpose is to moderate and present a **story** - more precisely a thematically defined message or concept, enriched by multimedia content and tied to some form of spatial information (Probst et al., 2014, 5). The audience as the author's unspecified target group shall be "informed, educated, entertained and involved" through content featured in the application (ESRI, 2012, 2). Contrary to the implication of "story" play text or narratives only a supplementary role in relation to the map and media as the applications central elements.
- As **web applications** are Story Maps meant to run in a browser environment. The application relies on web strategies [4] and is developed for deployment on web servers, either as part or outside of AGOL. The applications source code is written in JavaScript and makes use of the Asynchronous Module Definition (AMD) API as well as libraries like jQuery and Dojo. Story Maps are twofold as they contain apps to generate and view content. The application's builder part assists in creating and manipulation the DOM and relies on HTML5 and CSS3. Most applications support mobile devices through a responsive display. As the content is streamed from web servers Story Maps require a network connection to display the content.

[3] http://storymaps.arcgis.com/en/ (5/2015)

[4] https://developers.arcgis.com/documentation/guides/choosing-the-right-platform/

- To ensure a high performance, the app is kept **lightweight** - both in hosting content and in supported operations. Media files are stored outside the application and referenced by URL, greatly reducing its size. While basic content from AGOL is available as tiled raster layer (e.g. base maps), the platform favours vector data types to a large extent, especially for user generated files. Default operations on a Story Map consist of accessing and displaying tasks. Analysis and data manipulation are not the focus of Story Maps and these operations have to be embedded by using specified web-applications. Performance in the source code is enhanced by using AMD, which assures that only needed modules will be (asynchronously) loaded.
- Although developed and maintained by ESRI, Story Maps can be considered **open-source**. With restrictions from the licence agreement[5] users can utilize the documentation and resources provided by ESRI and are urged to modify applications to their specific needs. Several publications, e.g. ESRIs blog or support forum demonstrate the capacities of the application and provide users with instruction to extend the functionality. Templates are available for download and modification through ESRI's GitHub account and can be deployed wit full functionality on a private webserver.

4.1.2 Architecture and resources

ArcGIS.com is the central hub for all ArcGIS related web content. The network provides interfaces to various branches of desktop, server, online and mobile products, sharing resources, services and tools for the creation of online maps and web-applications (Peters, 2015).

Story Maps are rooted in the customizable web-application branch of the "ArcGIS Online" network, a cloud based, web mappping service emerged from the ArcGIS Desktop and ArcGIS Server product line (ESRI, 2012, 2). SM applications exceed the functionality of other available map-focused web-apps in being specifically designed to host multimedia content and to present this data alongside of maps. In doing so, Story Maps bear resemblance to content management systems (CMS).

[5] http://www.esri.com/legal/software-license

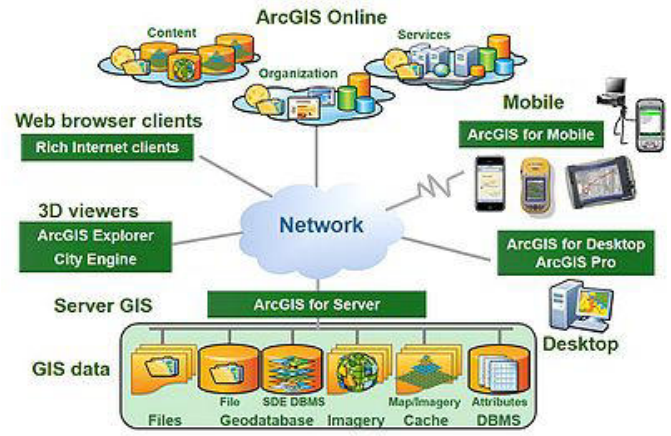

Figure 4.1: Component architecture of the ArcGIS platform (PETERS, 2015).

While Story Map applications are fully functional as a standalone product, their capabilities can be further enhanced when using resources from ArcGIS Online (AGOL) and ArcGIS for Developers.

ArcGIS Online provides global base maps, additional layers from various resources as well as tools to create annotations and to style or analyse map content. The centre point of the platform is the Map Viewer, which lets the user combine data interactively in web maps and passes maps to the webapp builder application to add basic functionality (e.g. sliders, overlays) to the content. The "Living Atlas"[6] is a huge online data repository providing a body of predefined maps, layers and satellite images. Web-maps generated that way can be stored and distributed within the network and are available to the Story Map's media picker by ID. Since ArcMap 10 it has been possible to use AGOL content in the Desktop solution and vice versa, enhancing data exchange between both products. Feature - and tile map services can be run directly out of ArcMap assisting in publishing user content to the platform.

ArcGIS for Developers provides resources and APIs for developing native apps (iOS and Android) or web-based strategies[7] and also manages authentication and credit consumption for specific services. The ArcGIS API for JavaScript section contains widgets, code

[6]http://www.arcgis.com/home/gallery.html
[7]https://developers.arcgis.com/documentation/guides/choosing-the-right-platform/

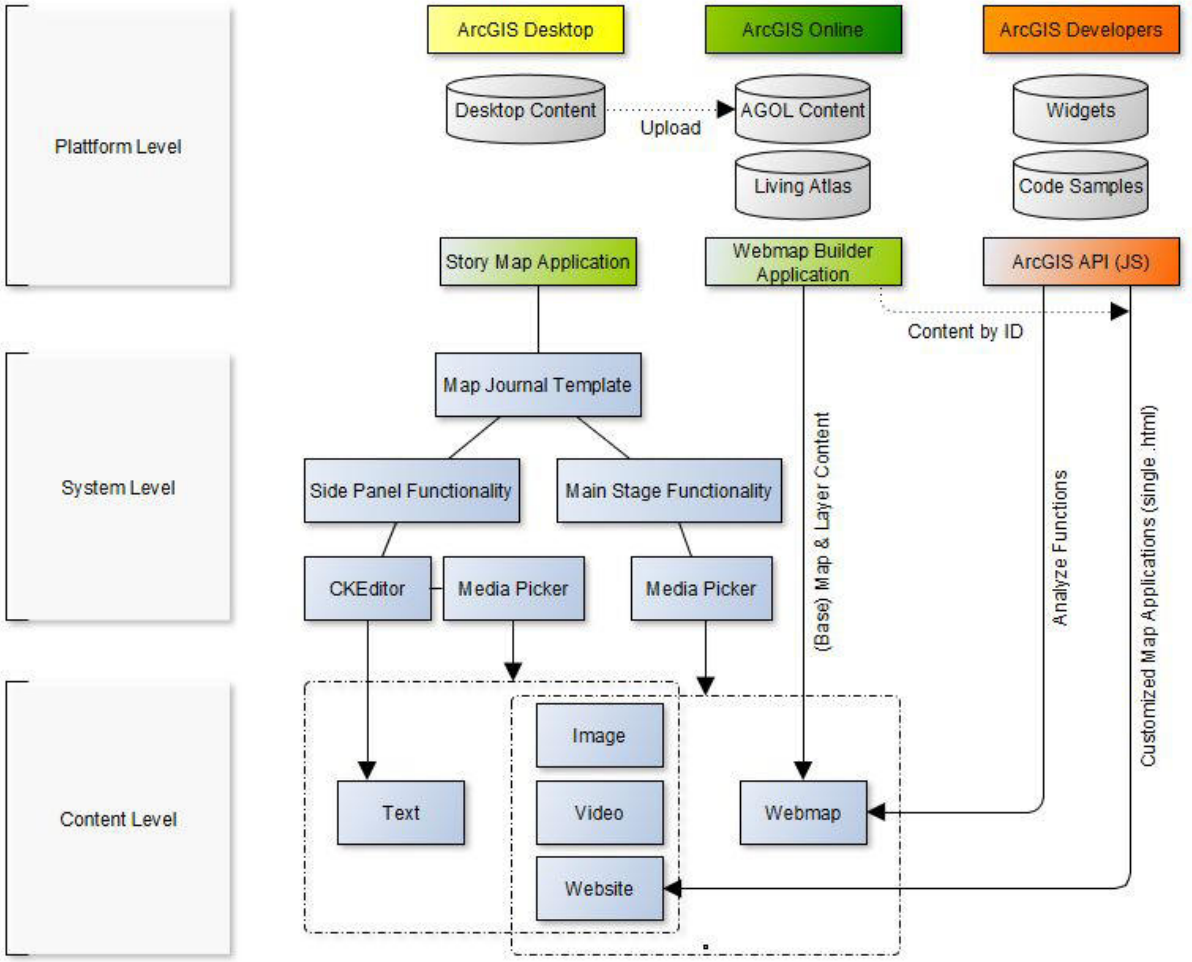

Figure 4.2: Architecture of the Map Journal template and interfaces to the AGOL framework.

samples and documentation to create customized applications containing structure, styling (CSS 3) and functionality (JavaScript) in a single html file. AGOL map content, layers and specific services can be incorporated using identifiers or URL references. Customized applications cannot be hosted in AGOL, but have to be deployed to an outside webserver. Story Map templates like the Map Journal allow webapps to be embedded by i-frame or URL like any other website through the "media picker".

4.1.3 Licensing and authentication

Licensing[8] for ArcGIS Online offers a free "public" license with limitations to functionality, storing limit, as well as the obligation to use the content for personal purposes. "Commercial" licenses (administrator or publisher permission) allow unrestricted access to the full range of applications. A registration with ArcGIS for Developers provides additional benefits like an organisational account (username.maps.arcgis.com) to host apps and customized content or an 'export to app' function for AGOL web maps.

For the usage of specific services like navigation and analysis (map algebra, data operations) tools, premium content or specific hosting and storage options, ESRI requires a commercial licence. These services additionally consume credits calculated by the type of operation and user number[9].

User authentication is handled either by OAuth2 protocol or by token, using a client ID [10] and unpublished or restricted content hosted by AGOL prompts users for their login credentials. Organizational accounts allow the management of user groups or access restrictions and using a "globally" published app this way will charge credits on behalf of the user. A group member role can be defined in a respective panel of an organizations administrator account (not allowed for public licences), charging the organization for any credit consumption of their members. Developer accounts have access to the admin panel but are the sole members of their organization.

Users have read access to data within the application, but cannot initialize the builder app without credentials. Write access, query, delete and update tasks can be set for in the content properties (layers, maps, services) dialogue in AGOL. As non-commercial licences do not allow specification of user groups, setting any flag to the content will unlock this operation when the application is set to "public".

[8] https://doc.arcgis.com/de/arcgis-online/reference/faq.htm
[9] http://www.esri.com/software/arcgis/arcgisonline/credits
[10] https://developers.arcgis.com/authentication/

4.1.4 Application development and deployment

Story Maps can be developed by using the builder application available online, by acquiring a SM template and using the builder provided in the source files or through the Snap2Map mobile app. It is possible to mix and match two or more methods.

a) By Builder

Except for three templates of the "Curated List of POIs" group all apps are either available through ESRI's Story Map specific portal[11] or AGOL's application list. Selecting a new template or using the "edit map" option will execute a builder application, which guides the user by a WYSIWYG editor through the creation or modification of a Story Map. This workflow requires the user to specify the source of media content as only text and URL references are stored in the application and hosted by ESRI. Some applications (e.g. Map Tour) allow the user to upload a single .csv table file with definitions of the names, coordinates, description and media content URLs of all sections, which can afterwards be further adjusted by the builder. Such a workflow is recommended for larger stories as components are easier to maintain or to replace. In either case will applications developed by using the builder be hosted with AGOL and do not require a deployment to a specific webserver.

b) By Template

All Story Map types are currently available through ESRI's GitHub[12] account. Users are provided with to two different versions: A "user version" allows basic modification of the (already compiled) files for purposes of advanced layout styling or basic alterations to the map functionality (mainly by editing the index.html or maptour-config.js). A second variant ("developer version") contains the (uncompiled) source code and has to be compiled with Node.js before being accessible. Templates are meant for authors who would like to deploy a Story Map to their own webserver. As AGOL is not allowing modified apps to be hosted by the network, this is the only way for developers to deploy customized application.Templates, however, also contain the builder application files and authoring does not differ from that in the AGOL network.

[11] http://storymaps.arcgis.com/de/app-list/

[12] https://github.com/Esri

c) By Snap2Map

A recent variant for story map creation via smartphone is provided through Snap2Map[13], a native iOS and Android based application, that lets users author Story Maps en route. The suggested workflow is to use the device to record content in the field, which will be automatically geotagged and uploaded to the user account. Fine tuning can be done with the map builder application if necessary. Currently, the app is restricted to users with a commercial licence and requires the consumption of credits. Voice-to-text caption recording and automatic geotagging of images are two exclusive features which provide functionality over the standard desktop variants.

4.2 Templates

4.2.1 Templates and story archetypes

ArcGIS.com is currently hosting eleven templates in five distinctive groups (see *figure 4.3*). These "blueprints" can be distinguished by the predominantly featured media type: Applications for area data are centred on one to several maps and often host additional information in a side panel or in tabs. Templates promoting specific locations in forms of point data often contain a single map and reserve most of their space for image data. Maps fulfil different roles in an application. A map can either act as the main source of information, serve as a stage to feature the actual content or is used to display background information for general orientation. Independently from the dominant graphical feature (area - point) templates vary in the text to image ratio as well as available tools to generate, modify and display the story.

According to (ESRI, 2012, 5-6) existing templates have been designed to represent various archetypes of "stories" and are based on atomic entities of cartographic information:

Point based - Locations: Points act as locators and indicate places of importance (called points of interest, POI), while other (map) features are used supplementary to

[13]http://www.esri.com/esri-news/arcwatch/1014/create-a-map-tour-with-your-smartphone (2014)

Name	Description	GitHub	Builder	Hosted	Mobile
Sequential, place-based narratives					
- *Story Map Tour*	Map-based series of geotagged photos and short descriptive captions.	x	x	x	x
- *Story Map Journal*	Two-split window for displaying large text and content simultaneously.	x	x	x	x
A curated list of points of interest					
- *Shortlist*	Similar to Map Tour but content grouped in preselected tabs.	x			x
- *Countdown*	Rank-ordered content featured in journal-like template.	x			
- *Playlist*	Blend of Map Journal and Tour for featuring locations through previews.	x			x
Presenting one map					
- *Story Map Basic*	Map-centric application with minimalistic interface options.	x	x	x	
Presenting a series of maps					
- *Tabbed-Layout*	Series of tabbed maps with descriptive content in side-panel.	x	x	x	x
- *Side Accordion-Layout*	Similar but maps stored in side panel, focused on time-dependend topics.	x	x	x	x
- *Bulleted-Layout*	Maps stored in bullet points, side panel free for content, focus on large data.	x	x	x	x
Comparing two maps					
- *Swipe*	Direct comparison between two overlaying maps or layers.	x	x	x	x
- *Spyglass*	Same as "Swipe" but with a smaller 'spyglass' focus.	x	x	x	x

Figure 4.3: Currently available Story Map applications.
Github = The application template is accessible for user download at GitHub.
Builder = A builder application is available online.
Hosted = ESRI is hosting the application online (and derived SM)
Mobile = The application supports mobile devices through responsive design.

display background information. Location centric maps are e.g. maps for city tours in tourism or hotspot maps used for "volunteered geographical information (VGI)". Maps of this category are rarely meant to feature large volumes of text, which is instead often reduced to captions, or means of higher interactivity except for location queries and buffers (ESRI, 2012, 5-6). "Map Tour" and "Shortlist" templates support location based maps.

Line based - Routes: Lines are used as connection of points and are thus suitable for routing tasks, e.g. giving the user directions from his location to a specific target. For navigation along lines in networks, point and polygon features play a minor role and are used to complement and illustrate the surroundings. A use case for line based story maps is demonstrated by (Probst et al., 2014). Currently no dedicated Story Map template exists for this type of map and implementation has to rely on work-arounds with other template types.

Point+line based - Sequential narratives and tours: Some narratives can be split into events bound to specific locations (points) but ordered along routes (lines). This pattern is common in tours or field trips as quantities of information are allocated to a tour stops (POI) but can, to a lesser extent, also be encountered en route. A genuine order of that tour is established through time (chronography), space or logical (content)

connection. To represent this style, ESRI (2012, 6) suggests either a linked sequence of separate web pages, or a map that symbolizes the route and organizes the content in labels and popups connected to the map features.

Polygon based - area patterns and comparisons Polygons are used to define areas of a specific geometric and spatial extent. These areas share some kind of property that is similar or equal within the boundaries and is highlighted by the signature's style (color, pattern, symbols). Maps based on this feature type are used to display distributions or patterns and if separated in layers of matching scale and extend can demonstrate spatial changes or dynamics. Points, lines and text are subordinate elements to provide information on context or background. Potential map operations contain timelines, overlays, multi-map views, animation and toggle-able themes with functionality (ESRI, 2012, 6). Story Map "Swipe" and "Spyglass" are examples for this group.

Hybrids - Complex topics - These application have a highly dynamic focus and use the full range of potential features, being flexible about what is taken in the centre of each sequence. Room for text and a larger toolbox allow high degrees of interaction with the content. Such maps can use additional resources from outside the core SM-applications, like ArcGIS Online or commercial tools. Use cases can be found in planning or presentation of complex topics (ESRI, 2012, 9). Story Map Journal and Map Series are representatives of this group, as a they contain two simultaneously displayed stages, hosting various multimedia types (text, maps, images, videos etc.) in addition to a central map.

4.2.2 Specifics of the Map Journal template

From the range of templates the Map Journal seems most suitable to be used in a prototype VFT and will therefore be illustrated in depth. In its core concept the template can be understood as a 2:X table, with two distinctive column types and rows labelled "sections". The view is split about 1:2 into the smaller Side Panel (SP, "section"), positioned left (by default, or floating) of the larger Main Stage (MS, "stage") o the right. The Side Panel is intended to host the section text, generated with the CKEditor, an open source WYSIWYG text editor similar to editors used by e.g. Wordpress. CKEditor hosts

various tools besides text generation and styling, most prominently the MediaPicker, a plugin that allows images, videos and websites to be imported into the text frame. The MediaPicker is crucial for the generation of the Main Stage view and is run outside the CKEditor for this purpose. As opposed to the Side Panel, web maps from AGOL can also be hosted within this frame. This architecture is visualized in *figure* 4.2, also showing interfaces and embedding in the ArcGIS framework.

The section "rows" contain one (and only one) Side Panel frame, introduced by a mandatory section title and linked to at least one Main Stage view. The Main Stage is highly dynamically as it can feature e.g. whole web sites or map applications and can be further manipulated using the Story Map Actions (see *section 5.2.6*). Nevertheless, the template is structured in a linear way without an build-in option to modify the general section display sequence (see a work-around in *section 5.2.1*). An alternative is selecting sections from the sidebar (DotNavBar), but as no thumbnail or preview of sections is provided, such behaviour is in fact only convenient for jumping back to previously viewed content.

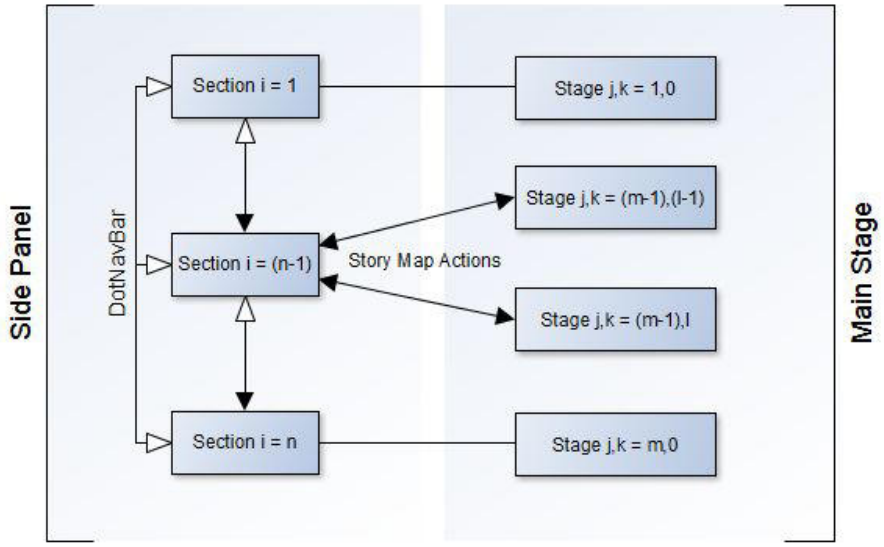

Figure 4.4: Template structure of the Map Journal showing a 1:n cardinality in Side Panel Section to Main Stage. Black arrows mark mandatory navigation along the story flow, white arrows indicate optional movement

A section selection fires an update on the Main Stage view, but MS actions do not update the SidePanel in return, except for the "back" button of the "Story Map Actions" toolset.

This principle is visualized in *figure* 4.4 and significantly different from that of other templates, e.g. the Map Tour where content and map are connected in both ways.

CHAPTER 5

Prototype - The Odertal Journal

The potential for representing immersion, interactivity and communication in Story Maps shall be evaluated by an explorative approach, in which a test case is constructed. This prototype VFT is based on a real excursion outlined in section *5.1* and will simulate an educational field trip for university students in geography. In the central part of this chapter, the construction and implementation process on content level (no source code modification needed) is described for each section. Motivated by a distinctive learning goal of the original field trip, a pedagogical tool is chosen, meant to be implemented and tested in the development process. The chapter closes with examples for template modification on system level, meaning additions to the source code prior to compilation of a new application instance.

5.1 Outline

This section describes initial considerations and design definitions used for the later construction of the prototype. These are based on a specific use scenario, defined according to the conceptional criteria of Kerres et al. (2003, 4), but intended to assist in the evaluation of the technology's potential for the general application scenario in educational VFTs.

5.1.1 Case description

The "Odertal" is one of the main valleys near the "Brocken" (1141m), the highest peak of the Harz, a mid-mountain area of Northern Germany. According to HOEVERMANN (1974) and others, the Harz was glaciated in the last cold phase (Weichsel-Würm Glaciation), which is insofar significant as local altitude levels and climate conditions were at a close minimum for a glaciation and such a possibility was therefore intensively questioned in research. Because of these peculiar circumstances, the Geography Department of the University of Goettingen visits the area on two field days as a required course for 2nd semester students. In the "Odertal", the students are given the opportunity to sharpen their eye for glacial landforms in a mid mountain environment, but also to find indicators of the complex geological and geomorphological history. While observation and note taking for a later assignment take most of the student's attention, smaller experiments and field work tasks are conducted along the way. The field trip, designed together with other members of the institute and held by the author several times, shall pose as a guideline for the prototype construction.

5.1.2 Initial considerations and design choices

a) Field Trip Type:
The prototype will be located in the classical domain of simulating a real excursion with a virtual counterpart, an approach followed by the majority of educational implementations (see e.g. Stumpf et al. (2008), Jacobson et al. (2009), Meezan and Cuffey (2012)). This field trip type can be classified either as "travel brochure" (when aimed at a preparation purpose) or as a "threaded" VFT in the taxonomy of Tuthill and Klemm (2002, 456) (*section 2.2*).

b) Target group and learning goal on meta level:
In accordance with the thesis aim defined in section *1.1*, the prototype shall demonstrate potential and limitations of Story Maps/Map Journal for the target group of educators and teachers (referred to as "authors")- either seeking alternatives for real field trips, developing e-learning applications or designing a sophisticated internet presence of their department or school. We assume that the target group has interest in the development of

a VFT in geo-, environmental or spatial science, has limited knowledge of web development or programming and prefers GUIs or editors over coding with APIs. The application shall be kept cost free, tasks requiring Arc Map can also be conducted in alternatives like QGis.

c) Target group and learning goal on content level:
The prototype is based on a real field trip, taken by students of the BSc. Geography or BSc. Geoscience at the University Goettingen. The excursion was part of a mandatory basic course in the second semester and participants had little to no prior knowledge of the topic. As such, this target group is simulated as audience of the field trip's content and referred to as the "students" or "participants". A leading assumption is that the "class" or "course" does not meet face-to-face and all activities are carried out online. The prototype will thus be constructed for "immersive web use", in the taxonomy of HARMON (1999 after HOUTSONEN ET AL. (2004, 166)), requiring a simulation of all course activity related to the trip.

While the development of the VFT's content is not goal of this thesis, learning goal definitions help to motivate sections and make design choices and steps conducted comprehensible. The excursion's leading question was "How can large (erratic) granite boulders in the valley mouth of the Odertal be explained?", ultimately leading students to exclude all possible answers except for a glaciation of the mid range mountain area. In doing so, the field trip has connections to the topics of

- geoscientific research methods and tools in aglacial-geomorphological context,
- landscape and sediment indicators for the reconstruction of a (historic) valley glacier in the Odertal,
- mechanisms and environmental changes by a glaciation,
- the differences in climate, landforms and vegetation between a glaciation period and today's interglacial conditions,

some of which have already been introduced in lectures and seminars during the semester and prior to the field trip. The course is based on consecutive content, as earlier stages are necessary for the understanding of later sections. Physical "movement" trough the valley, but also the thematic navigation along the content will thus follow a linear route.

d) Template choice:
In this prototype, information management and teaching is the main goal. Although large text bodies are not desired in multimedia applications, explanations to the content are very much needed. The Map Journal features explanations in a separate Side Panel while leaving room for various media types in the Main Stage. This distinctive twofold structure matches the parallel, text and image, input channels of the "cognitive theory of multimedia learning" (MAYER and MORENO, 2003, 44-45) (*section 3.1*) and thus qualifies the template for the task.

e) System choice:
The prototype will be based on a desktop/web-browser approach without a mobile component. While Map Journal applications support mobile devices through interfaces for reactive displays, broadening the use case to mobile scenarios would have fundamental consequences on prototype construction and evaluation criteria. Some of the reasons speaking against extending the use case are:

- Costs - navigation and location based services of ArcGIS consume credits, preventing a cost free approach or limiting any navigational support to a minimum.
- Screen size - the relatively large Side Panel uses a large portion of screen size for text and is thus marginally suited for handheld devices.
- Sensors - to create a meaningful experience, the application would have to make use of a device's sensors (e.g MUENZER ET AL. (2007)) which is not fully supported by most applications of the JavaScript API or the intended browser environment.
- Surroundings - prototype construction would have to respect the physical environment, both in design and technology (e.g ABOWD ET AL. (1999),RAPTIS ET AL. (2005)),
- Logistics - The VFT's stage is located in a remote area with mountain shadowing and limited reception.

A browser environment, in contrast, remains cost free, can be run from all types of devices and is not influenced by context or environmental characteristics.

5.2 Application design on story level

This section describes requirements and workflow of the prototype implementation on content (story) level. The test application features several Side Panel sections, including introduction and summary. Location identifier, topic, elements of both stages, target principle and account requirements are displayed in the "story board" (*figure 5.1*).

Section	Location	Main Topic	Concept	Side Panel	Main Stage (Picker)	Account Type
0	Oderhaus	Overview and Section Links	Interactivity	Section Links	Web map	Online
1	Valley mount	Map Comparison, Webservices	Interactivity	-	Website / application	Developer
2	Oder river	Experiments	Interactivity	-	Website / iframe	Online
3	Tributary valley	Time Aware Data, Query Layer	Interactivity	-	Website / application	Developer
4	Traverse	Audio and Image Galleries	Immersion, Communication	Audio player	Website / iframe	Online
5	Terminal moraine	Story Map Actions	Interactivity	Story Map Actions	Web map	Online
6	Terminal moraine	Layer Manipulation and Contribution Tools	Interactivity	-	Website / application	Developer
7	Ground moraine	Assignment: Mapping Tools	Interactvity, Communication	-	Website / application	Developer
8	Hahnenkleeklippen	Visual Content from Ground Perspective	Communication		Website / iframe	Online
9	Forest	Discussion and Feedback	Immersion	Discussion	Website / iframe	Online
N	Königskrug	Embedded Story Maps	Interactvity, Communication	-	Website / Story Map	Online

Figure 5.1: "Story board" of the prototype application. Each section hosts a single, self contained topic. Element definitions of both stages are orientated at educational concepts. Account type displays requirements.

Each section of the Story Map is intended to host a single, self contained topic with a distinctive learning goal. Based on this goal, an adequate pedagogic tool is chosen that shall either foster understanding of a topic or assist in the conduction of learning task. Required steps of the workflow and design decisions are documented in the implementation paragraph. Each section of the prototype will be described in detail below.

5.2.1 Introduction - Overview and Section Links

Learning goal:
Introductions are in general used a) to motivate the audience for a topic or lesson, b) to order the content and to break it down into units of manageable chunks and c) to provide guidance for inexperienced users. While the original field trip was motivated by the question "How can large (erratic) granite boulders in the valley mouth of the Odertal be explained?", such an opening question would prove confusing for a virtual environment, as the user would neither be familiar with the Odertal nor the characteristics of its surroundings and appearance of erratic boulders. In fact, a VFT's introduction has to take a general unfamiliarity of remote, global users with the research site or stage into

account and has to respect the inherent inability of the audience to sense and acquire orientation from their surroundings. Thus, an overview is required to guide the user through the program.

Pedagogical tool:

Both sections are utilized to host introductory content. The Side Panel, generally responsible in the application for hosting text, will be used to establish a table of contents, while the Main Stage uses an overview map, displaying the field trip's course (see *figure 5.2*). Which media is used for motivation in the end is solely up to the author's preference. The latter stage could also be used to display vivid introductory content, like videos, sideshows or animation and to provide some first impressions on the environment as it would be encountered on a real field trip in that area.

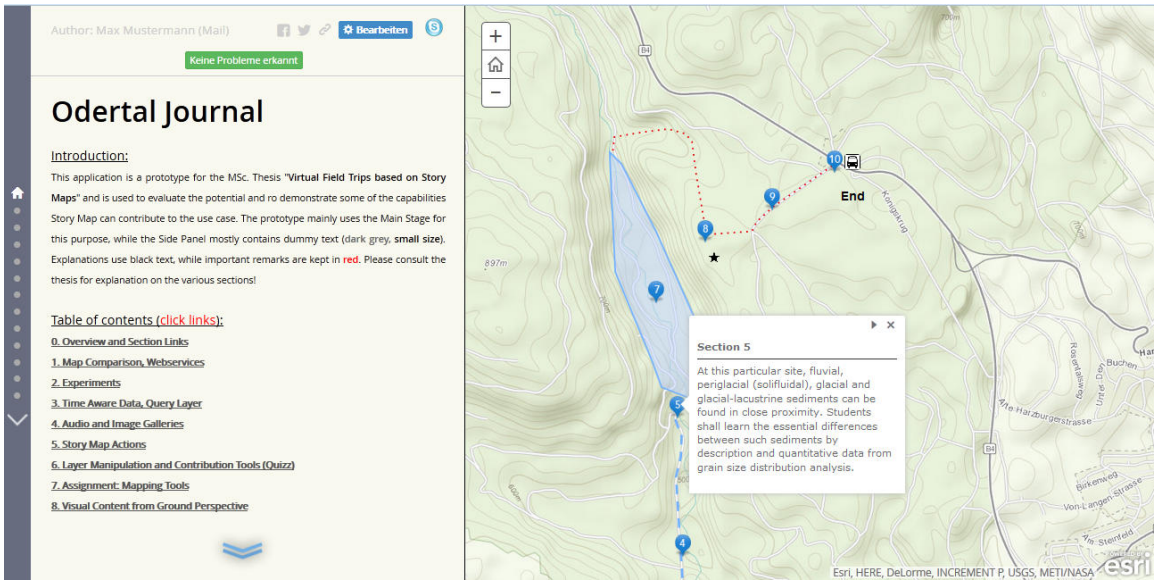

Figure 5.2: Web map designed as an overview for the Odertal Virtual Field Trip. Numbered icons reference stages in the table of content and can be selected to open a popup window.

Implementation:

a) Side Panel - Table of contents:

The template generally provides two types of links that assist in navigating the content: Story Map Actions are meant for updates on the Main Stage, while links[1] (more precisely

[1]http://blogs.esri.com/esri/arcgis/2015/06/24/adding-links-to-sections-in-story-map-journal/

onclick events) on the section index can be used to shortcut to specific parts of the application and are thus useful for setting up a table of contents.

Section indices are generally hidden from the user, but define the template's behaviour in the source code. The script sets and an onclick event that executes an update of the corresponding section index (i = 0,...,n):

```
<p><a onclick="require(['dojo/topic'], function(topic) topic.publish('story-
navigate-section', i); );">text node</a></p>
```

With a modification on the inner html element, images can also be used to anchor links:

```
<a href="" onclick="require(['dojo/topic'], function(topic) topic.publish('story-
navigate-section', i); );"><img src="image" alt="text node"></a>
```

As the CKEditor only handles plain text input by default, the source code widget (available to the standard editor used for Map Journal) is needed to switch into source mode. Section *5.3.2.1* introduces a tool to simplify and automatize this workflow. The section is invoked with the first (default) Main Stage view, irrespective of the number of Main Stages attached. A specific Main Stage view cannot be defined this way, as these are registered through Story Map Action identifiers (*section 5.2.6*). If a section does not exist (i > n), the Main Stage throws a 404 error.

b) Main Panel - Overview map:
Each section requires at least one mandatory Main Stage view which is registered by selecting a single media type (video, image, map) by the "media picker" script. Users familiar with other templates (e.g. Map Tour) expect the application to automatically generate an overview map from the section pool. This is, however, not the case with the Map Journal. The first reason is that Side Panel sections are "locationless" text-fields, and thus differ from geotagged or geolocated content like e.g. the POIs from the Map Tour template. Second, a single section might be connected to one or several (un-)related Main Stage views, all containing different data types with no (e.g. a website) or variable location, spatial scale and extent (web map/app). Any overview map intended for a Map Journal therefore has to be created manually, either through ArcGIS Online's map builder

or external programs.

For the instance used in the prototype, a web map was created through AGOL's map application. Maps hosted in the author's "my content" repository are directly available for Story Maps. Any tour points, routes and explanation were defined on an annotation ("map notes") layer, linking graphical symbols by default to a popup window. These popups can optionally contain heading, description text and images. The workflow requires the user to assign a section to a specific location on the map and to choose a corresponding point, line or polygon symbol that tells the user whether the section is meant to cover a location, route or area. It might seem obvious to insert html markup into the popup's text area to extend the rather static nature of AGOL map icons. Especially in terms of linking of sections, authors might want to anchor links that redirect back to Side Panel content. However, web map popups only support html (or code) for image (link) definitions, but will display scripts as plain text in the text area. Although links of <URL>?appid=<ID>&section=<index> syntax can be anchored to images, these will open a second application instance in a new window instead of updating to the specified section.

5.2.2 Section 1 - Map Comparison, Webservices

Learning goal:
The first step in a geomorphological survey is to gain an overview of the surrounding topography and bedrock geology of the research site. The goal is to identify different rock types and conclude that erratics in the riverbed and on terraces cannot originate from the valley flanks through e.g. mass wasting or rockfall.

Pedagogical tool:
Overlays of several maps and images, ideally with a matching extent and spatial reference can be used to directly compare visual information. As opposed to simplistic buttons that adjust the overlaying layer or its opacity, "swipe" or "spyglass" tools allow the user to dynamically define the extent of an overlay, either by one-directional horizontal/vertical slider ("swipe") or by two-directional circular area ("spyglass"). A drop down menu with different layers and a legend assists in comparing and experimenting with information.

AGOL's base maps and layers from a webservice form the applications data base (see *figure 5.3*).

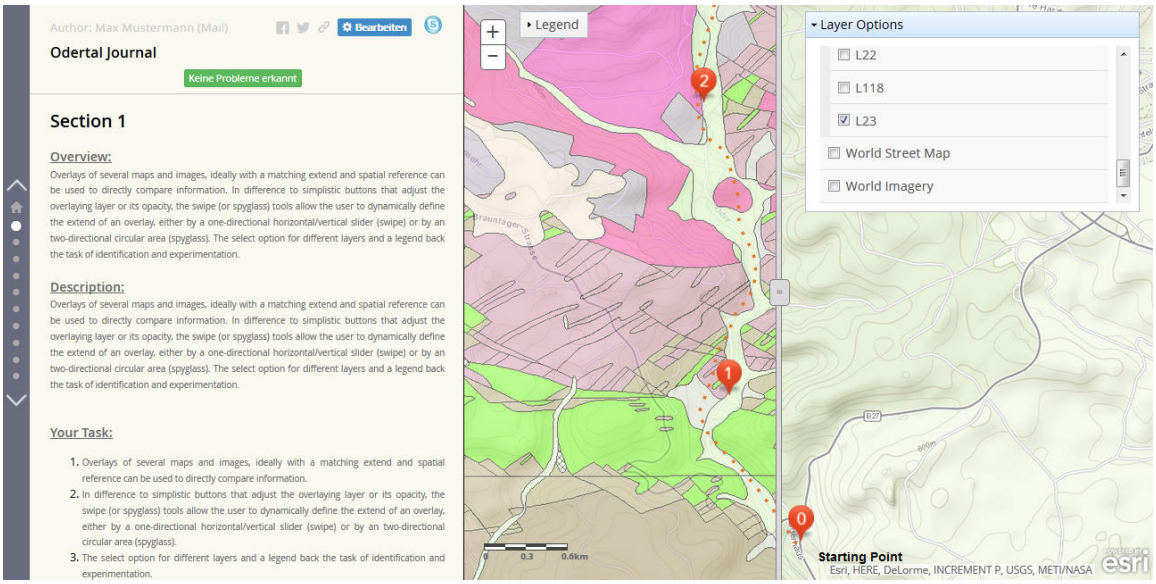

Figure 5.3: Web application of section 1 features a slider to display data from a webserver as overlay of basemap content from AGOL. Data can be toggled with "layer options" and "legend" drop down menus.

Implementation:

A hybrid AGOL - JavaScript API approach is used to define an AGOL web map as data source and to add functionality through the API by referencing the map ID in a customized application file. Although a pure JavaScript implementation is possible, an AGOL-based approach greatly enhances the workflow and ensures the consistency of data.

a) Data source preparation:

At least two (three) layers are needed for the comparison: First a basemap (base layer), which is always visible and acts as foundation. Second, the layer to be swiped, meaning being dynamically toggled over the basemap. Its opacity percentage is either set to 0% if only one layer shall be visible at a time, or to a specific transparency if the basemap shall be visible through the layer. Third, an optional annotations layer can provide further information, highlight points of interest or host general map annotations. This layer is always visible by default and can neither be toggled nor swiped.

Base layer: AGOL basemaps[2] provide global coverage, sufficient detail at flexible resolution levels and high performance (although being dynamic maps), hence act as a sufficient starting point for almost all application scenarios. The JavaScript API also allows customized base layers e.g. through the *ArcGISTiledMapServiceLayer*-Class[3] and with version 3.3, even maps without a specific basemap[4].

Layer:
The second layer can be chosen from various local and web sources[5], including the "Living Atlas" repository. To use custom layers together with ArcGIS basemaps, it is mandatory that both use the same spatial reference as no re-projection functionality can be provided[6]. Web map standard is the WGS84 Web Mercator projection (EPSG:3857, wkid:102100).

Annotations:
Annotations can be created through a "note layer" in AGOL and contain descriptive text or symbols. This layer is suitable for instructions, to highlight areas of interest or to establish a sequence in the learner's task.

The ArcGIS Online map builder is used to set up the web map components and to arrange the different layers. Basemap choices include "satellite", "topo" and "osm" data, which correspond to the sections topic. The osm layer is chosen as basemap, as it provides a general orientation, while the other layers add imagery and relief information. Geological data comes from a webservice[7] hosted by the LBEG Niedersachsen. The most convenient way is to use AGOL's WMS-OGC-Web-Serivce interface and to select all relevant layers of the service. Transparency is set to 0% for the basemap items and 40% for the layer group, to ensure that geological data can be combined with general information from the baselayer. The annotation layer is set to contain instructions for the task, e.g. query points and feature descriptions. The web map is published to AGOL and referenced by ID in the app.

[2]https://developers.arcgis.com/javascript/jsapi/esri.basemaps-amd.html
[3]https://developers.arcgis.com/javascript/jsapi/arcgistiledmapservicelayer-amd.html
[4]https://developers.arcgis.com/javascript/jssamples/fl_no_basemap.html
[5]http://blogs.esri.com/esri/arcgis/2012/09/24/arcgis-online-layers/
[6]https://developers.arcgis.com/javascript/jsapi/basemaptoggle-amd.html
[7]http://nibis.lbeg.de/net3/public/ogc.ashx?PkgId=22&Version=1.1.1&Service=WMS&Request=GetCapabilities

b) Application development:
While it is possible to pass the map to a web app ("slider") or Story Map ("swipe", "spyglass" templates) builder in AGOL, such strategy is either of low performance or not suitable for further customization. By using the ArcGIS for JavaScript API, an application file can be defined, hosting map reference, style definitions and the overlay functionality through customizing predefined widgets. A web application created this way has to be hosted on a web server and is referenced by URL in the Story Map media picker using the website option. As content data is hosted in ArcGIS Online or provided by a webservice, this solution has a high performance, consumes very little storage space and generates less traffic on the author's webserver compared to hosting the content by oneself.

The web application constructed for this section uses code from the "LayerSwipe", "LayerList", "Legend" and "Basemap Toggle" widgets (all in ArcGIS API for JavaScript "map" book):
The "LayerSwipe" widget forms the core application. By the createMap method, a map instance is created on basis of AGOL web map content. While this allows loading the map in the original setup and avoiding a manual WMS Service definition (which is still buggy and not fully supported by the API), opening the application locally from the hard drive will throw a NS_ERROR_DOM_BAD_URI Error in the browsers console. By referencing basemap and layers individually (as demonstrated in the following sections), this error can be avoided.

The widget allows the setup of a horizontal or vertical bar and a "spyglass" alternative as swipe tool. A definition of the swipe-able layer is realized by looping through available layer names. By using the webservice name in the definition, all sublayers remain accessible by the application and can be toggled by the user per checkbox. Basemaps and layers are stored in a 'LayerList' menu that allows deselecting of all items except the base layer and annotations. Storing all layers in a single lists makes a separate widget to toggle basemaps redundant. In contrast to the original item, taking up much room as a side panel, the layer list utilizes the dojo toolkit (parser) to style buttons and panels as dijit elements in a declarative way.

A similar container is used for hosting the map's legend. The script dynamically queries

the "LegendLayers" property to obtain legend information of *visible* map layers[8]. Basemaps do not generate legend information.

If both the Layerlist and Legend menus are maximized on a small screen, the former is set to be displayed over the latter to guarantee functionality. Lastly, a scalebar item is added to the bottom of the main map.

5.2.3 Section 2 - Experiments

Learning goal:
The students shall consolidate their knowledge of fluvial processes and entrainment forces. The task is to determine critical boundaries of erosion, transportation and deposition settings in a stream and to conclude that boulder sized debris cannot be transported by a fluvial agens.

Pedagogical tool:
This section shall account for modelling environments and scripting interfaces that allow experiments and simulations to be included in Story Maps. A specific model is **not** provided with the prototype.

Implementation:
Desired is an environment that allows the user to experiment with preselected models, supports the alteration of parameters or code bits and features a graphical interface to display the results. None of these operations can natively be supported by the Story Map application. Such functionality can however be provided for instance by NetLogo (CCL), a modelling environment that supports simulations based on the programming language LOGO. NetLogo Web is a browser application with reduced functionality to the parent desktop edition. As java applets are neither supported any longer by Oracle nor recommended by CCL[9], the only option is to include NetLogo (or any equivalent) via iframe into the application. This work-around also guarantees a usability with iOS and

[8]Default layer "L23" of the webserver is missing legend information and will show an error box instead.
[9]Source: https://github.com/NetLogo/NetLogo/wiki/Applets (10/2015)

Android based devices. The Map Journal's media picker script can feature websites in iframes both in the Side Panel or the Main Stage. It is advisable that the Side Panel contains a task description and an instruction on the necessary steps to conduct the experiment, as such information is difficult to display in the NetLOGO environment. The Main Stage is set to feature the iframe container in which NetLogo Web is displayed: Similar to the desktop version, code, model, command centre and infobox are hosted in (vertical) tabs. To avoid (horizontal) scrollbars and to increase the usability on devices with a smaller screen, this stage can benefit greatly from the "fullscreen"-plugin, which hides the Side Panel and is introduced in section *5.3.1.1*.

5.2.4 Section 3 - Time Aware Data, Query Layer

Learning goal:
"Glacial Lake Outburst Flood" (GLOF) events can transport even large boulders by an excessive flow of water. Such an event requires a specific topographic and topological setting, in which a glacier from a tributary valley forms a barrier to a non-glaciated main valley. Students shall falsify this hypotheses alongside a simple visual experiment that demonstrates glacial evolution in the Harz: As temperature decreases the accumulation area (zone of snow - ice transformation) progresses downwards and increases in size. The front of glaciers responds accordingly, filling the Odertal with ice, before any tributary glacier can block the main valley - therefore preventing the GLOF specific setting. On the meta level students can learn which parts of a mountain range generally glaciate first and how glaciation progresses downwards. Lastly, the relationship between ELA (the accumulation's area lower border) and glacier tongue altitude can be deduced.

Pedagogical tool:
The progression of temperature decrease, glaciation, accumulation area increase and glacier tongue response is time dependent, thus requiring an appropriate data representation. Using time-aware data in form of two feature layers in combination with a time slider to toggle the animation lets users experiment with the progression. An overview map shall help to easily navigate between different valleys. Features from the accumulation area layer can be selected to display further information on the specific zone. A box-chart visualizes the share of the selected altitude band in relevance to that of the

maximal accumulation area extent (see *figure 5.4*).

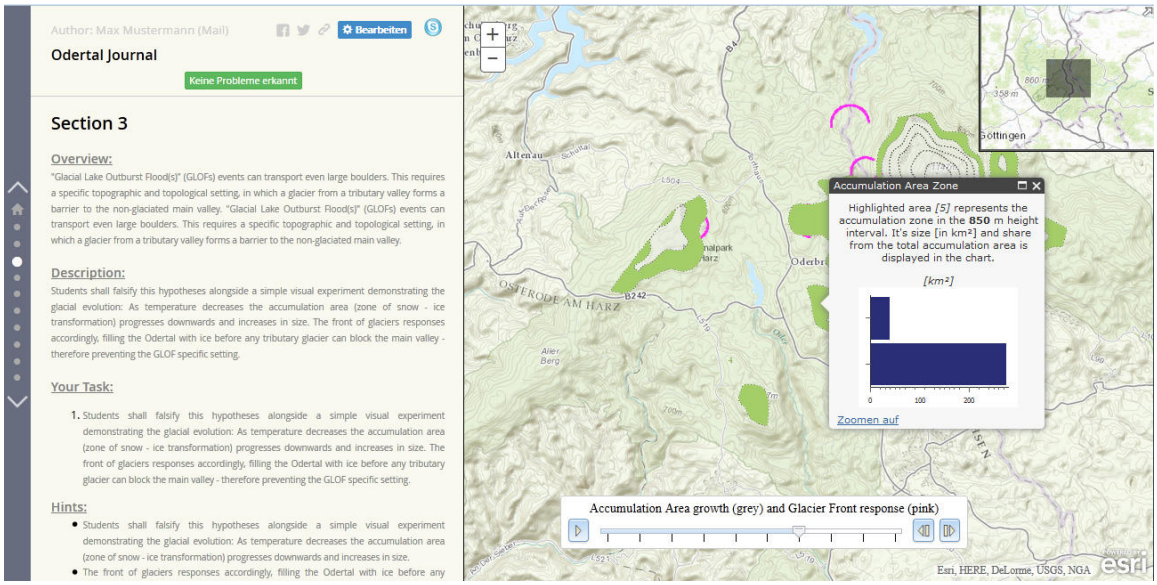

Figure 5.4: Web application of section 3 displays time dependent data that can be toggled with a timeslider. Grey areas represent the accumulation area (AA), pink lines the simplified tongue of glaciers emerging out of the AA. Selecting an area opens a dialogue window with information and charts.

Implementation:

The approach makes use of time-aware feature layers. These layers are created in ArcMap, hosted in AGOL (via a REST service) and queried by URL in the script file. The "time slider"[10] widget from the ArcGIS for JavaScript API animates data layers and allows a manipulation based on time interval definitions. Additional tools can be added for further data analysis, with the results displayed in popup dialogues. While comparable technology is available for raster data sets[11], raster data compilation and storage via AGOL's tiled map service requires careful preparation of the desired output (resolution and cache) and consumes credits for hosting the tiles. Raster data should therefore be converted into feature layers whenever possible. As conversion cannot be performed inside AGOL, it requires ArcGIS Desktop or any other adequate tool. The approach is spilt into data preparation, performed in ArcGIS for Desktop/ArcMap and application development (ArcGIS API for Javascript):

[10] https://developers.arcgis.com/javascript/jssamples/time_sliderwithdynamiclayer.html
[11] https://developers.arcgis.com/javascript/jssamples/layers_raster.html

a) Data preparation:
The goal is to generate one or more layers of time-aware data in ArcMap. This can be achieved by creating a shape layer, containing point, line or polygon features and adding a time field of the "date" data type to the attribute table. The time animation follows the chronology provided in this specific table field. Dates may be displayed explicitly or as "ticks", allowing the setup of (consistent) pseudo-data. After enabling time settings in the options, the layer can be deployed in a zipped folder to AGOL. Time settings may have to be activated a second time in the "own content" section of ArcGIS Online. Layers can be referenced by REST service-URL in the application definition file.

In the current example the first (polygon) feature layer, meant to symbolize the accumulation area extent, was created using SRTM height data. After re-projecting the raster to the Web Mercator system, the dataset was converted into a shape file, smoothed (Bezier-Interpolation, 500m tolerance) and manually rectified in areas of steep contour lines. Each feature was allocated a datum of pseudo data, corresponding with the altitude level represented in the shape. The attribute table contains the extent, calculated from the projected shape size, as well as the total area, calculated by the sum of all projected features. A second (line) feature layer was created manually, representing a simplification of glaciers fed by the accumulation area. The height was estimated using a TSAM calculation method and the time field was set up synchronous to the first layer. Both layers were marked time-aware and deployed to AGOL.

b) Application development:
To have full customization options, the web app was created with the ArcGIS API for JavaScript, using the "time slider"[12] widget as basis. A default basemap is assigned to the application and both layers (accumulation area and glacier tongue) are referenced by layer ID from AGOL. The content is styled by declaring symbols (SimpleFillSymbol, SimpleLineSymbol) for a renderer (SimpleRenderer) using the API. With setting the "output fields" definition, the target layer (glacier) is made queryable. The "layers-add-result" fires on the widget when layers are successfully loaded to the map and initializes the time slider.

[12]https://developers.arcgis.com/javascript/jssamples/time_sliderwithdynamiclayer.html

The slider plugin queries the time field(s) of the target layer(s) and can be customized by setting start/end date and time step intervals, subdividing the slider's legend. Output is either displayed in a fixed time span (two "thumbs") or progressively (one "thumb"), with the slider proceeding at a fixed moving rate or by user input. For the current implementation a steady, cumulative progression (one "thumb") was chosen to simulate glaciation. As pseudo data is used to define the chronology, labels are omitted and time intervals are visualised by a simple bar signature. The slider is displayed in a div container at the bottom of the map.

Two further additions are made: As it is likely that the user will explore data in depth, say e.g. to investigate the glacier progression in one valley, an overview map is provided. This is the same widget as available by default for AGOL web maps. The second widget added is a popup[13] plugin used to identify data and to display information from the feature's attribute table. The widget's definition code has to be declared before the layer initialization to work correctly. The "PopupTemplate" object definition can query field values from an attribute table if corresponding field names are unlocked in the "out Fields" property of a layer definition (as done above) and marked by curly braces (e.g. target) in the description. In contrast to AGOL popups, html is supported for styling the elements. Furthermore, the popup can dynamically visualize table data as a chart, using the dojo-toolkit charting library. Charts defined by this approach are in so far responsive, as they adjust to data changes in the attribute table. By providing additional information to the attribute table and expanding this functionality to other layers, the usage scenario can be extended to deliver profound information on glacial phases and progression (e.g. terminal moraine information, isotope data, erratic content etc.).

Selecting a (visible) layer highlights its extent with a customized style (using the SimpleRenderer class) and toggles the popup. As layers can only be selected when displayed in the corresponding time extent interval, the browser console displays (non-critical) errors on application startup.

[13] https://developers.arcgis.com/javascript/jsapi/popup-amd.html

5.2.5 Section 4 - Audio and Image Galleries

Learning goal:
The original field trip requires participants to traverse a larger part of the valley without any major stops. This leaves room for a small break, to ask questions or to survey the surroundings. As the audience of a virtual excursion does not move physically, this part is used for investigating media types that would be suitable to (passively) simulate or attend a relocation. A more active way to relocate perspectively will be demonstrated in section *5.2.9*.

Pedagogical tool:
The section uses an image gallery (slideshow) to simulate passive movement from one part of the valley to another. The Side Panel hosts various audio elements, which can either accompany a slideshow or replace descriptive text.

Audio in the Side Panel:
a) ESRI's default "audio controls" element:
At the current time, the Map Journal template does not support audio data to be managed by the media picker. Users who would like to use sound in the application have to set up an audio plugin by themselves, e.g. by embedding code into a website or web app stage. However, a basic player by ESRI is available[14] and can be integrated into the Side Panel through CKEditor's source code mode:

> <audio controls> <source src="<filename>.mp3" type="audio/mpeg"> <embed height="50" width="100"> </audio>

The mark-up creates a new "audio controls" html element that requires a URL reference to the sound file's location (with explicit filename extension) as well as an optional definition of the players css styling. The audio plugin comes with minimal functionality that lets users start/stop the recording and toggle the volume. Playback has to be manually started and leaving the section will not stop the recording. This makes the audio player impracticable and less suitables for longer recordings and scenarios where switching

[14] http://blogs.esri.com/esri/arcgis/2014/02/20/adding-audio-to-your-story-map-map-tours/

sections is common.

A tool to automatize setting audio controls elements to story map sections is described in section *5.3.2.1*.

b) Soundcloud:
Soundcloud is an audio distribution and social media platform that lets users host and access sound files. Like other major websites Soundcloud's API supports short code for embedded links which can be placed in websites.

Two styles can be defined by iframe container, either an icon that will link to the user profile on Soundcloud or a player plugin, which allows sound files or playlists to be toggled out of the application. Except for a different styling, Soundcloud's plugin also allows users to comment and share the audio file. Setting the auto_play attribute to "true" will automatically start playing a sound file when the user accesses the corresponding section. Playback is stopped in either way if a user leaves the section, but with auto_play=true, audio is played starting from the beginning with re-entry in the latter case.

Image slideshow in Main Stage:
In this case a slideshow of images shall be used for the Main Stage to visualise moving along a route. A single Flickr[15] gallery hosts the image files, as media content cannot be stored directly in ArcGIS Online. Embed-code provided by Flickr[16] is inserted in a html file which can be stored on a webserver and referenced via URL in the Main Stage to display the images. While this workflow is sufficient for a successful embedding in Chrome, the gallery flash object has to use a specific "windowmode" attribute (<param name="wmode" value="opaque" /> to work correctly in Firefox. The size of the gallery can be modified using css markup. Depending on the properties defined in flickr, the images will be displayed as a gallery or slideshow.

[15]Flickr, Picasa and Facebook galleries are natively supported by Story Map applications.
[16]http://blogs.esri.com/esri/arcgis/2015/09/19/adding-flickr-albums-story-map/

5.2.6 Section 5 - Story Map Actions

Learning goal:
After assessing the coarse size sediment spectrum of gravel and boulder, the fine particle classes of clay, silt and sand shall be investigated, connecting a characteristic grain size distribution of an ideal-typical sediment sample to the corresponding relocation process in the valley. At this particular site, fluvial, periglacial (solifluidal), glacial and glacial-lacustrine sediments can be found in close proximity. Students shall learn the essential differences between such sediments by description and quantitative data from grain size distribution analysis.

Pedagogical tool:
The time-consuming processes of sample acquisition and lab-work is simplified due to working directly with results. Dynamic Stage Updates from the "Story Map Actions" are used to incorporate various sources of information in a single section and to geo-localize POIs on the web map. A basemap visualizes the sample location and their surroundings or is temporally swapped for content that requires hosting in the Main Stage (e.g. due to size requirements).

Implementation:
The implementation can be realised completely within the Map Journal application using the build-in tools of "Story Map Actions". While such strategy limits the overall customization options for the map in comparison to an API approach, only AGOL web maps or content can be updated currently by Story Map actions. As map updates are specified in an overview map, location, extent and zoom level can be defined without exact coordinates of a bounding box. Alternatively a geolocalization and reverse geocoding service accepts user input in form of coordinates or addresses, especially useful for urban areas.

Set-up requires a default view for the Main Stage, while further views are defined by using the "Story Map Actions" plugin of CKEdior. Highlighting relevant text passages in the editor allows two type of link definitions:

<a data-storymaps="MJ-ACTION-'ID'" data-storymaps-type="**media**">'Text'
and

<a data-storymaps="MJ-ACTION-'id'" data-storymaps-type="**zoom**">'Text'

It has to be noted that while the plugin restricts anchors to plain text, the markup can be manipulated using the editor source code option. This allows e.g. css styling or an image anchor for the link. Each action is tracked by a 13 digit ID number and referencing the ID can replicate a specific action. "Media" and "Zoom" define one of the two action types, performed in the Main Stage when clicking the link:

a) Toggle media type ("media"):
This swaps the current main stage media type with a new element, defined by using the media picker. Options allow a single image, video, i-frame container/website or web map to be hosted in the main stage. This also allows the nesting of a separate Story Map in the main application as demonstrated in the last part of the prototype. The user returns to the section with a button displayed in the upper corner. Links can be removed by using the corresponding button in the "Story Map Actions" toolbar.

b) Map Update ("zoom"):
While this plugin is meant for reverse geocoding by searching for a specific address (by name or coordinates), it also allows the user to define a map update of the currently displayed web map. As the user sets extent and resolution in an overview map, changes are stored in the link. It has to be noted that this "definition" map consists only of the current base layer, omitting potential annotation layers and complicating exact positioning (e.g. centring of features, icons). Furthermore this method defines a target area, but not a layer's specific feature or data type, including annotations. Lastly, zoom updates allow either to set a default icon that indicates an exact position on the map (e.g. to hint to a specific point of interest) or to highlight areas of unspecified regions without the icon.

The prototype uses the "Story Map Actions" tool to point out areas of a map previously created with AGOL. The map contains a topographic baselayer plus an annotations layer defining several features of interest. Selecting a feature displays an image and description. The Side Panel contains the units' lecture about sediment grain sizes. Keywords are highlighted to direct the user to resources outside the application (e.g. articles, charts) expanding the actual extent of its content and allowing the user to decide about the level of detail. A second type of link updates the map to connect background content with live examples from the Odertal. By clicking on the annotation layer, feature spe-

cific information is displayed. The user returns to the main application with the "back" button.

It has to be noted that the Story Map Actions are the closest approach to Main Stage branching, although being in fact one directional, as all actions ultimately link back to the origin section and user action has no effect on the further course of the program. In this matter, the tool varies form linking sections as illustrated in section *5.2.1*.

5.2.7 Section 6 - Layer Manipulation and Contribution Tools

Learning goal:
A small exercise shall verify that the different mechanisms of sediment deposition are understood and can be identified in the grain size signature displayed in charts. The quiz requires students to analyse a set of fictional samples in the map and to assign symbols of the matching transport and deposition agents (glacier, river etc.) near the sample's location. The exercise can be extended by asking the students to draw box charts and sum curves of the popup's samples data or to write a small report and to attach this content to the symbol.

Pedagogical tool:
The former task focused on various forms of object access and display interactivity. Here, students are asked for activity in form of a simple multiple choice test. Several sample locations are defined in the map, containing IDs and grain size data from an attribute table. The corresponding feature layer is locked for edits. A side bar hosts symbols of a second, modifiable feature layer. New features can be placed on the map while input of meta data into the popup's dialogue box is stored in the layer's attribute table (see *figure 5.5*).

Implementation:
User access to layer and feature manipulation distinguishes the functionality from the review task on the same topic in section 5. As user input modalities have to be predefined and visualized in an appropriate way, a customized web application using the ArcGIS for JavaScript API is developed for the task. Data sources have to be defined outside AGOL, e.g. by using ArcGIS for Desktop.

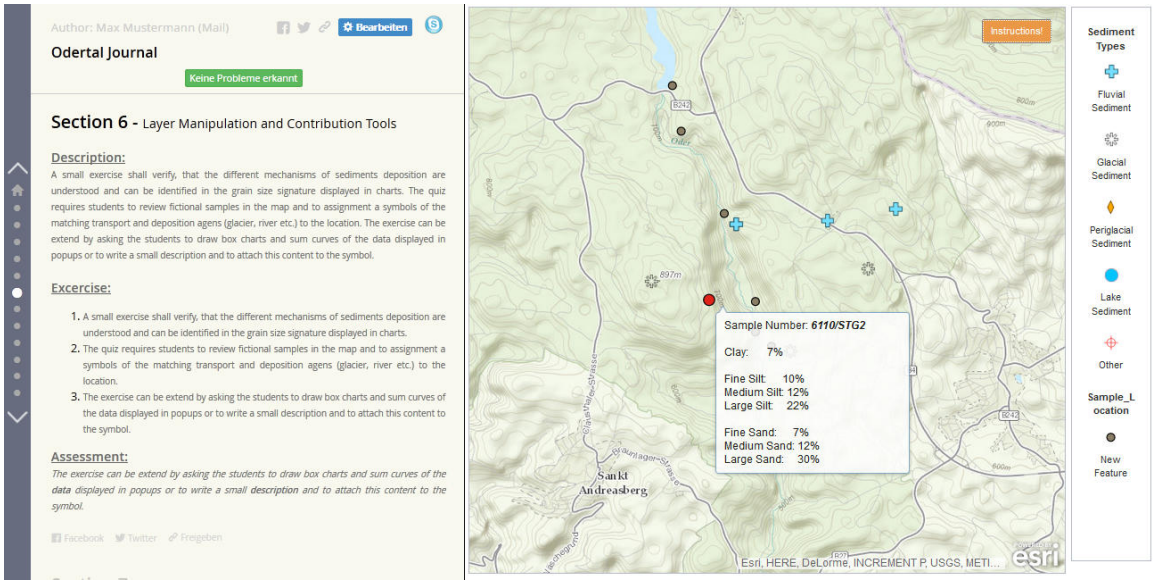

Figure 5.5: Web application of section 6 displays various sample points and an icon toolbar on the right. Symbols of the latter can be placed on the map while their dialogue window accepts input of metadata and attachments. Sample points can be accessed by hovering over the icon (brown dots).

a) Data preparation:
Two feature layers are required and prepared in ArcMap: First, a point feature layer symbolizing samples locations in the map and storing sample data to be displayed in the popup. To simplify the process, round numbers mimic percent values. As the user is asked to identify samples by their signature, all symbols were styled in the same way. The layer is uploaded to AGOL, with settings to allow queries but to prevent edits or feature deletion of the data.

A second, operational shape layer is needed to host the custom signatures for the symbols to be placed in the identification task, as well as to store the user edits. Elements are defined as features of a single or multiple layers using "unique values" symbology. All symbol properties (names, labels, attribute fields) have to be specified and stored in a feature template before the layer is deployed to AGOL using ArcMap's "feature access" service option. It is imperative to allow "create", "delete", "query" and "update" operations on the service in order to enable user modification of the layer. Second, "track editing" has to be set to restrict edit and delete tasks to own data input. Both options can be set in the edit feature service properties in the "my content" section of AGOL.

In this case, a point feature layer was set up for the prototype, containing icons for the sediment type classes of the previous section as well as an attribute table with field names used for the popup window. Symbols are styled to bear some resemblance to the sediment's specific transport medium, e.g a white star for glacier.

b) Application development:
The first part of code contains definition of the data sources (basemap and layers) and the symbol styling of the "sample" features, using a "simpleMarkerStyle" renderer to highlight the selected point to which the corresponding popup dialogue belongs. In contrast to Section 3, data is accessible by hovering with the mouse pointer over the icon. To achieve this effect, two mouse events are registered. A mouse pointer hovering over the feature's geometry will fire a "mouse over" event on the layer and create a new temporary (highlighting) symbol and corresponding dialogue. Moving the mouse to a map location not containing a feature fires the mouse out event, which clears the graphic and closes the dialogue. Symbols of the second, edit-able layer use complex icons. These were predefined outside the application and do not use highlight effects. Accessible layer attributes are limited in the layer output field definition to what is actually needed due to performance reasons and to prevent users from editing any other properties. Fields set in the output definition are allowed to be queried by popups.

The second part of the script uses a template picker object[17] to display selectable features from a separate symbol panel. Selecting icons and placing them on the map will result in an update of the feature layer's attribute table. This mechanism is also used to write user input from the dialogue (e.g. name, date and description) to the respective table fields and to personalize user input.

The popup can be set to host attachments from a user's local drive. This requires the author to allow this feature in the content panel of the respective AGOL hosted layer. Attachments are restricted to a size of 10MB and can contain e.g. various image formats or pdf[18].

[17]https://developers.arcgis.com/javascript/jsapi/templatepicker-amd.html
[18]https://doc.arcgis.com/en/arcgis-online/share-maps/manage-hosted-layers.htm

An potential alternative to accessing sample data by popup can be established by a text query[19] on the attribute table. Queryable datasets are defined similar to those which are editable, but require a map service instead of its feature equivalent. The corresponding query flag has to be set when publishing the service to AGOL and its URL and queryable "outFields" array have to be defined in the script.

5.2.8 Section 7 - Assignment: Mapping Tools

Learning goal:
The area around the terminal moraine is rich in landforms of glacial origin. Students of the analogous field trip are asked to wander around the site to examine, identify and describe these forms to gain a feeling for their size, shape and distribution. An assignment, simulating a simple (geomorphological) mapping is chosen for this lecture to reassure an intense examination of the features encountered at this stage. It is assumed that explanation was provided prior to the task and adequate data sources were chosen for the mapping.

Pedagogical tool:
Geomorphological mapping on micro- and mesoscale landforms is often conducted in the field and uses simple tools like sketchbook, folding rule and GPS. While map layers replace information encountered at a real research site, replacements for the tools are simulated in this approach. The implementation consist of a draw and edit tool to sketch point, line and polygon features, a measurement tool to determine the size and extent of landforms as well as a widget to obtain map coordinates with the mouse pointer. As students are not used to sketching, means to manipulate and delete features or vertices are provided through hotkey combinations (see *figure 5.6*). Data sources can be manually defined using the workflow of previous sections.

Implementation:
As multiple tools shall enable an extensive assignment, predefined stand alone web-applications from AGOL are not sufficient for the task and a web application is developed

[19] https://developers.arcgis.com/javascript/jsapi/query-amd.html

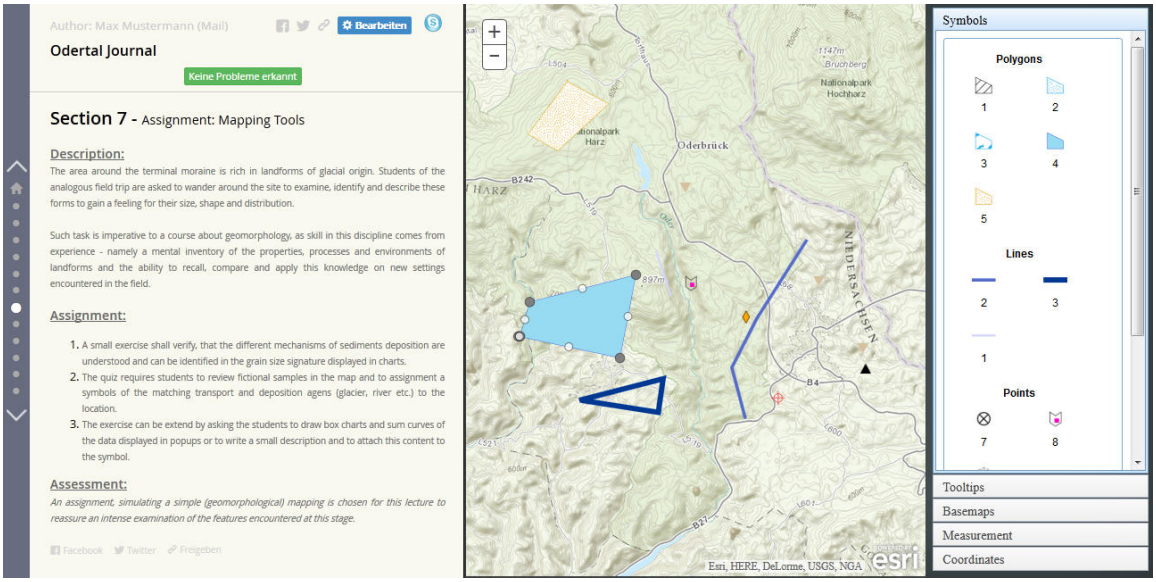

Figure 5.6: Web application of section 7 lets users experiment with various mapping and measurement tools, hosted in an accordion container. Vertices of line and polygon features can be modified with a combination of keyboard and mouse actions.

with the ArcGIS for JavaScript API.

a) Data preparation:
In practice, the task would actually require data of very high quality (at least a high resolution DEM), as landforms in the mid mountain range area are relatively old, not as well preserved and smaller than in the high mountains. Such information sources can be implemented manually through custom layers as demonstrated in previous sections. Data layers have to be locked to prevent modification by the user. Actual data is replaced by AGOL base maps used as dummy data.

The draw(-able) layer-set is prepared in ArcGIS for Desktop, using the workflow from *section 5.2.7*. Instead of a single layer, a feature-set of point, line and polygon shape files is defined in a geodatabase and set as template using unique value classification. Any tool intended to be accessible later has to be defined and styled in this stage, as modifications cannot be made later. Each feature layer remains to have its own service ID and has to be set to allow edits and deletion of features. In an assignment setting, operations have to be restricted in the "Editing" and "Track Edits" definition of each layer. Setting the appropriate flag will hide input content from all users but the administrator. Any

modification to the layer ca be tracked and remain revisable, as long as the layer is not shared with everyone (public settings) but with individual allowance for members of a group.

b) Application development:
The application shall provide tools for sketching and feature manipulation, for distance and area measurement and the detection of point coordinates. As drawing and editing is the most extensive task, it is useful to start from a widget that supports both. The "edit without editor" widget[20] is specifically suited for the task, as it can be used together with a template picker, hosting predefined symbols from several symbol layers, created in the first part of the script.

A sketching function is called upon a successful "layers-add-result" event, and contains definitions for sketching and editing from the "esri/toolbar draw" and "-edit" classes. The first part declares a new edit toolbar instance that will allow the modification of map features by a combination of onclick (mouse) and onpress (keyboard key) events fired on the corresponding, editable feature layer. Operations contain the following key combinations:

- simple click - Deselects feature if in editing mode
- simple click + CTRL key - toggles move mode
- simple click + ALT key - toggles feature rotation and scale (except for point features)
- simple click + CTRL key + ALT key - deletes feature from map.
- double click - toggles display of vertices and geometric manipulation.

As edit mode is toggled by clicking on an editable feature geometry (the corresponding layer is automatically selected), it is advised to keep features to a click-able size (esp. lines). A feature has to be de-selected before continuing with other operations.

The second part of the function defines a template picker (see section *5.2.8* for explanation) to display a number of previously defined symbols. Selecting a symbol and placing it on the map will either set a new point feature or a single vertex (in case of lines and polygons).

[20] https://developers.arcgis.com/javascript/jssamples/ed_feature_creation.html

Double-clicking will exit the drawing mode. New user created geometries are stored in their corresponding features layer.

'Measurement'[21], 'Basemap Gallery'[22] and 'Show Coordinates'[23] are predefined, self-contained widgets of the API and thus incorporated without further modification. To manage these additional tools in the limited Main Stage space, an "accordion dijit" html item was set in the panel. The container allows a logical separation of tools in various tabs, with the active tab using all but the vertical space required for tab labels.

A useful addition for authors with access to an ArcGIS Server instance would include a print tool[24] that prints or exports the final map as pdf-file.

5.2.9 Section 8 - Visual Content from Ground Perspective

Learning goal:
The Hahnenkleeklippen are a scenic viewpoint on the right flank of the Odertal. Located on the 700-750m height level, they allow a great view into the valley and onto the terminal moraine but also over the Harz and - a little walk required - to the highest peak, the Brocken. At this point participants are given a broad overview of the greater surroundings hidden until now by the steep valley flanks.

Pedagogical tool:
For the virtual instance, various types of immersive, ground perspective images shall be used. A great range of online tools and APIs for panoramic images or virtual tours is available and the specific embedding work flow varies in detail between the different distributions. Thus, the listing is far from comprehensive and not intended to test the Story Map capability, but rather the functionality or potential of the embedded product.

Media types:

[21] https://developers.arcgis.com/javascript/jssamples/widget_measurement.html
[22] https://developers.arcgis.com/javascript/jssamples/widget_basemap.html
[23] https://developers.arcgis.com/javascript/jssamples/map_xycoords.html
[24] https://developers.arcgis.com/javascript/jssamples/widget_print_esri_request.html

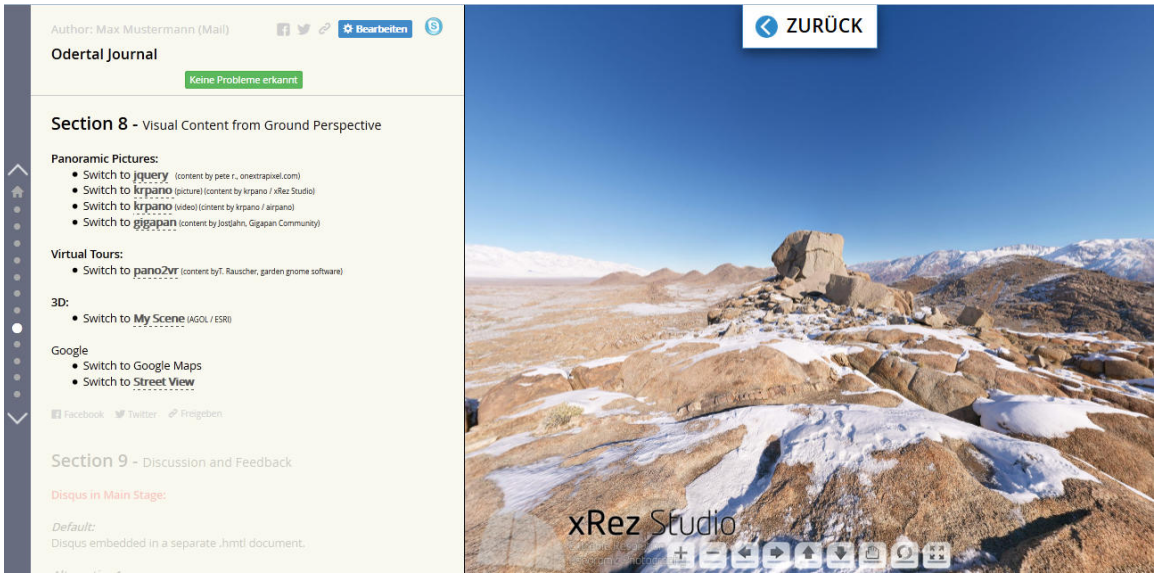

Figure 5.7: A 360° panoramic picture in the Main Stage of the Story Map Journal. Image content courtesy of krpano / xRezStudio.

a) Panoramic Images:

A vast range of tools exists to stitch, view and manipulate panoramic images. Former technologies mostly relied on Java (applets), Flash or Quicktime, considered "old technology" by now[25] and leaving stand alone viewers and web-centric approaches as the remaining options. For the latter, various choices exist, ranging from jQuery coded applications[26] to proprietary products. JQuery solutions have the advantage that the viewer is open source and can be customized in depth, although the majority of approaches is limited to scrolling or pan tools. Sample data of krpano, a flash and html based viewer for panoramic pictures and videos is included in the section to demonstrate the capabilities. Larger photo community platforms also provide embed links or iframe markup for website integration. As with e.g. Gigapan[27] it can be necessary to set up CSS styling in a specific html document to display the container correctly in the Main Stage. Still some browser specifics might apply and lead to errors or distortions.

b) Virtual Tours:

[25] http://wiki.panotools.org/Panorama_Viewers (11/2015)

[26] see e.g. http://www.sitepoint.com/10-jquery-panorama-image-display-plugins/ (10/2015)

[27] http://www.gigapan.com/cms/create-embed (10/2015)

Virtual Tours do not only display 360° panoramic images but also tools to change between different places or stages. This allows navigation through a graphically intensive, immersive environment combined with perspective changes of 2D imaginary. Again, any tool that allows embedding or sharing of HTML or Flash output in browsers can be used to create content for the Story Map application. The example features an pano2vr[28] offical sample, which was stitched (merging all images) before using the tool to add parameters, hotspots, links and media.

c) 3D - ArcGIS Online "My Scene":
The online equivalent of ArcScene features 3D basemaps, pan and rotate tools as well as several sample data sets and is specialised on visualizing data from a birds eye perspective. Scenes can be saved as thumbnails or embedded in websites via iframe container. As a toolbar is provided for embedded scenes, these can be modified out of the Story Map application. Currently, sample content of "My Scene" is rather limited, while rendering the application requires a high amount of browser cache and resources.

d) Google specific technology:
Google and Bing Maps are now widely common and serve as map basis for applications. While the latter is still lacking in API support for embedding scenarios and could not be used with Story Maps, the Google product range of "Map", "Streetview" and "Photosphere" interacts with each other, is easy to implement and free to use.

The easiest way to feature "Google" Map or "Street View" content is to obtain an embed link directly from a Google application and paste it into the MediaPicker/Website iframe container. Attributes like map coordinates and view direction are stored in the URL key (source element) and will be adopted by the Main Stage. Content featured that way will contain GUI elements (e.g.navigational tools, overview map, image carousel), and remain fully interactive inside the container, except for routing functionality, which will open a new window. An alternative is to setup a html file using the Google API. This approach will require an API key and a definition of start coordinates in lat/lon format. Heading and pitch properties have to be customized to define the angle of view.

[28]https://ggnome.com/samples/pano2vr_4/tour/

"Photosphere", Google's spherical panorama format, can be used in a similar way. In contrast to Map and Streetview, most images are user generated content and restricted from embedding in other websites by there owner through the "sameorigin" x-frame-option. Embedding the images manually in an iframe or html document outside the origin page will result in an error. While Google Maps is available area wide, Street View and Photosphere depend on availability of data in the target region, currently restricted to larger cities. The prototype thus has to use the city of Hannover as dummy data.

5.2.10 Section 9 - Discussion and Feedback

Learning goal:
The field trip draws to a close as participants of the real excursion are leaving the surroundings of the Odertal and head for the bus stop. Before the VFT will be recapitulated and reviewed in the last section's summary, the audience is given the opportunity for questions and comments.

Pedagogical tool: Communication tools for a locally dispersed audience range from message boards and chat rooms to social media and video-conferencing. The implementation's work flow depends on whether the content will be hosted on the authors webserver or externally. While whole message boards would be over dimensioned for a single section, chat rooms are often disallowed by providers due to generating high volumes of traffic. An appropriate tool would allow the author to mediate a discussion, which is difficult to maintain in chats or social media. "Disqus"[29] is a comment hosting service, that will host a discussions content, provides authoring and user management tools and can be used synchronously as a chat or asynchronously as some form of message board.

Implementation:
"Disqus" can be placed in various joints of a Map Journal application. A plugin for universal code[30] is provided by the company. The script consists of very few lines of code setting up the configuration for a new discussion. Authors need to register with "Disqus"

[29] disqus.com
[30] https://disqus.com/admin/universalcode/

and have to reference their short name in the code, as the name is used as identifier to link the discussion instance to the user profile. URLs of the website running the script have to be declared in the code or set in the user control panel at the Disqus web site.

Setting "Disqus" as the only Main Stage Content can be advisable if a voluminous discussion is expected or to close an array of multiple stages defined by Story Map Actions. The code can be embedded in the DOM of a html document, attached afterwards with the website/URL picker option.

Web applications created through the JavaScript API allow "Disqus" scripts to be embedded in larger div containers or modal popups. The prototype demonstrates both strategies with content from Section 5 (container) and section 3 (popup). Which way to choose depends on how large the discussion is to be expected and whether comments have to be visible when interacting with the app. Fixed panels limit the space of the central map element but might have a use case for chat-like Question & Answer boxes. Real chat boxes might be a better room-saving alternative.

A modal popup contains dependencies with the bootstrap library for styling and effects, but is defined similar to any other popup. A new button element is set to float on the application's main map. The "Disqus" plugin is placed in the app's code as a second script element near the modal body definition. Clicking the button opens the body container with a transparent, full sized discussion window.

"Disqus" can also be set for the Side Panel, although doing so can sometimes crash the application builder and prevent the Story Map to be saved. Instead of setting a .html document, script and "discussion thread" element are pasted into the CKEditor, switched to source code mode. Bugs can occur if both the Side Panel and Main Stage contain "Disqus" plugins. Although the SP seems to be without any length restriction, discussion threads will increase the section's length and can make scrolling within the application uncomfortable. Hosting "Disqus" in the Main Stage seems to be the better option in all cases.

5.2.11 Summary - Embedded Story Maps

Learning goal:
While introductions provide motivation and guidance, summaries finalize a topic. A synopsis can round up critical points, remind the audience of learning goals and exams or highlight further reading and related contend.

Pedagogical tool:
A summary is meant to highlight critical points without repeating whole sections. While this task can be done by pictures and text alone, a spatially related topic can benefit from a reminder *where* information was obtained. A map to localize images and captions will thus prove useful for this task. Using a second, embedded Story Map template allows additional forms of interactivity that foster active recapitalization of the sections: Users can be invited to contribute their own content (images, comments) to the map or are tested in a quiz that summarizes the findings at any specific tour stop (see: *figure 5.8*.

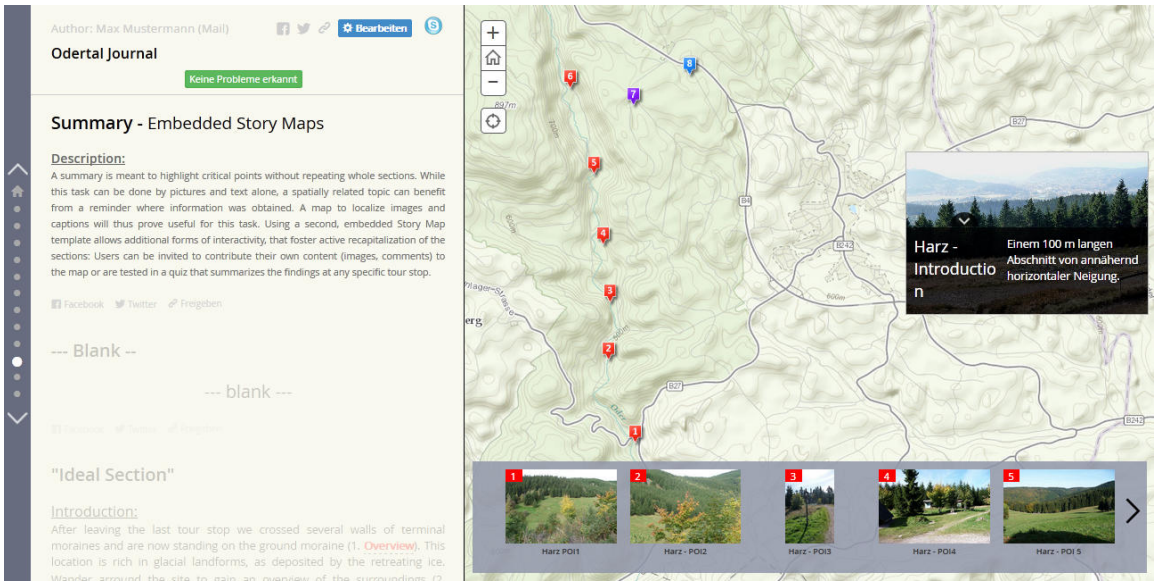

Figure 5.8: A second, "child" Story Map of the "Map Tour" type can be nested within the main application. In comparison to a stand alone app, the text fields are distorted by the Main Stage container and cannot be used to their full potential. Selecting a POI will lead to an update of the corresponding picture and vice versa.

Implementation:

A second Story Map[31] can be created the same way as the main instance or by converting a web map to a Story Map using the build-in AGOL webapp builder (may require a Developer Account). Styling to the map has to be completed before using the second SM, as its builder scripts cannot be invoked out of the main app by the URL edit attribute. The child application is referenced as website with URL and appID using the format http://www.arcgis.com/apps/<templateType>/?appid=<IDnumber>. By appending the URL with an "embed" attribute, GUI elements like the header bar can be hidden, leaving more space for the central map elements. By invoking the section containing the child Story Map, credentials have to be provided if the application is not publicly accessible.

The prototype uses a Map Tour template to create an interactive map of various POIs encountered along the field trip. This template consists of a Map displaying geotagged photos (or videos) and short captions, both using dummy data. Map icons and images are connected and by selecting one or the other, the respective content will be updated. This is useful to review all data from a specific location, or to follow a route by numbered POIs through the content.

While in this case dummy data consisting of geotagged photos was used, the template also allows a manual setup by uploading a single "locations.csv" table file[32], containing map coordinates, picture URL, name and description fields (*section 4.1.4*). Such an approach is useful when quickly establishing a MapTour for review purposes, as it circumvents the need to have geotagged photos for each POI. Setting up the application by .csv table data is also recommended when managing several tours with slight differences, as it prevents the author from setting up a whole new app for each instance. Data can be adjusted by using the builder application afterwards, especially to adjust the location of images.

Besides image data, the Map Tour is able to also host video and audio files, as demonstrated in tour stop and 8. Videos can be embedded through the builder or by setting the "Is Video" property in the locations.csv table entry. A thumbnail different to the starting screen can be defined for the preview carousel. Audio files can be embedded by

[31]http://blogs.esri.com/esri/arcgis/2015/04/21/embed-story-map-in-story-map/
[32]http://www.esri.com/esri-news/arcwatch/0513/make-a-map-tour-story-map

using the description field which takes text and html markup as valid input. A new audio control element[33] is defined to load a slim audio player (see *section 5.2.5*) which can be customized to some extend with css styling. The mandatory source definition references a single sound (.mp3) file.

An advanced use case would allow the child Story Map to be editable by multiple users. The audience can be encouraged to upload their own content of photos and descriptions, either as a form of assignment or to capture the best moments and impressions of a physically taken field trip. As most cameras save location data to the EXIF file, photos are automatically geotagged and placed to the corresponding location on the map, assisting students in recalling the trip.

5.3 Template modification on system level

The implementation of the prototype was carried out using solely the built-in options and functionality provided by the Story Map application (ArcGIS Online) and the ArcGIS for JavaSript API (ArcGIS for Developers). Following the educational rational in designing a prototype for a pedagogical use scenario, it becomes clear that not all demands could be addressed sufficiently with a default template, but that modifications are required. Authors who want to access the source code have to use the developer version of the Map Journal template (marked with a "-master" suffix), also freely available through ESRI's GitHub Account. Master templates have to be compiled with *node.js* and *grunt* before they can be deployed on a webserver. As the source code is now customized, it is not possible to deploy the application in ArcGIS Online (AGOL). However, as Story Maps are referenced by AppID in an index.html file, the map content (section, media and preference definition) remains accessible in AGOL and changes to the content will be saved under the AppID, also changing any deployments outside the platform. Therefore, a compilation is only needed when modifications are made to the source code (system level), but not when manipulating the content afterwards.

[33] http://blogs.esri.com/esri/arcgis/2014/02/20/adding-audio-to-your-story-map-map-tours/

Modifications to the general application, also including any Main Stage changes, again have to be distinguished in their development strategies from those of the Side Panel, as different mechanisms are used. After briefly discussing the development process, examples for template modification are provided in the following sections.

5.3.1 Application/Main Stage

Modifications to the application in a master template prior to its compilation have to be made to its source code, containing Javascript, CSS and HTML files. As opposed to the Side Panel, the Main Stage does not use a specific editor for generating content as it is meant to host a predefined, attached media type. The AMD structure of the application is based on complex dependencies and media processing definitions are distributed around several files. Modifications to the source code require a deep understanding of the application and cannot be advised to non-professional users. Support for Story Maps is ongoing and updates to the application become available every couple of months. Any modification to the source code thus has to be adopted by developing authors if these do not want to stick to older versions of the template. As demonstrated in the prototype design on story level, a more comfortable strategy than modifying the app's innermost mechanics to manage new media types is generally to attach stand alone applications with the URL/iframe interface of the media picker, if possible.

5.3.1.1 Fullscreen Main Stage

Problem Statement:
Immersive visuals and aesthetics require a sufficient resolution to attract the user's attention. Applications that need the whole extent of limited screen size for their functionality also often stand in the centre of the Main Stage. Sections 3 and 7, for example, contain media types that require a full screen - either to avoid scrollbars hampering the workflow (section 3), or to display large image content that provides its own navigation tools (section 7). The Side Panel, although fundamental for the application in navigation and for displaying text, is much of a hindrance in both sections. While the Side Panel size can be customized in the properties to use 30%, 40% or 50% of a browser's window space, this

still might not be sufficient for the described use scenarios.

Implementation:
The fullscreen toggle is a small plugin that omits the Side Panel section except for the DotNavBar element, thus maintaining full navigation functionality, but hiding any of its content. As the Main Stage can host several different - and changing - media types, a button in this view would prove distracting, especially as it might overlay items of the featured content. The Side Panel, on the other hand, shall be omitted, leaving the sub-element titled "DotNavBar" as the only option to host a button for this task.

The fullscreen button was implemented into the template's source code and is therefore only available for a user-compiled version on self-hosted webservers, but not for ESRI hosted applications. Modifications where made to the DatNavBar.js and ~.css, handling the application's navigational functionality. As this navigation bar is a child element of the Side Panel, the visibility status of the latter has to be explicitly restored to be visible using css styling. Parallel to hiding all dispensable sub-elements, the main container classes are set to a fixed, corresponding width by the switch. A html element in the SidePanelSection.html tracks the state of the panel ( ). Clicking the button again will restore the panels to their default state. This solution works for all containers except AGOL hosted web maps.

5.3.2 Side Panel Content/CKEditor

While Side Panel definitions are rooted in the application's source code, its content is set up by using CKEditor[34] to create, style or modify text and DOM elements of the content container, injected as a whole into the application.

Except for general functionality and appearance changes, alterations to the Side Panel (sections) *content* can only be achieved by modifications of the CKEditor instance, also rooted in the application source code (builder/ckeditor). This is done by developing new plugins for the Editor - self contained packages of manageable amount, which *add*

[34]Confusingly the editor also uses the media picker to reference external media

features and functionality without *changing* those of other components or the source code in general. (De)activation and modification of plugins is therefore much quicker and safer than to interfere with the complicated dependencies of the template's source code.

It is important to note that the CKEditor is meant to define content in a single text body, before posting the container to the Side Panel. This mechanism sets boundaries on what can be achieved with the editor, as common web development strategies are limited to what is supported by the CKEditor API[35] - also sometimes leading to strange errors and deviant effects.

To change the editor's functionality and to unlock new content options, a new plugin has to be registered with the CKEditor instance contained in the Map Journal template. Source files are stored in the "plugins" folder and consist of a single code file (plugin.js) as well as resources (e.g. icon folders) in the same branch of the source tree. Plugins have to be referenced in the ViewText.js file (line 420, editor.config.extraPlugins = '...') as well as around line 550, which defines the Editor's tool bar properties and adds button to access the plugin (*figure 5.9*). Lastly, all files added to the templates source tree have to be referenced in the gruntfile.js (line 247, src:[] array) using their relative path within the application to be considered by *grunt* in compiling a new app from the template's blueprint.

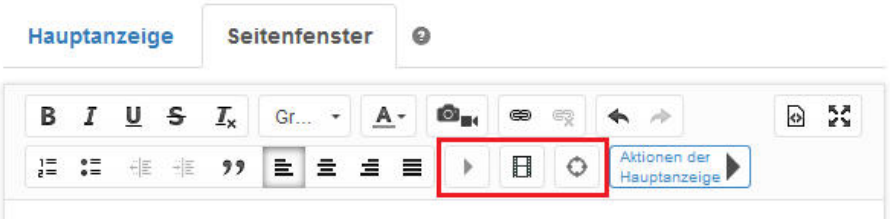

Figure 5.9: Custom plugins as displayed in CKEditor's toolbar. The button on the left inserts ESRI's audio player into the text field, while the right icon opens a dialogue to define section links. The button in the middle is a default plugin.

The *grunt* console will abort compilation in cases of syntax errors and facilitate debugging by logging error address and (assumed) type. Formal but syntactically correct errors cannot be detected, however, and can lead to the application loading indefinitely on startup

[35] http://docs.ckeditor.com/

(both before or after credentials have been provided) or to malfunction and artefacts in the CKEditor. It is advisable to test a new plugin in a simple browser environment[36] before adding it to the application to save compilation and debugging time.

5.3.2.1 Example: Automation of section linking

Problem Statement:
Links between sections of the Side Panel can be created manually, using the workflow described in section *5.2.1*. However, when creating a larger project or often using references between different parts of the application, toggling the CKEditor between code and text mode can be inconvenient, especially when having to keep track of references and editing the appropriate nodes in html.

Implementation:
A small JavaScript plugin shall simplify the workflow by prompting the author for input on the section index and text node, displayed as link (*figure 5.10*). The script is initialized by using a button placed in CKEditor's toolbar that will open a dialogue frame (CKEDITOR.dialog.add()). User input is mandatory and will create two objects for the target section's index (beginning from 0) and textual description. On confirming the dialogue (onOk event), a function transforms the input object values to separate html elements (instance.document.createElement(),
id.setHtml().getValue()). Elements are concatenated with the rest of the code as strings and posted as single element to the text box (CKEDITOR.dom.element.createFromHtml(), instance.insertElement()). Button definition and registering of the new command in CKEditor's title bar close the plugin file.

The same workflow was also used to set up a plugin that automatizes the setup of ESRI's default audio player for the Side Panel. The dialogue prompts the user for the source of the media file and inserts html definitions into the text panel.

This strategy can be used for simplifying all kinds of html based input, as long as the

[36]http://docs.ckeditor.com/#!/guide/dev_installation

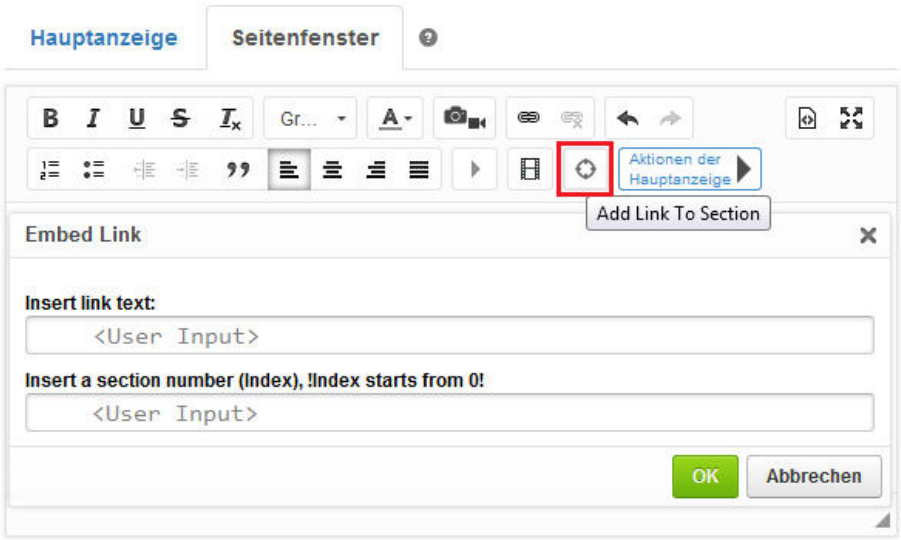

Figure 5.10: Dialogue as opened by a custom plugin to define links between sections. User input is required to set up the section index and a textual description used as anchor for the link.

code is not too long or too complex. It is mandatory to escape html and JavaScript syntax properly as those tend to interfere with the API in plugin definition. CKEditor is especially sensitive in regards to quotation marks and apostrophes, which are used to differentiate between html and JavaScript strings.

CHAPTER 6

Findings and Results

As the concept of Virtual Field Trips does not contain any definition of inalienable factors which have to be met in a successful implementation nor criteria to which this effort can be evaluated, a concept of transferable, universal factors was constructed in chapter 3. A prototype application was developed in the previous part to test the capabilities and potential of the ArcGIS framework. This chapter shall review how well the principles of immersion, interactivity and communication can be met by Story Map build-in and related tools and which consequences for the use scenario of educational VFT arise.

6.1 Immersion/Sensory Experience

As described in section (*section 3.1*) ,the factor of immersion describes the feeling of presence in a virtual environment and is characterised by the depth (quality) and width (quantity) of experienced "vividness" (Steuer, 1992, 6,10). While not real world realism but authenticity is desired in the construction of a virtual environment, sensory stimulation leads to learning in the affective domain (Meezan and Cuffey, 2012, 34) and a natural application of "real world" learning and progressing strategies to the environment (Slocum et al., 2001, 63).

From a perspective of "quality" in the simulation of reality, a browser based solution cannot compete with the vividness in sensory stimulation of systems using true 3DVR e.g.

by utilizing head mounted displays and multi-sensor systems to adapt to user behaviour. From the senses of sight, sound, touch, smell, and taste only the first three can be simulated at all at the moment in a computer environment. By using standard input devices, only sight and sound are left for a sufficient implementation - with the former exceeding in richness and variety over latter.

In- and output options for sound are handled differently within the Story Map application. Audio files containing explanation or background content (atmosphere, noise, music) can be used by embedding video formats (whether they contain visuals or not), by referencing sound files or by implementing audio players. The prototype demonstrated in section 4 shows how media players can be embedded via CKEditor into the Side Panel. This can be achieved easily with a single htlm element or iframe definition but without any changes to the applications source code, making the integration of audio a relatively simple extension. While ESRI provides a lightweight sound player, using e.g. the "Soundcloud" plugin allows a great variety of use cases, e.g. by auto play, hosting or playlists, assisting in more audio-rich Story Maps. Embedding audio in the SidePanel has the advantage that its playback will not be effected from any changes to the Main Stage, therefore allowing the parallel use of both views as input channel for textual/auditive and visual media, matching the "Cognitive theory of multimedia learning" by MAYER and MORENO (2003, 44). Featuring audio in the main stage is also possible for applications and websites, but has to consider how much time a user will spend in this particular stage before switching to another.

Use cases for audio can be found in instruction/explanation or ambience and background sound, adding to the feeling of immersion, e.g. for panoramic pictures in the main stage. Replacing instructive text with audio explanation, however, has the disadvantage that build-in markup tools (Story Map actions, section links) cannot be included into the description. As the Story Map application is complex due to its (potential) variety of views, buttons and tools, replacing instructive text with audio can be considered to raise the cognitive load for the audience even more, instead of reducing it. This could lead to a core problem of "one or both channels overloaded by essential and incidental processing of confusingly presented material" by NELSON and ERLANDSON (2008, 624)).

However, all factors considered, audio output might be required when developing an application targeted at handheld devices, where screen size is limited and needed for

the main media content. Audio input, e.g. in form of voice commands to navigate the application are not supported by Story Maps in any way and can not be used of a barrier-free or natural language processing approach (see e.g. ELLEVEN ET AL. (2006)).

Visuals are of great importance in the story map application and featured in many ("quantitative") forms. Common media formats of two-dimensional still or animated pictures are supported through videos and various forms of image data. From aerial and satellite pictures to maps and panoramic images, visual representations (or abstractions) of the real world can be incorporated into a Story Map. The broad range of available resolutions in default base maps - although generally depending on the source data - potentially allow topics from global (macro) to local (micro) scale and different perspectives (topics) to be implemented. The general perspective of ArcGIS Online products (maps, apps, scenes) is that of "bird's eye view", not naturally encountered in the real world. Panoramic images or the higher interactive instance of virtual tours, can however be implemented with ease into the application as demonstrated in section 7 of the prototype. While the ground perspective can be established, any means of its manipulation are left to external programs (e.g. the Google API, model viewer) and not supported in any way by the SM application. However, true 3D (or 4D) VR visuals as the most "qualitative" form of immersion and natively encountered in the real world could not be implemented into the application.

The prototype demonstrated, that the ability to feature a great variety of multi media types, especially through the website/iframe interface, can be seen as a core strength of Map Journal applications. Illustrating topics from several perspectives would require a splitting of content over a number of stages, e.g. in combining maps for overviews with various panoramic pictures to go visually in-depth at POIs. Interplay between both media types would, however, remain limited, as Story Map Actions to change Main Stages cannot be used out of maps or map-applications - meaning that selecting POIs in the map would not lead to an update to panoramic content and vice versa. As Virtual Tours demonstrate, (*section 5.2.9*) this kind of interactivity is pretty much standard to merge both (or more) views (ground perspective - bird's eye view) and remains to be solved.

In the theory of multimedia learning by NELSON and ERLANDSON (2008), several more principles can be addressed by the application sufficiently. The Map Journal with its two views again stands out from other approaches in regards to *spatial* and *temporal* contiguity, principles stating that explanation (text, audio) and visual information are

best presented closely together and animation and narration occur simultaneously or within a small time frame. By using the Side Panel as an information-, explanation- or instruction-frame and the Main Stage as sandbox for experiments and inquiry, both principles can be established.

Signalling and *segmenting* concepts help to break down information into chunks, thus reducing the cognitive load encountered (Nelson and Erlandson, 2008, 624). The Map Journal purports segmenting by its section structure as well as by Story Map Actions allowing the "portioning" of attached Main Stage content. Highlighting ("signalling") content for relevance or adding explanation outside the Side Panel text body (e.g. by tooltips) is less supported and has to be implemented manually.

Lastly, the principles of *coherence* (omit extraneous content), *modality* (auditive instead of textual information) and *redundancy* (content through different media/approaches) depend on user design choices. From its capacity, there seems to be no limit for neither the Side Panel symbol count (the complete MSc. thesis fits inside a single section) nor the number of attached Main Stages. It is the responsibility of the author to choose the correct amount and representation of content and to prevent an overload by "processing of essential information" (Nelson and Erlandson, 2008, 624), that might happen in an environment rich in visuals and interaction and without a limit to the number of Main Stage sections.

6.2 Interactivity with objects

Interactivity by Steuer (1992, 14) has been defined as interaction within a medium's form and content and has been subdivided into a) navigational/explorative, b) costructive/contributive and c) manipulative interactivity by Roussou et al. (2008, 142) or navigational and instructional interactivity by Sims (1997). The Story Map application handles all three (two) forms very differently, especially depending on the template choice and the utilization of external functionality, e.g. through main stage hosted webapps.

6.2.1 Navigational Interactivity

Navigation in the Map Journal application follows linear movement by scrolling through various story points (sections) of the Side Panel leading to an update of the Main Stage in the course. While the user can skip sections and navigate freely by using the DotNavBar in the left part of the Side Panel, such an action is not intended as the main form of movement by the application. Sections are uniformly displayed as dots in the bar and a tooltip displays the section's title, although without a content dependent icon indication or a preview of the section, any "explorative" movement along the dots will lack information or guidance on how to navigate through the Story. Realistically, this movement type can be used to jump back to already known parts, although this behaviour will be complicated if story points are exceeding a critical number. As sections cannot be highlighted or weighted to indicate main topics from supplementary content, methods of branching and hierarchies (CRAMPTON, 2002, 87) cannot be indicated visually in the Side Panel, treading all sections formally equal.

There are, however, ways to use the Side Panel as initial point for Main Stage branching. Section (*5.2.6*) demonstrated how the Main Stage and web map content can be updated within a section by using the "Story Map Actions" tools. This 1:m cardinality in SP/:MS relation allows the illustration of large topics, as no specific cap for m exists and all media types can be picked for an update of the stage. Using text-links to anchor these updates in the SP and allowing no further branching from an updated view (the user always returns to the SP via "back button"), prevents an over-complication and the risk of loosing focus in the section. However, it is up to the author to keep section and branching size reasonable and to scaffold the user in his navigation through each part. Users cannot forced to click "Action" links and skipping content can happen easily. Only text can be used as anchor for links, but in practice, this may be sufficient for most use cases as the SP space is too limited to hold spacious data like large images or video.

Navigation and manipulation of the Main Stage never leads to an update of the Side Panel. This assures coherence of the application as the MS can contain a variety of media types without interfering with the main logical structure. Changes to any of the content (e.g. by clicking links, using tools) are discarded when a stage is left, except for edits performed on an editable data layer (see *section 5.2.8*).

A connection between various parts of the Side Panel can be established by querying the section index. *Section 5.2.1* demonstrated how links can be anchored in text or image files and update the application on a onclick event. In contrast to Story Map Actions, this operation is not invertible. In the prototype, links were used as a table of contents, but further branching in navigation is possible. An implementation would require careful planning of the story board as well as a consequent anchoring of all desired connections between sections. As the user could escape the predefined sequence of sections by skipping to the next part in order, or using the NavDotBar to directly access a section, both strategies have to be blocked by source code modification. Scrolling operations are defined in the SidePanel.js script, while the NavDotBar can be hidden through CSS, as demonstrated on the Side Panel in section (*5.3.1.1*). Modification to either however bears the risk that missing links between sections leave the application unusable.

Lastly, there is the option to host a second Story Map within the main instance (see *section 5.2.11*). While this approach comes at the expense of performance, it is a manageable option for non-technical users to extend the applications functionality. As several SM types are already available as standalone apps for single web maps (e.g. the "Swipe" and "Spy Glass" Story Maps) for users with a developer account, it is almost always a better option to use such apps from AGOL than to author a whole new Story Map. A potential exception may be the Map Tour template, as it is not available as stand alone app and complements the Map Journal by providing a tool to host location based - and map related - image data. In this scenario, the second SM would be an subordinate instance of the main application and is again bound to a specific section. As the Side Panel remains active, the main Journal application can be advanced without a specific exit of the inner SM application.

Conclusion:
Archetypes of navigational interactivity in design of Virtual Field Trips are displayed in figure *6.1*. A-D vary in complexity and structure of content. While the default path through a Map Journal is strictly linear by scrolling through a set of sections, its complexity can be extended by Main Stage branching to the more complex type B. Each subsection remains isolated and leads back to the main course - making this type of vertical hierarchy suitable for optional or consolidation topics. Complex sections will be constructed out of several subsections that host distinctive media types, underlining the content or learning goal displayed in the Side Panel. Links between sections (white

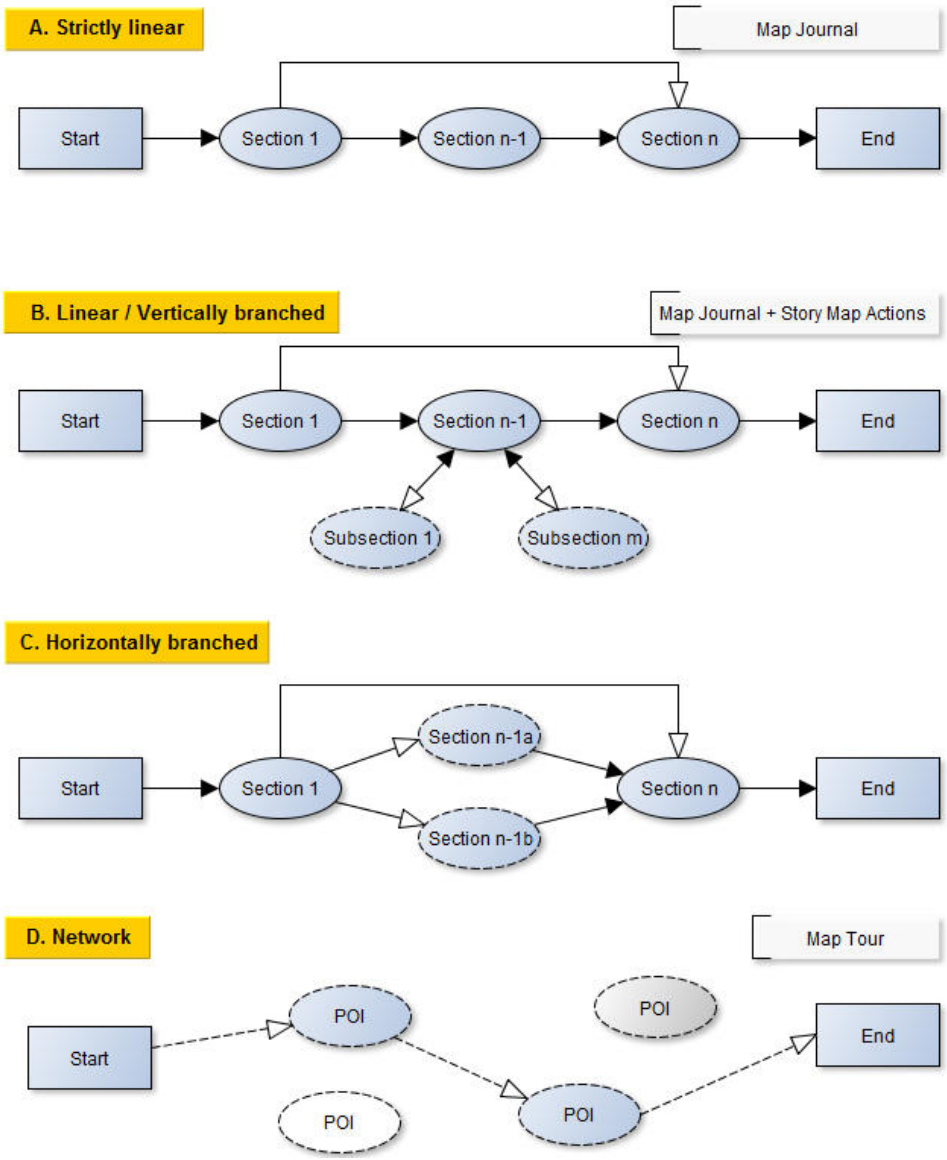

Figure 6.1: Types of navigational interactivity. A. is the default, "re-active" and linear type of the Map Journal, B. its alternative if Story Map Actions are used. In C. the learner has control over navigation and topic through horizontal branching of optional topics ("co-active"), while in network D. he is in full control of both ("proactive" after Rhodes and Azbell (1985)). Required movement is indicated by black, optional by white arrows, non-required topics with dashed lines. In D. sections are replaced by isolated Points of Interest (POI).

arrow) and free movement along the DotNavBar (not displayed) remain supplementary. Higher forms of navigation (C, D) are not possible with the Map Journal template as such movement is only partially supported. Free navigation requires guidance absent from the

template in which sections are displayed as uniform dots and mainly accessed by scrolling. A network structure of POIs is supported by the Map Tour template, which abandons complexity (text, multimedia types) for freedom in navigation. Applications of the latter type can be used e.g. in city tours where no specific course or consecutive content is required.

6.2.2 Instructional Interactivity

In the tripartite classification of RHODES and AZBELL (1985), the unmodified Journal application only allows *reactive* interactivity, as the user has little influence on structure and content, except for determining the viewing pace or skipping and jumping to specific sections or stages. On content level, modifications are allowed when using interactive web maps, although these task mostly incorporate simple "click and view" *exploration* and *object* accessing tasks (in taxonomy of SIMS (1997)), not different from other media types natively hosted in the Main Stage. Constructive, contributive and manipulative interactivity can be added through interactive web pages (see *section 5.2.3*) or, to a much higher degree, when embedding web applications into Story Maps. This can lead to a *semi-coactive* (RHODES and AZBELL, 1985) interactivity level, with the user having control over content and navigation within predefined bounds of the Main stage.

The prototype demonstrated on the content level how instructional interactivity of the object (sections 1,3,6,7), update (6), construct (7) and simulation (section 2) types (SIMS, 1997) can be conducted in an educational and geography related application scenario:

Object, reflective and update types are rather similar in concept but differ in the depth of response by the system and therefore in the "degree" of interactivity (KRYGIER ET AL., 1997). The object type is the main class for inquiries and exploration of the content, while update and reflective types require the construction of a predefined setting to initialize user action and a evaluation method to analyse user response. The design of an initialization setting is rather easy to establish, as most maps are at least graphical data bases natively rich in content. An opening questions and optionally a tool assisting in map exploration can trigger user interaction with the content. In practice, the intensity of a task depends on whether a web map or web application environment is chosen to represent data and

host operations. This choice has to be done by the author of the Story Map, either by using the build-in functionality of Story Maps and AGOL, which do not require any scripting skills, or by using APIs like the ArcGIS API for JavaScript, which will require a developer account and web development skills. Customized web applications do not only allow the incorporation of multiple and customized tools to a web map but the critical transition from explorative interactivity, to forms of costructive, contributive and manipulative interactivity (ROUSSOU ET AL., 2008, 142). A simple "swiper" can toggle overlays of layers to a basemap (AGOL functionality, explorative), while an app e.g. allows the user to manipulate features and contribute his own content. It can be stated that, while applications will require more effort in preparation and design, they will reward this labour by allowing higher forms of interactivity (KRYGIER ET AL. (1997, 27), CRAMPTON (2002, 87)).

Reflective and update interactivity in the taxonomy of SIMS (1997) differ from the object type by an evaluation instance that weights the user behaviour or input and responses accordingly. The evaluation result can range from simple wrong/right output to intensive system adaptation, e.g. through altering a program's course or difficulty level. Such system behaviour is also a prerequisite for any individualization or personalization of the application in adaptation to the user's characteristics.

Evaluation and feedback are integral components of assessment functionality intended neither in the "story telling" focus of Story Maps, nor in the design of other predefined ArcGIS applications that fulfil illustration and presentation purposes. Thus, educators that wish to use these apps are forced to either spend time on ground work to develop response behaviour and feedback mechanisms in the template, use applications that provide these means temporarily in a Main Stage view or have to outsource assessment completely and to replace it by traditional means (e.g. write an essay, provide screenshots).

The quiz and assessment sections 6 and 7 indicate that a mixture of the latter approaches had to be chosen in the prototype. Reflective tools can be constructed from the input side, in requiring the audience to do something (here assign symbols as answer to a question), but assessment of the outcome has to be done manually and outside the application. Authoring of assessment and other forms of user output is a major drawback in the automation and duplication of Story Maps as learning environments and will restrict use scenarios to smaller, manageable audiences. An alternative approach would thus have to

outsource assessment to aiding resources, easier to construct or modify by the author, like e.g. quizzes set up on separate webpages and featured in the Story Map.

This strategy was illustrated with section 2 of the prototype, using "Net Logo Web" as a modelling environment. According to SIMS (1997, 6), simulation interactivity depends to a much lesser degree on specific instructions and settings (as with update and reflective tasks) than on a "mutual elaboration" between program and learner. "Net Logo" is a prime example for an environment allowing this degree of freedom and responsibility alike, as it allows full customization options of models, built or modified by the user on the basis of an inherent programming language. Output can be visualized and evaluated in form of models or plots, being corrective for the users efforts.

A "construction" example in form of a classical mapping assignment was shown in section 7 of the prototype, allowing the modification of a feature layer by setting symbols. Widgets that foster construction tasks are otherwise either still under development[1], or, most often, consume credits for analysis and calculation tasks (e.g. viewsheds, DEM generation, statistical tools). Multi user management is provided if the appropriate flags are set for the layer to which modification is applied. Edits can be locked for other users, or even hidden in an assessment scenario, thus allowing several users to experiment on the same source without interference. Tracking edits is not available if a layer is set to public (sharing with everyone) but will otherwise provide a log of user actions[2]. Administrators can overwrite input of group members.

CRAMPTON's "Taxonomy of Interactivity in Geovisualisation" (CRAMPTON, 2002) (*section 3.2*) values interactivity not by a generalistic class (as done by SIMS (1997)), but by specific operations in the context of geovisualisation and their supposed impact on learning. In figure *3.6* KATTERFELD and PAELKE (2007) subdivide interaction with the a) data representation, b) geometric and textual dimensions c) aim of comparison and d) data itself. Application of this taxonomy to the Map Journal as a whole as well as to specific content types shows very different results regarding how and to which degree interactivity types are supported (potential impact on the learning process as assigned by

[1] e.g. https://developers.arcgis.com/javascript/jssamples/exp_dragdrop.html

[2] https://doc.arcgis.com/en/arcgis-online/share-maps/manage-hosted-layers.htm

KATTERFELD and PAELKE (2007) in square brackets):

Zoom and rescaling operations [high] of the data representation (a) are supported by default in web maps, apps but also the panoramic pictures of section 7 of the prototype. Perspective changes [medium] in viewpoint and orientation of data are, however, not permitted and remain in bird's eye view for the former two media types. Panoramic pictures and virtual tours depend on their own design and API, but most often support both operations by default, as they come with navigational tools and the option to switch to a map overview. Using these media types in combination with an array of Main Stage views allows Story Maps to use perspective changing interactivity in sections. Remapping functionality [low] can be implemented in map apps, while lightning [low] requires write access and is neither supported on system nor content level.

The prototype uses media and data of plain, two-dimensional geometry in most cases (panoramic pictures and tours can be considered as 2,5D in some cases), thus interactivity in this domain (b) is rather low. Navigation [high] in a textual sense is understood by CRAMPTON (2002) not only as 3D movement but as "cognitive spatial decision-making" on how to navigate through the content. While this degree of freedom exists on content level in panoramic pictures and VTs to a certain extend, maps and map application behave more static and merely allow the user to decide "where to focus". Movement on system level is predefined along the content and while branching can include optional stages or further reading, it will be orientated at the section's progression, more or less linearly defined in the Side Panel (see "linking" below). Narrative themes or branches thus remain mono dimensional. All navigation has to be initialized by the user and more complex types of automatic movement, like fly throughs [medium], are not supported on either level.

"Toggeling" [medium] and "sorting" [high] are forms of user-initialized interaction with data and are supported on content level in the temporal and spatial sense by applications and maps (prototype section 1 and 3). The range of methods and tools is further extended when using AGOL's commercial options. The same can be said about any interactivity types of the contextualization and comparison branch (c), which have been noted as a speciality of ArcGIS by CRAMPTON (2002) and still holds true for the Story Map application range or the Map Journal in specific: Multiple views and linking [high] are the fundamental concepts of the template while layer, (or data) combination [high] is

supported naturally on both levels. Splitting and reordering of windows (juxtaposition [medium]) is in contrast to the ArcMap counterpart currently not supported and would require a major rework of the app. Any approach would have to rely on an application solution.

Lastly, the complex of data manipulation (d) comprises queries, filtering, analysis and highlighting [all high] - sophisticated actions performed generally by GIS and adjacent technology. In spite of the process of making tools available in applications and services on AGOL, most high end functions remain restricted to simplified versions and/or require commercial licences and the consumption of credits. In general, if neither new data is generated through processing algorithms nor data has to be fundamentally modified, web applications of the ArcGIS for Java Script API can be used as a cost free alternative.

Conclusion:
In essence, these findings show that interactivity is supported by a wide range of build-in functions of the template and optional addons through media and apps. In the classification of interactivity levels by CRAMPTON (2002, 88), all stages up to extract/surpress could be simulated in the prototype (see *figure 6.2*).

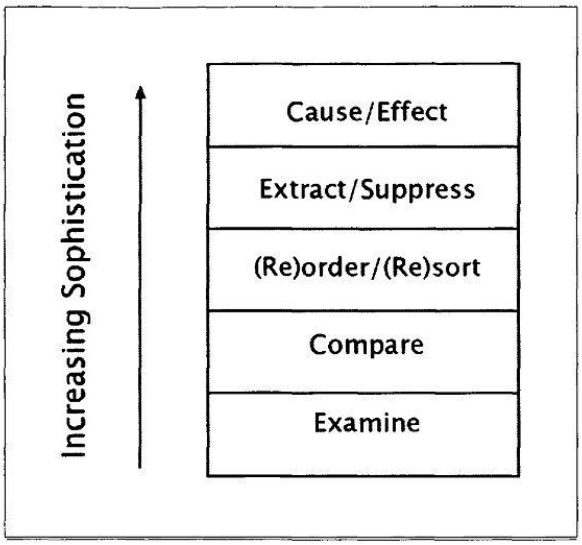

Figure 6.2: Interactivity levels by (CRAMPTON, 2002, 88) based on the complexity of tasks.

The analysis of geovisualisation principles and impact on learning, elaborated by CRAMPTON (2002, 88) and KATTERFELD and PAELKE (2007), showed that for one, the ArcGIS

applications do what ArcGIS does best - handling of geodata and GIS functionality - but tend to be limited to presentation and visualization tasks. Many of the analysis tools and functions known from the Desktop product are performed by and restricted to commercial services in the Online counterpart. Strong points, however, exists in visualization, comparisons and inquiry by combining maps with the variety of multi media types, as it was already stated by ESRI (2012) in the use case description of "Story Maps".

Interactivity in terms of creating new data or free experiments and simulation with a variety of data types, options and tools, is possible to a much lesser extent, and the application has to rely on specialised platforms from the outside due to its limited functions. Tasks not related to maps and graphics or requiring feedback and response mechanisms to user input on a cause/effect basis find little to no support by the ArcGIS application range and would have to be implemented by the developer.

With regard to learning styles (Trindade et al., 2002, 2), Story Maps enable visual based learning through a variety of media and an emphasis on graphical representation with maps. By presentation of this data in parallel with text as enabled through the specifics of the Map Journal Templates, the concept fulfils the three principles of multimedia, spatial and temporal contiguity for multimedia learning systems (MAIER (2007) after Crampton (2002, 1148)). In combination with customized web applications, they further allow active and inductive knowledge gain (Trindade et al., 2002, 2) on the basis of predefined (map) exploration, analysis and visualization tools, but severely lack dedicated (conditional) response mechanisms as well as personalization and adaptation options. Therefore, from an instructional designer perspective, great care has to be taken to maintain a high level of interactivity and to prevent a relapse into passive consumer behaviour caused by static, animated or sequential interactivity types (Krygier et al., 1997).

6.3 Communication

Interactivity between humans in a mediated (virtual) environment relies on the concept of "social presence" (Short et al. (1976), Richardson and Swan (2003) (*section 3.3*)), determining which level of "connectedness" can be achieved and how far persons can be

involved or immersed socially and emotional (Bocconi et al., 2012, 12). While the technical side of communication is characterised by factors of medium/tool, synchronism, cardinality and content (Dillenbourg et al., 2002), research demonstrates that instead of a single, most beneficial communication tool, a combination of methods has the best impact on learner involvement and engagement (Richardson and Swan, 2003, 69-70).

By their innermost structure Story Maps are a publishing and presentation tool, consisting of a general 1:n or m:n cardinality between author and user: In most cases, they are authored by a single storyteller or a small group of designers (m) and intended for a larger audience (n). Communication between members of the audience or in-depth feedback to the author is not intended in the concept as it is not needed for the general application use. Therefore, the design supports only a one-directional information flow (storyteller *rightarrow* audience) with limited joints for any reverse or two-sided communication.

In an educational setting the role of the storyteller being adopted by a teacher or lecturer and that of the audience by students. Here, a two-directional communication between author and audience as well as interaction within the recipient group is desired. As the systems structure and cardinality are inherited from the general use scenario of Story Maps, adequate tools for the specific, communicational demands in education have first to be implemented into the application. The extent of modifications needed depends on the content and purpose of the prospective approach. Application with low forms of learner interactivity, like read and review tasks, will need very few alterations, while using Story Maps as a self-contained Virtual Learning Environment will require major modifications to the applications source code.

Figure *6.3* illustrates potential joints for interactivity between persons in the Map Journal template. Changes to the Side Panel have to be hard coded into the application, while for the dynamic Main Stage an implementation largely depends on the featured content type and write access to resources.

6.3.0.1 Interfaces in the Main Stage

The Side Panel remains singular and static for each section, but multiple Main Stages can optionally be attached (1:m cardinality) and might change during the section. This

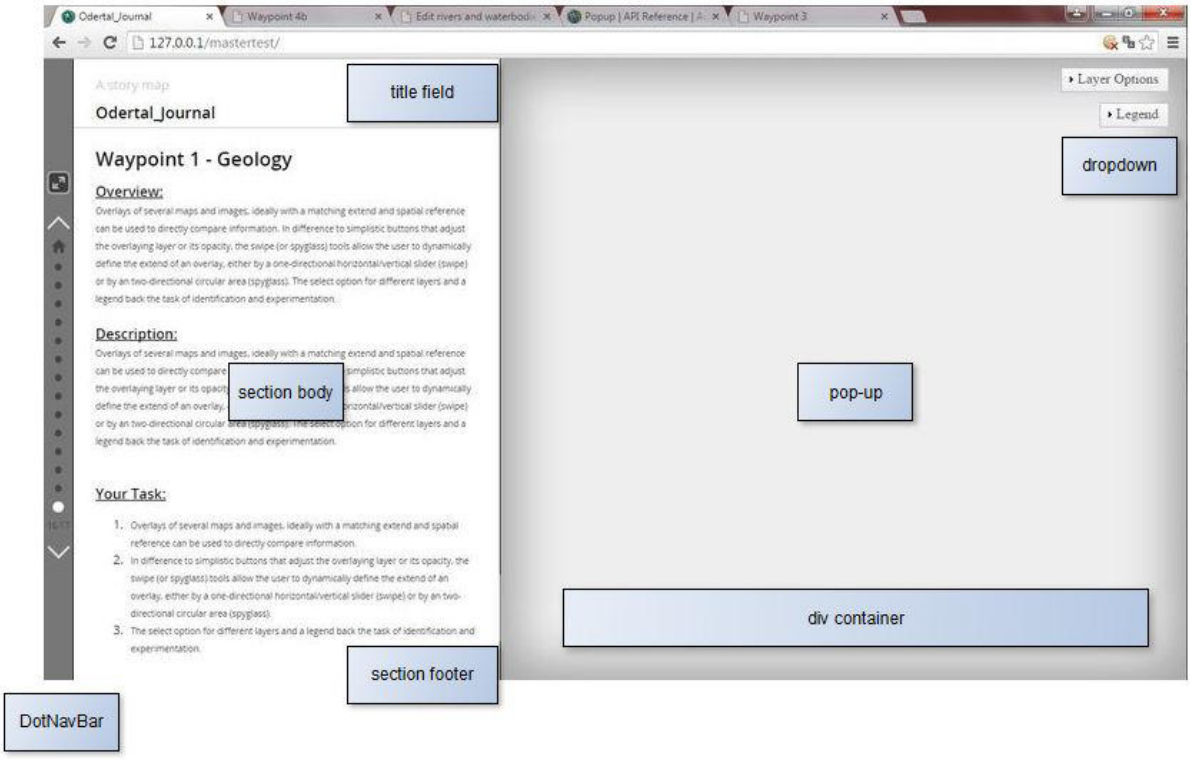

Figure 6.3: Joints for the implementation of communication tools in a Map Journal application.

structure limits the usability of communicational joints in the Main Stage to concern the actual view rather than the whole section. Which tools can be considered, depends on which media type is featured in the stage. While image data has limited potential, web maps and applications do allow a great range of options if the author has access to the resources code.

a) Instruction and description:

An important form of one directional communication between author and audience are instructions, explanations and descriptions for tools and tasks. The prototype demonstrated in section 1 and 5 how annotation layers can be used in *web maps* to display information through symbols and text. Popups are containers for larger pieces of information bound to a specific feature and location but have to be actively accessed (opened by click, mouse hover) by the user. Text annotations are placed directly on the map, they also remain in absolute position but are directly visible. Both forms have their use case in maps, but are only suited for short descriptions or "tool tips" and not for longer

instructions on how to use the medium.

The *website* media picker class (for any content that can be referenced via URL or hosted in iframe containers and thus also including web applications), allow much greater flexibility through full access to structure and styling of the DOM. The prototype demonstrated in sections 1, 3 and 6 how task descriptions can be appointed to a web app by popups, div containers and drop down menus. Basic popups in web apps, created with the ArcGIS for Javascript API, behave similar to those of web maps, as they are anchored to a single feature and bound to its location. As opposed to their AGOL counterpart, these API defined popup classes can be customized for the user's needs and can, as section 3 and 6 demonstrated, not only contain text and images, but are able to query a layers attribute table and to display the results e.g. in charts. In the atomization of instruction, as it might be required for large, repetitive tasks, attribute queries can be used to some extent for simplifying the workflow. The strategy would use the attribute table as data base for small text bits which are queried by the popup's selectors. Multiple variants of a course (e.g. for different levels or classes) can be realised by changing the selector to the respective attribute table field. A careful data preparation can allow course adaptation with simple changes in the application, without modifying the data source. While this method is not suited for larger text description and lacks behind a true database approach in data retention and performance, it is an easy to use replacement for inexperienced users or small projects.

Instruction not bound to specific locations can be displayed in div containers and drop down menus, as done in a declarative way in the prototype. These items will use the limited space of the Main Stage to display "global information" to a map or application and have to be designed in a way that prevents interference with other containers hosting tools or data. Headers, footers, side panels and text boxes are static containers always visible to the user, whereas drop down menus and modal popups are interactive elements that use less room by hiding their content. As the Map Journal's Side Panel is already using 30-50 % of the space and taking into consideration the smaller screens of tablets and smart phones only the latter two can be recommended to be used for any longer textual elements.

b) Questions and comments:

Section 9 of the prototype demonstrates how div elements can be used to provide means for

questions and discussion within the Main Stage. All implementations were use "Disqus" as comment hosting service for two-directional a/synchronous communication between members of the peer group or with the Story Map's author(s). Using a modal popup to host the discussion does not interfere with the application's content, as these element can be displayed and hidden when desired. Storing threads or chats in a fixed div container can have side effects on the application's functionality and is not recommended. It has to be kept in mind that updates of the MS will hide the discussion. Therefore, a separate (and closing) comment stage is advisable for sections hosting more than one view.

c) Exercises and collaboration:
Exercises and assignments are similar to instructions but require some sort of feedback. Such a response can occur transmitting the result inside or outside of the application. Section 6 and 7 of the prototype feature exercises that require the user to modify an editable feature layer, with the output being automatically saved and stored within the layer. The user-management options of AGOL allow inputs to be locked for edit and deletion and also to be hidden from other members of a group through the edit tracking options. Especially in an assignment scenario, personalized and protected input is required that is not visible to users other than the administrator (educator). Disallowing deletion tasks in general, by setting the corresponding flag in the edit layer properties is not practical for tasks susceptible for incorrect handling (like e.g. sketching maps).

Allowing modifications to a layer for all members can, however, be advised in cases of group assignments and collaboration, as peer members have common interests and goals and are able to work synchronously on the same subject (the feature layer). As edit tracking options are not available if layers are shared publicly, illustrated mechanisms will only work for use scenarios where the audience is group member of an organization but not for a general, global audience.

A hybrid of creating and reporting results in- or outside of the application is demonstrated section 6 (*5.2.7*). Users are asked to write a report (or conduct an analysis) and to upload the result as an attachment to the layer. The popup design expects input of a user name and time stamp for personalization purposes.

Embedded Story Maps can be used for collaboration tasks and user generated content. This is advisable, as users can experiment with the product themselves but without in-

terfering with the core application. A use scenario was demonstrated in the summary section by collaboratively authoring a Map Tour application and uploading content.

Conclusion:
In summary, interfaces located in the Main Stage are suitable mostly for one-sided (lecturer to audience) and a-synchronous communication in form of explanation, descriptions and instruction. The specifics are depended on the actual media type used in the Main Stage. For map data (web maps or web apps), popups provide means to store localized information. With full access to the DOM in web-applications, information with a "global" scope can be kept in various div-containers or modal popups, depending on the tool and room needed. Using the "Disqus" comment hosting service, questions, feedback and discussion to the content featured in the actual Main Stage view can be supported. Results of user tasks can be stored to some degree in editable feature layers, either by modifying the layer itself (place symbols, upload attachments) or by using the output in an external report. User right management limits the usage to collaborative tasks or smaller groups. As the Main Stage is updated within a single, or between several stages, its view is not suitable to provide interfaces for multi-stage sections or the application in general.

6.3.0.2 Joints in the Side Panel

The Side Panel is a static element, features textual content and appoints the application's course. Map actions that modify the Main Stage will always route back to the same origin-section, effectively establishing a 1:m cardinality between both parts. These characteristics make the Side Panel a container to host overview content or general communication and less a place to display detailed information on specific content (e.g. features in a map). Descriptions of the Main Stage should only be stored in the Side Panel if the MS content is not accessible by the author (e.g. videos, not-owned websites) and its information is not too complex or too clustered among several stages (best a 1:1 cardinality between SP and MS). Story Map Actions can, however, be used as tool to explain the specifics of a map, as they anchor links to updates of a map's extent and zoom level. A possible use scenario can be found e.g. in a map explaining a research site and jumping to "Points of Interests" within the area.

Figure *6.3* shows four different joints in the Side Panel that allow an implementation of communication tools not depending on Main Stage specifics. "Title field" and "DotNavBar" are static elements and always visible through the course of a Story Map. The Title section is defined in the properties when setting up a SM and can contain buttons to share the application via facebook, twitter and bitly. Two fields are editable (logo, title) and can be used for links. With a simple html markup definition, mailto (default mail, mailto:<name>@<host>.com?Subject=<Input>) and callto (Skype, callto:<username>) links can be anchored in the title. Adding a "?chat" parameter to a skype callto link will start a chat conversation instead of a call. As the Story Map's title bar will remain visible throughout the application, this location is suitable to define a contact field, allowing means to reach the author by mail, voice/video chat or phone.

The DotNavBar provides navigational support and links sections by an array of dot icons. Except for highlighting the current section point and displaying additional icons when a critical number of sections is reached, the DotNavBar remains static and is neither influenced by Main Stage updates or Side Panel behaviour. As such, the bar isa place for buttons needing to be available through the whole application, like chats or 'global' discussion. Section (*5.3.1.1*) demonstrated how additional buttons can be placed on the navigation bar. Space on this bar is, however, limited as additional icons (dots, indices, arrows) will be displayed for larger Story Maps, limiting the use as a taskbar for a large number of items.

The section body is populated by input generated through the CKEditor. While the editor can help with a variety of tasks in setting up the Side Panel, direct manipulation of the DOM is not possible and restricted to what is allowed by the CKEDitor API. Injecting scripts into the editor's text field can lead to unwanted effects, even if the code is escaped and masked properly. Adding help fields through buttons, popups or modal dialogues might seem a natural way to implement additional (dynamic) windows and boxes for support content, however, any attempts to manipulate a section's DOM with style and structure elements failed. The editor's text field is not meant for longer html and script definition, neither through elements added in source code mode, nor for plugins using a similar strategy. Additions to CKEditor are therefore restricted to short scripts of a single language and without any additional dependencies (*section 5.3.2*). In conclusion, the editor is useful to define a text body for the Side Panel and to incorporate media in it, but not an advisable tool to extend the application's features. "Discus" in the Side Bar

is in so far exceptional, as a short script can be used to initialize the widget that comes with a wide range of tools and no specific content limit. Potential use cases can be found in section wide discussion, comments or question & answers to the Main Stage's content. A disadvantage of this technique can be seen in the fact that the Side Panel is very much needed for introductory content and any additional discussion (of unrestricted volume) will extend the section's length, negatively affecting the usability of the Panel. Especially for a smaller panel (30 % screen size), any longer text will be disrupted by line breaks and graphical content (avatars, tools, structural elements) that comes with the plugin.

The section footer is not accessible through CKEditor and a recent (post 06/15) addition. Its settings are globally defined in the Story Map properties and allow Facebook and Twitter to obtain section indices, which can be used to reference and comment directly on the specific content. A similar result can be achieved by using CKEditors mediaembed plugin to paste customized Twitter code into the CKEditor. In this case, the button will be placed in the section body and not in the footer section. This method is useful if authors would like to use self-customized buttons, e.g. to predefine hashtags or click counters.

Tweeting and sharing a story map(s) (section) on Facebook allows the user to comment on the content and deliver feedback and questions. This method is of limited use for an educational settings, as the message's content will be visible to all members of the group, if not for everyone on the web. Help requests or evaluation, however, require a more private form of communication and will rarely use social media. A use scenario can, however, be found in group tasks and collaboration where e.g. tweeting about a specific section can help to organize work or answer group members questions. As such, social media can be seen as a tool to establish peer communication but instructor - group exchange to a much lesser extent.

Conclusion:
The Side Panel allows the incorporation of section- or application-wide communication tools through modification of the template's source code. Two strategies are possible, either to enhance CKEditor with additional plugins, or to directly change the functionality and structure of the Side Panel. While the first technique is controlled by CKEditor's specific API and cannot use the full potential of web development, the latter requires careful alteration of several scripts to preserve the application's consistency. Both ways

thus have their disadvantages and cannot be implemented lightly. With the exception of Skype calls, all demonstrated tools of the Side Panel feature textual communication between author and audience or between peer members (1:1, 1:n to n:n cardinality). As the Side Panel remains visible through any modifications made to the Main Stage, this view is generally suited for synchronous communication, like chats, but can feature asynchronous tools like mail and discussion threads in an equal way.

CHAPTER 7

Discussion and Summary

7.1 Discussion

The purpose of this MSc. thesis was to investigate the potential of Story Maps for the construction of educational Virtual Field Trips. As the concept of VFTs remained vague in requirements and criteria, this question was tried to be answered by testing the factors of immersion, interactivity and communication together with educational principles in online teaching:

Figure *7.1* visualizes that Story Maps can cover most critical aspects of online teaching by their own means and especially in combination with selected multimedia types and specifically designed web applications. Except for feedback mechanisms and automatic system responses to user input, all factors could be addressed by the example technology demonstrated in the prototype. Said communicational factors are object to the course construction outside the Story Map and the frame work in which the application is embedded.

Nevertheless, it became clear from the review in this chapter that the fundamental factors of immersion, interactivity and communication can only be included to a limited degree in the application's design. While communication tools can be implemented using common platforms in various joints of the template, immersion much more relies on what can be accomplished outside the application (e.g. in media content, supportive tools). Sensory

	Criterion	Method or tool	Related Section
Study skills for online learning	Online study aids	Interfaces in both views	*6.1.3*
Cognitive skills	Cognitive tools Reflective tools Multiple channels Multiple paths and solutions	Multimedia, Webapplications Multiple Views, Attachments, Discussion Multimedia Section Links, Story Map Actions	*5.2.2 / 5.2.4* *5.2.6 / 5.2.7 / 5.2.10 / 5.2.11* *5.2.5 / 5.2.9 / 5.2.11* *5.2.1 / 5.2.6 / 6.1.2.1*
Content structure	Manageable sized 'chunks' Overview over content, goals Different learning pathways available	Map Journal Sections Overview Map, TOC Section Links, Story Map Actions	*5.2.6 / 6.1.2.1* *5.2.1* *5.2.1 / 5.2.6 / 6.1.2.1*
Meaningful activities and learner motivation	„Situated" learning, relevant context User choice on content level, detail Feedback on learning progress	Manual / Outside application Webapplications Manual / Outside application	- *5.2.2 / 5.2.4 / 5.2.7 / 5.2.8* *6.1.2.2*
Learner control and interactivity (navigation)	Various sources of information Active participation possible Intuitive interface design Consistent content structure Navigation and orientation tools	Multimedia, Webapplications Webapplications, Multimeida NetLogo System Level (Template) System Level (Template) Section Links, Story Map Actions	*5.2.2 - 5.2.11* *5.2.2 - 5.2.11* *4.2.2* *4.2.2* *5.2.1 / 5.2.6*
Embedded activities – interactive learning objects	Quizzes, exercises, experiments Collaborative learning, group communication.	Webapplications, NetLogo Webapplications (collaborative tasks on feature layer), Story Map, Disqus	*5.2.6 / 5.2.7 / 5.2.3* *5.2.7 / 5.2.8 / 5.2.11*
Social relations and social presence	Live interaction Tools to reach lecturer individually	Disqus, Twitter Mail, Skype	*5.2.10 / 6.1.3.1* *6.1.3.1*
Assessment	Clarification of assessment purpose Authentic assessment tasks Collaborative or reflective assignment Traditional assessments	Manual / Outside application Webapplications Webapplications Webapplications	- *5.2.8* *5.2.7 / 5.2.8 / 5.2.11* *5.2.7 / 5.2.8*
Student feedback	Immediate ,frequent, detailed Focus on positive and further improvement Intrinsic, attention focusing	Manual / Outside application	- - -
Course feedback	Reflection of successes, concerns and problems	Manual / Outside application	-

Figure 7.1: Critical factors of online teaching (Reushle et al., 1999) as addressed in this thesis.

stimulation will fall behind of what is possible by more immersive VR (desktop systems) and AR (mobile solutions) technologies. This problem is system-inherent, as the application is focused on maps (bird's eye view perspective) and the browser environment. A seamless transition between different media types remains one of the major tasks to increase immersion within these limitations. Interactivity can, however, be seen as the domain of Story Maps and the full potential is shown wherever map related content or actions are required. While overall functionality is still restricted in comparison to what can be accomplished with a true GIS, ArcGIS applications allow a variety of tasks in which map modification or contribution is in the centre of activities. Simulation and experiments that include a great range of parameters and different angles are less possible with Story Maps.

These findings demonstrate that Story Maps might be more suited for general online

teaching along maps and multimedia than to realistically simulate the "essence of a journey" (Nix and Australia, 1999, 5) in a Virtual Field. However, when comparing Story Maps to other former approaches (*section 2.4*), all but AR and VR can be included in some form in the application. The most important aid in this regard is the ability of the Map Journal not only to host predefined media types (as it is the case with other templates) but to allow an interface for referencing websites, web applications and even media data through iframe and by URL. This ability sets no boundaries on what is possible within a Story Map Journal, as long as it is intended for use within a browser and hosted online. The second biggest advantage can be found in the clear, twofold structure of the template, displaying a text specific container along multimedia and application data. With Story Map Actions to switch the latter view, each section can be used for a POI, a topic or a whole lesson, while the overall course remains segmented and structured.

The linear structure of the Map Journal, however, comes at the price of freedom of navigational choice. For the application scenario used as blueprint for the prototype, linearity comes naturally and is to some extent desired, as the audience follows a defined route of learning goals. A more complex pattern can be established by using build-in means of the template, but a Map Journal application will rarely be used for horizontal branching or a network type structure of complex movement (*section 6.2.1*). While Main Stage branching and links between sections can be used to convey subtopics, most of the time they will be needed to feature the content for a single section, as every MS is restricted to a specific media type.

The "ideal section" *7.2 /*, of a VFT made by a Journal Story Map would consist of a set of Main Stages, linked by Story Map Actions. The topic is introduced and motivated by a descriptive text in the Side Panel, followed by statement of the specific learning goal as well as instruction and support for the required task (containing links to each part). This container remains visible through the whole section and provides guidance to the user ("student") in navigating the content hosted in Main Stages. The latter is highly dependent on the VFT's topic, learner characteristics and learning goal. For a "classical" Virtual Field Trip, the first task would be to "localize" the user and the section's content on an overview map, showing specifics of the surroundings or "progress" from the prior section (relocation). To create a feeling of immersion, panoramic pictures or 3D content visualizes the environment graphically, ranging in complexity from single 2D images or galleries, over 360 degree panoramas (both for POIs) to clearly arranged and limited

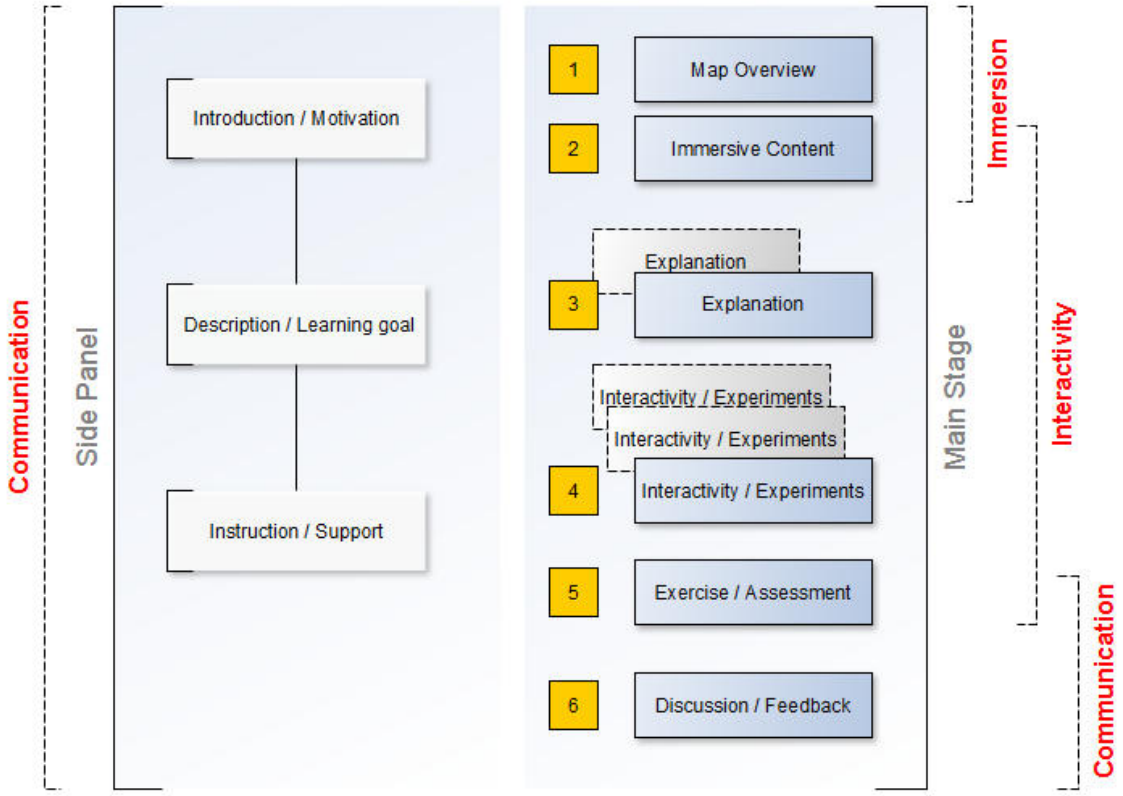

Figure 7.2: Design proposal of an "ideal section" as a self-contained unit within a Story Map VFT. The Side Panel contains a single text body with various types of instructive content, while the section's course consists of several stages from introduction to discussion. Related principles in red.

virtual tours (e.g. for a larger research area). While sections are able to host a large amount of text, it might be required to attach external sources to convey a topic. Doing so in step three will break large content into smaller chunks of potentially better structure - aiding in the management of cognitive load. The forth step requires the user to interact practically with the content, e.g. by performing experiments or conducting inquiries. It can be expected that several stages are required for interactivity and that additional explanation on tools or instruction are provided in textfields and by help buttons in the Main Stage. In the fifth part, quizzes or exercise are used to enhance and assess the learning effect. However, no direct evaluation within the application can be provided. In the last stage, room for discussion, questions and feedback is given (e.g. by "Disqus", chats) and participants can communicate with each other.

7.2 Summary

The underlying question of this thesis was: "Can Story Maps be used for Virtual Field Trips and where do limitations lie?". To solve this question, the MSc. thesis established a working definition of the term VFT in section *2.1* and discussed general obstacles and advantages of the concept in section *2.3*. It became obvious that an analysis of the concept's specific demands has to be orientated at the intended use scenario. To sketch the technological environment of VFTs and to prime for the discussion of Story Maps, examples of previous attempts were provided in section *2.4*.

Chapter *3* established a framework of the fundamental factors of immersion, interactivity and communication as well as educational principles related to these concepts. Immersion, as a factor for sensory experience, originates from the domain of VR systems, where it is intended to measure the amount of "telepresence" in an artificial environment (Steuer, 1992). Interactivity, the second factor, contains all interaction with a program's content (instruction) and course (navigation) (Sims, 1997) and is either initiated by the user or the machine. The final principle is communication, which is a factor for interactivity between humans, and is therefore of specific importance in an educational setting (Dillenbourg et al., 2002, 5).

To evaluate the genuine potential and possible joints for the continuative incorporation of these principles into Story Maps (*chapter 4*), a prototype application on the basis of the Map Journal template (*section 4.2*) was outlined (*section 5.1*) and implemented on content level. The goal was not to create a fully functional Virtual Field Trip, but to test the template's functionality in a set of smaller test scenarios ("sections"), mimicking a real excursion (*section 5.2*). These test cases incorporated immersive content in sections 4 and 8 (visual media and audio content). Interactivity, either established by build-in functions or extended by referencing external content (e.g. web applications of the ArcGIS for JavaScript API) was illustrated in sections "introduction", 1, 2, 3, 5, 6, and 7. Communication was addressed in 9 and "summary" as well as among other sections. Lastly, joints for additional functionality through modifications to the application's source code ("system level") were illustrated by small examples in the last part of the chapter (*5.3*).

The outcome to this effort was illustrated in chapter *6*, evaluating to which extent the principles of immersion, interactivity and communication could be met by the prototype and can be addressed by Story Maps in general. The results show that options for immersive content seem to be rather limited and mostly restricted to two-dimensional, graphic content, like maps, images and videos as well as audio output through sound files and videos. Including virtual tours and panoramic pictures, however, seems to be no major problem if adequate software is used and the media content can be hosted in the Main Stage (*section 6.1*).

The application is focused on maps and allows a wide range of tools and tasks that foster interactivity in this context. While web map content from AGOL allows little customization, web applications of the ArcGIS for JavaScript API are suitable additions that greatly enhance Story Maps (*section 6.2*). In terms of navigation, the Map Journal is restricted to rather linear movement through the content ("re-active" interactivity after RHODES and AZBELL (1985)), while section links and Story Map Actions add some degree of freedom over navigation and topic. Conditional or reactive behaviour of the application could not be established.

Communicative tools could be included to some degree into the application, depending on the targeted stage. As space in the Side Panel is limited, tools have to be implemented outside the section body, in task bars, footers or Main Stage containers. In the latter case, this depends on the feature medium and write access by the author (*section 6.3*).

In summary, Story Maps can be used by non-technical users for the application scenario of (educational) Virtual Field Trips to a large degree, as setting up an instance can be accomplished with help of the builder application and media picker tool for external content. The quality of this application will, however, depend to a great part on the author's developing skills, as any use scenario beyond presenting multimedia data alongside of maps will require modifications, either on content design (web applications) or on system level. The "ideal section" (*7.1*) proposed a design that could act as a starting point for the construction of a Virtual Field Trip or for modifications to further enhance Story Maps for this task. Overall, the results of this thesis suggest that there still is a wealth of potential research and meaningful developments in the application of Story Maps to Virtual Field Trips.

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Story Maps as development and authoring tool for educational Virtual Field Trips.

Friedrich Striewski, University of Salzburg.

1 Abstract

Virtual Field Trips (VFTs) are computer simulated excursions that are meant as a replacement or addition to a real journey. The concept became popular with the advent of internet technology in the beginning of the 90's. Of the great number of educational VFTs available on the net, only a minority is, however, based on pedagogical principles, cost free and easy to incorporate into an institution's curriculum.
This paper reviews Story Maps, an application of ESRI's ArcGIS Online product range, as a potential tool to create and author Virtual Field Trips, which allow meaningful learner experiences. The evaluation is based on the factors of immersion, interactivity and communication as well as educational principles related to these concepts. A prototype VFT was created with the Story Map Journal template, simulating a student trip to the Odertal, Harz (Germany). The results show that, while browser based applications can not compete with highly immersive VFTs in Virtual Reality, Story Maps can incorporate a variety of multimedia data types and web-applications, allowing meaningful learning experiences. The ability to also host communication tools in the modular application framework, make the Story Map template a useful addition in the toolset of educators and educational developers.
Keywords: *E-learning, Online Education, Virtual Field Trips, ArcGIS Online, Story Maps.*

2 Introduction

Virtual Field Trips, as a computer based alternative to real excursions or journeys, emerged with the advent of the internet in the early '90s. The concept quickly gained popularity in areas of digital education and tourism, where benefits were seen in its cost-effectiveness, accessibility and global scope, making journeys to remote or dangerous

places possible and affordable for everyone. Over the course of a decade, a vast number of private, commercial, educational and scientific VFTs was developed, while attempts of evaluation, classification and standardisation were lacking far behind (Spicer and Stratford, 2001, 346).

Educators as a generally non-professional target group for educational software can be considered to be interested in cost, time and effort of the potential technical solution, but also in the outcome of their work in using this specific technology. In eduction, teaching technology is measured to whether it will permit innovative and meaningful teaching (Warren and Jones, 2014, 623), where an optimal tool would be coming at a minimal price, is easy to use by non-professionals and is well documented to allow adjustments of content or software to the developer's specific demands.

ESRI's Story Map applications are freely available with a subscription to ArcGIS Online (or ArcGIS for Developers), come with builder applications and GUIs to automate and simplify the workflow for a non-technical audience of authors and are well documented by the vendor and examples on the net. Using Story Maps as tool for educational VFTs results in the question whether the application can be used to create and author meaningful learning experiences. This question shall be answered by an analysis of system behavior and potential regarding the factors of immersion, interactivity and communication. The leading questions of this research framework are:

- How can immersion be created or substituted by multimedia content in the application?
- Which forms of interactivity can be established to modify content and course of a Story Map?
- How can communicational tools be implemented in the template?

3 Background

Educators who want to develop VFTs on their own face the problem that the concept is neither defined by a set of principles or requirements, nor that previous attempts provide guidance, as the implementations are vastly different from each other. On top of that, the majority was not based on a solid pedagogical principle. Therefore, it seems suitable to define VFTs over their intended use scenario and to deduct requirements from research on this level.

According to Felder and Silverman (1988) (Trindade et al., 2002), most learners favor sensory, visual, inductive, and active learning over the more common verbal, deductive and passive teaching. For VR systems and online learning in general, Trindade et al. (2002, 2) identify interactivity and immersion as key factors, while Reushle et al. (1999, 4) and others also stress the communicational factor.

Immersion describes the feeling of presence in a virtual environment ("telepresence") as well as representation of phenomenons, concepts and forms, partly not possible to be experienced in the real world (Steuer, 1992, 5). A vivid, "immersive" simulation of reality is considered to permit the application of "real-world cognitive processing strategies" in learning and less distraction by background noise of the actual surroundings (Slocum et al., 2001, 63).

Interactivity is understood as any user modification of a medium's form and content (Steuer, 1992, 14) and is distinguished in navigational and instructional interaction types (Sims, 1997), or explorative, constructive and manipulative classes (Roussou et al., 2008, 142). Both the system and the user can initiate interaction, with the complexity of the task and the system's response determining the level of interactivity (Crampton, 2002, 88). Learners are supposed to benefit from a learning environment that fosters individual problem solving strategies and control over when (structure) and what (content) information is displayed (Evans and Gibbons, 2007, 1149).

(Tele-)Communication is defined as interactivity between humans in a computer mediated environment (Reushle et al., 1999, 4). Forms of communication are characterized by medium (e.g. text, audio), content (information, objects), cardinality (n:m users) and

synchronism (immediate vs. delayed response) (Adedokun et al., 2012, 613). The necessity of communicational tools to enable a social component in virtual systems and to "populate" a learning environment is stressed by several authors (Dillenbourg et al. (2002, 5), Robert and Lenz (2009, 121)).

4 Methods

Story Maps are part of ESRI's ArcGIS Online framework and defined as "lightweight, open-source web apps [which] combine web maps (...) with multimedia content - text, photos, video, and audio - to let you tell stories about the world." (ESRI, 2012a). The application is meant to inform, educate and involve an audience (ESRI, 2012b, 2) through a "story", which is not necessarily a narrative, but more generally a message or concept enriched by multimedia content in combination with spatial information (Probst et al., 2014, 5). Therefore, Story Maps can be considered to be of interest as a VFT-authoring tool for educators and educational developers in the field of e-learning. The evaluation

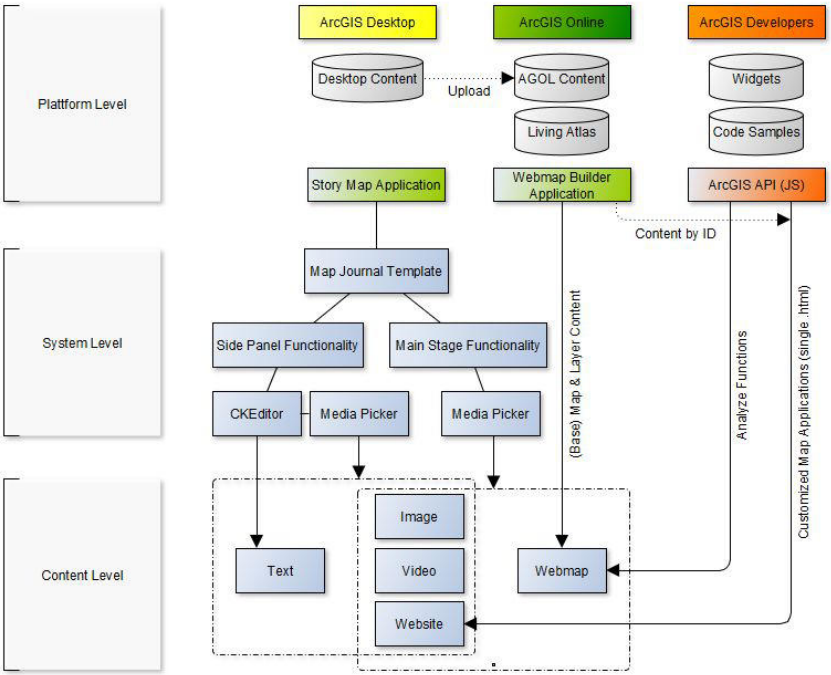

Figure 1: Map Journal template architecture and interfaces to AGOL resources.

of Story Maps as a tool to create and author educational VFTs, was conducted on a prototype application based on the Map Journal template. This analysis was conducted in tree steps:

In a first step, the prototype application was outlined regarding the target group, learning goal and template choice. The Map Journal template was identified as the most promising tool for the creation and authoring of Virtual Field Trips because of its two fold structure and the ability to host various multimedia content (Main Stage container) alongside textual descriptions in a Side Panel. The technology is browser based, cost free but not intended for mobile systems.

On its content level, the VFT is based on a real excursion of the Geography department of the University Goettingen and simulates a student visit to the Odertal, Harz (Germany), where a glaciation of the valley during the last glacial maximum shall be reconstructed by the students. The Story Board (*figure 2*) shows the Virtual Field Trip in eleven different stages, each motivated by a distinctive learning goal and with an adequate pedagogical tool to be implemented into the application.

Section	Location	Main Topic	Concept	Side Panel	Main Stage (Picker)	Account Type
0	Oderhaus	Overview and Section Links	Interactivity	Section Links	Web map	Online
1	Valley mount	Map Comparison, Webservices	Interactivity	-	Website / application	Developer
2	Oder river	Experiments	Interactivity	-	Website / iframe	Online
3	Tributary valley	Time Aware Data, Query Layer	Interactivity	-	Website / application	Developer
4	Traverse	Audio and Image Galleries	Immersion, Communication	Audio player	Website / iframe	Online
5	Terminal moraine	Story Map Actions	Interactivity	Story Map Actions	Web map	Online
6	Terminal moraine	Layer Manipulation and Contribution Tools	Interactivity	-	Website / application	Developer
7	Ground moraine	Assignment: Mapping Tools	Interactvity, Communication	-	Website / application	Developer
8	Hahnenkleeklippen	Visual Content from Ground Perspective	Communication		Website / iframe	Online
9	Forest	Discussion and Feedback	Immersion	Discussion	Website / iframe	Online
N	Königskrug	Embedded Story Maps	Interactvity, Communication	-	Website / Story Map	Online

Figure 2: Story board of the prototype. Each section of the VFT hosts a single, self contained topic based on educational principles. The simulation is based on a real excursion in the valley with Geography students of the University of Goettingen, Germany.

In a second step, the prototype was implemented on the content level and the development process was documented in requirements, resources and workflow. While dummy text was used for the Side Panel, content of the Main Stage consisted of either multimedia data, web maps or web applications. The data base for the latter two types was created either in ArcGIS for Desktop or ArcGIS Online, where the content was also hosted. Web applications were developed with the ArcGIS for JavaScript API as single html file containing struture, styling and code as well as references to layers and maps hosted on

AGOL.

In the last step, the template's source code was modified to increase the usability of the product and to implement tools that could not be attached by content in the Main Stage. The Map Journal template uses CKEDitor to generate the textual body of the Side Panel and modifications to the editor were made using CKEditor's own API. The customized template was compiled with *Node.js* and *grunt* and hosted on a web server, while the content remained on AGOL and was referenced via URL.

5 Results

Analysis of the factors of immersion, interactivity and communication in the prototype shows mixed results for the three principles:

a) Immersion:
Browser based web applications cannot compete with true Virtual Reality systems in terms of sensory experience and vividness. As such, Story Map applications are restricted to hearing (audio) and sight (visual content).

Sound output in form of audio descriptions, music or podcasts is not part of the template but can be implemented with little effort in form of audio elements or iframe containers. Audio players give author and user control over when, where and which audio content is activated. Using audio additionally to text in the template can foster learning by addressing visual and auditive input channels at the same time, following the "cognitive theory of multimedia learning" by Mayer and Moreno (2003, 44). Using audio instructions as a replacement of text is, however, not advised as the complexity of buttons, stages and views in a Map Journal application will lead to increase of cognitive load (Nelson and Erlandson, 2008, 624). Audio input in form of voice commands is not supported by the application.

A wide range of multimedia data types for visual content is supported by Story Maps. Besides the emphasis of data from bird's eye perspective, like maps, satellite scenes and

aerial images, immersive panoramic pictures or even complete Virtual Tours can be hosted in the Main Stage, allowing interactivity with scales and perspectives and navigation through a set of scenes. 3D data (e.g. ArcGIS MyScene) is only rudimentarily supported and cannot compete with true 3D as known from VR.

b) Interactivity:
Navigation in the Map Journal template follows a linear set of sections, which are accessed by the user by scrolling through the Side Panel. With each new section, the corresponding Main Stage is updated, displaying the attached multimedia content. While this form of navigation can considered to be mainly "re-ative" (Rhodes and Azbell, 1985), the linearity can be softened by two additional movement types: "Story Map Actions" are text links in the Side Panel that update the Main Stage to a new view, either a new media container or a map update, thus increasing the volume of a single section. Section links can be incorporated via a small script and will update the Side Panel to a new section, allowing forms of content branching.

On content level the application allows forms of "examine", "compare", "reorder" and "extract" tasks (Crampton, 2002, 88), but not the highest form of "cause-effect" instructional interactivity. Interactivity depends on the content and media type featured in the Main Stage, with web maps and web applications allowing the greatest variety in tasks. With their strong ties to the ArcGIS product range, Story Maps are meant for interactivity based on map data and operations, but lack experiments or simulations. External applications or websites can, however, also be embedded by i-frame container or included by url reference, setting no limit on what is hosted in the Story Map application.

c) Communication:
The need for communicational tools depends on whether Story Maps are used stand alone or embedded into a larger learning framework. In the former case, all necessary tools have to be provided in the application. Both Side Panel and Main Stage can be used for this task. As the Main Stage hosts multimedia content and is updated regularly, it is only suited as a container for task or view specific communication, like e.g. instruction or tool tips. The Side Panel is independent from Main Stage updates and the right place for "global" communication concerning the whole section or application. Buttons for social media, mail or (voice) chat communication are therefore best placed in this container or the application's title bar. In general, Story Maps are meant for one-sided, non-verbal

communication of 1:n cardinality between the application's author and his audience. Any other form has thus to be implemented manually into the application.

6 Discussion

The results show that Story Maps are generally suitable for the creation and authoring of Virtual Field Trips and allow the construction of a course based on pedagogical principles. Multimedia has to be used as immersive content, but this can be done without any technical knowledge and with the build-in tools. Interactivity depends on to which

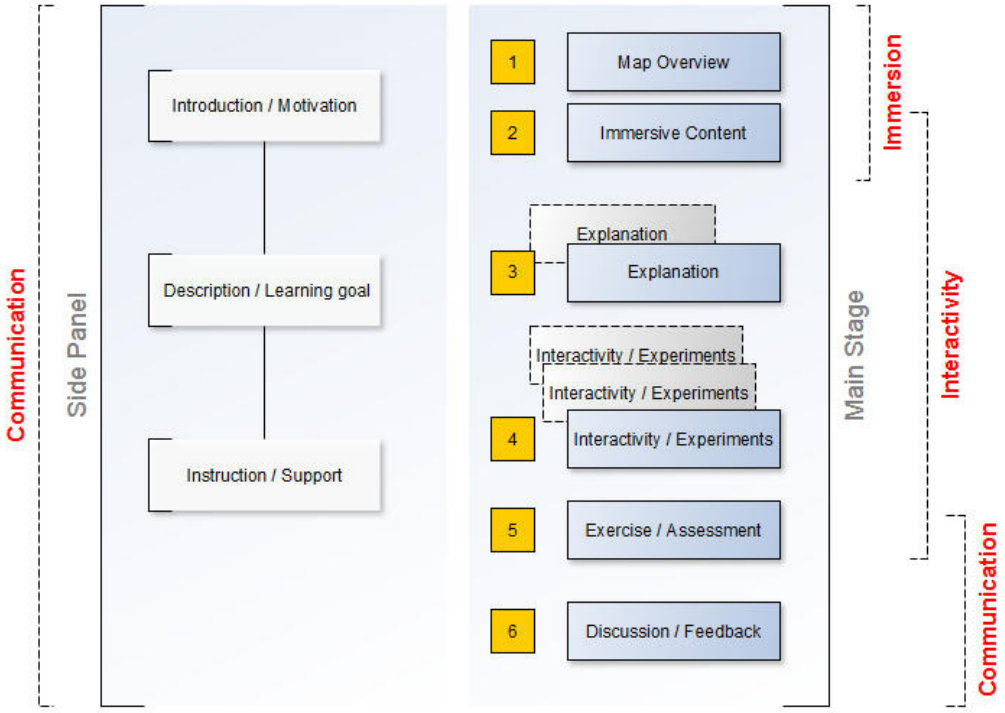

Figure 3: "Ideal section" design proposal for a self-contained unit within a Story Map VFT. The Side Panel contains a single text body with various types of instructive content, while the Main Stage is splitted into different views. Each view consists of a specific media type to convey a goal, related to an educational principle (red).

degree an educator wants to "invest" into the technology, with customized applications of the ArcGIS for JavaScript API allowing sophisticated tasks and high levels of interac-

tivity. This, however, requires basic programming skills and can prove a time consuming tasks, depending on goals and prior knowledge. Changes to the program's core functions require modifications on the source code and can only be conducted by educators with fundamental developing skills. The same holds true for communicational tools, depending very much on what the educator wants to convey and achieve.

The "ideal section" (*figure 3*) is a design proposal for a learning unit within a Map Journal VFT. It consists of a single Side Panel container for various forms of textual description and several Main Stage's different media types. The first two stages (1,2) are meant to motivate, inform and update the user of his new surroundings and address the immersive domain. In 3-5, the section's actual topic is conveyed through external content (e.g. web sites) and several web-applications, ultimately leading to some form of quiz or exercise to review and test the participants' learning outcome. Room for questions, discussion and feedback is provided in 6 through communicational tools, e.g. by a discussion platform. Because of the modular structure of the template, any section can be customized to the specifics of the application scenario and without restrictions on what can be incorporated - as long as it can be referenced in any of the containers. In combination with the simplicity of required workflows, these specifics can be seen as the core strength of the Story Map Journal, making the template a helpful tool for non-professional educators that want to generate VFTs based on media content.

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Virtual Field Trips based on Story Maps

Master Thesis

Friedrich Striewski

2015

Virtual Field Trips based on Story Maps

Table of Contents:

1. Problem Statement

Virtual Field Trips based on Story Maps

Virtual Field Trips based on Story Maps

Definition attempts:

"Virtual Field Trips utilize state-of-the art technologies to create immersive, multi-sensory, interactive experiences with real world environments (...) [and] are designed to be an integral part of a technology-enabled educational system to teach targeted material and motivate students" (**Sanchez 2005).**

"VFTs can be described being an electronic exhibition of diverse natural and cultural phenomena that also provide digital simulations of the threedimensional processes of surveying, observing, exploring and adventuring in some actual field site" (**Qui & Hubble 2002**).

Virtual Field Trips based on Story Maps

Working definition of VFT in the thesis:

- A Virtual Field Trip is based on information technology.
- It is composed of various media types (multimedia-mash-up)…
- ...allowing to visit time(s) or place(s), reduced to their "essence".

- VFTs share defining criteria of immersion, interactivity and engagement with VR.
- They enable users in surveying, observing and exploring of content.
- A concept shall be based on good design and a solid didactic framework.

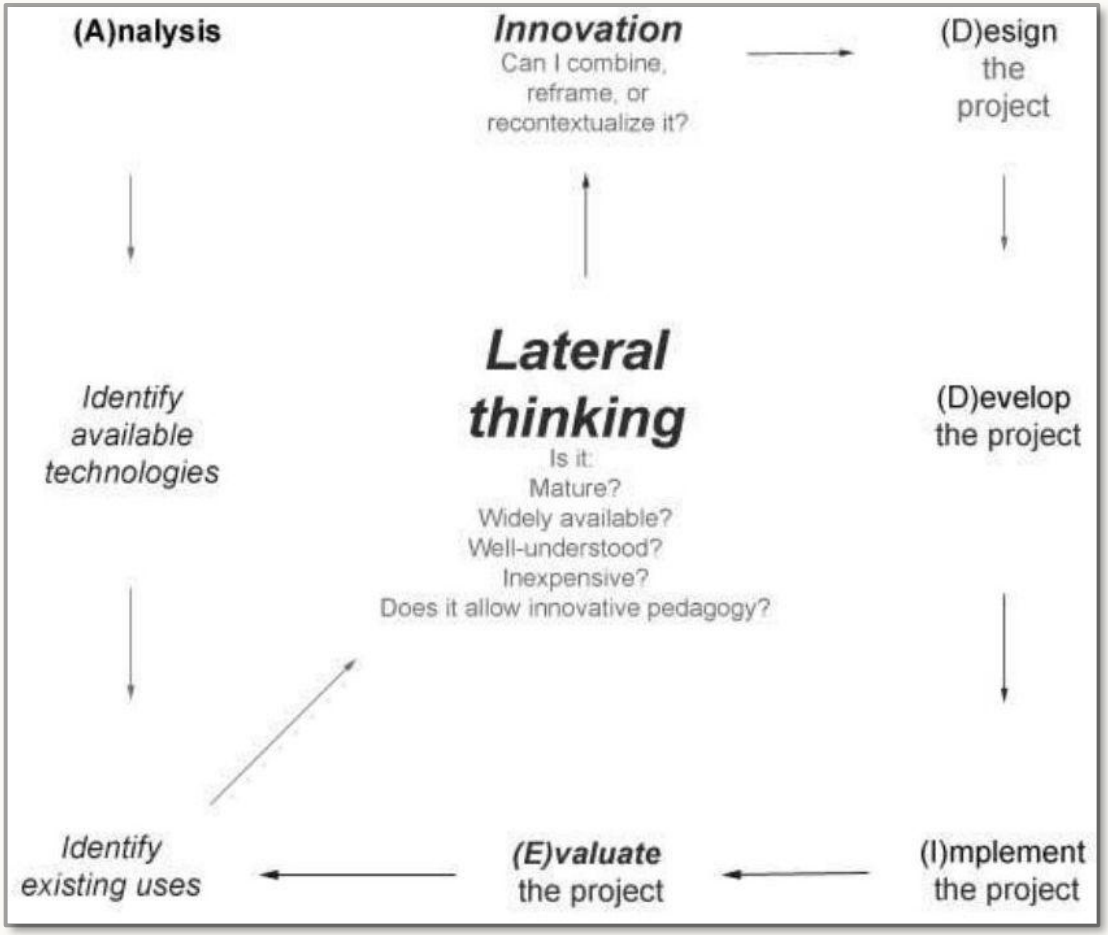
- A VFT still qualifies for the term if physically taken to the time or place represented in its specific content.

2. Structure of thesis

Virtual Field Trips based on Story Maps

Virtual Field Trips based on Story Maps

Structure of Thesis:



The "process of technology re-examination" by Warren and Jones (2014)

Virtual Field Trips based on Story Maps

Assessment of factors:

• **Immersion** - as a factor for the representation of phenomenons, concepts and forms, partly not possible to experience in the real world - also adding towards user perception through telepresence (*Trindade et al., 2002*).

• **Interactivity** - defined as interaction with the (virtual) environment (human<->computer) in content and structure, thus resulting in meaningful responses and feedback (*Trindade et al., 2002*).

• **Communication** - as interactivity between humans, mediated through a virtual environment (human<-computer->human). This incorporates feedback, evaluation, assessment as well as peer activities and collaboration (*Reushle et al. 1999*).

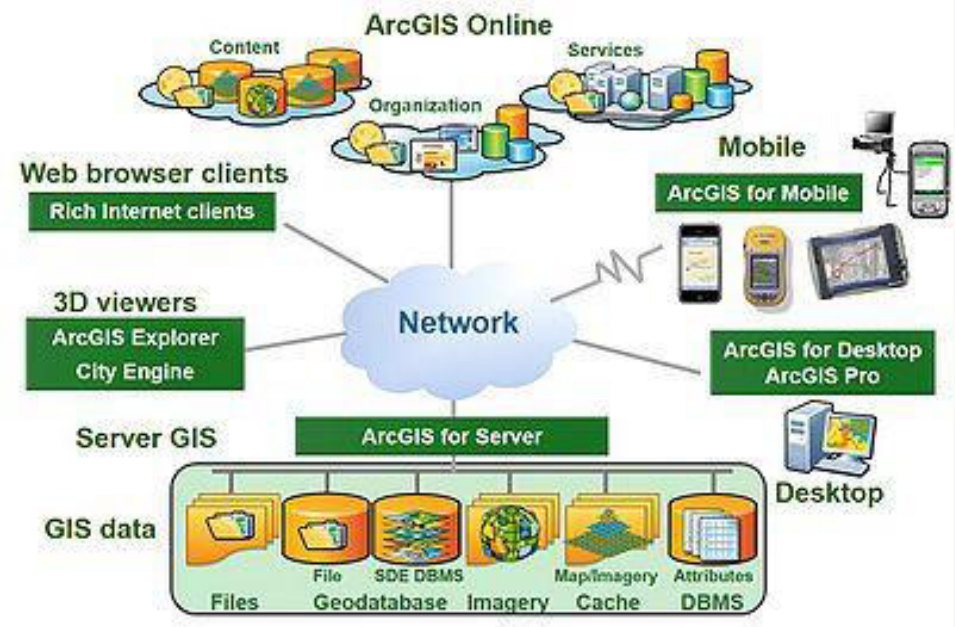
3. Methodology

Virtual Field Trips based on Story Maps

Virtual Field Trips based on Story Maps

Story Maps as a tool for educators:

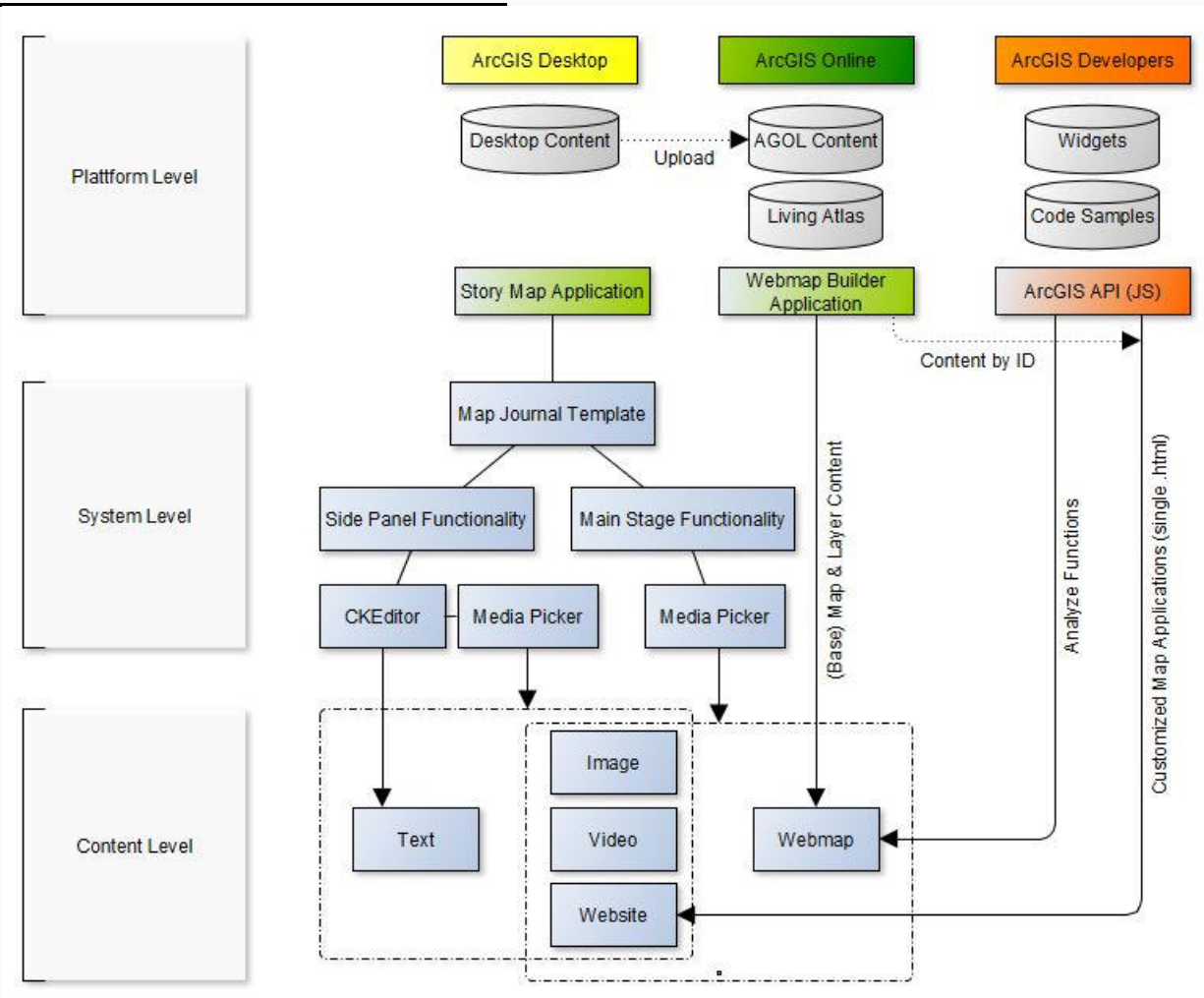
Story Maps are "*lightweight, open-source web apps [which] combine web maps (...) with multimedia content - text, photos, video, and audio - to let you tell stories about the world*." (ESRI 2012)



Component architecture of the ArcGIS platform (Peters, 2015)

Virtual Field Trips based on Story Maps

Story Maps as a tool for educators:



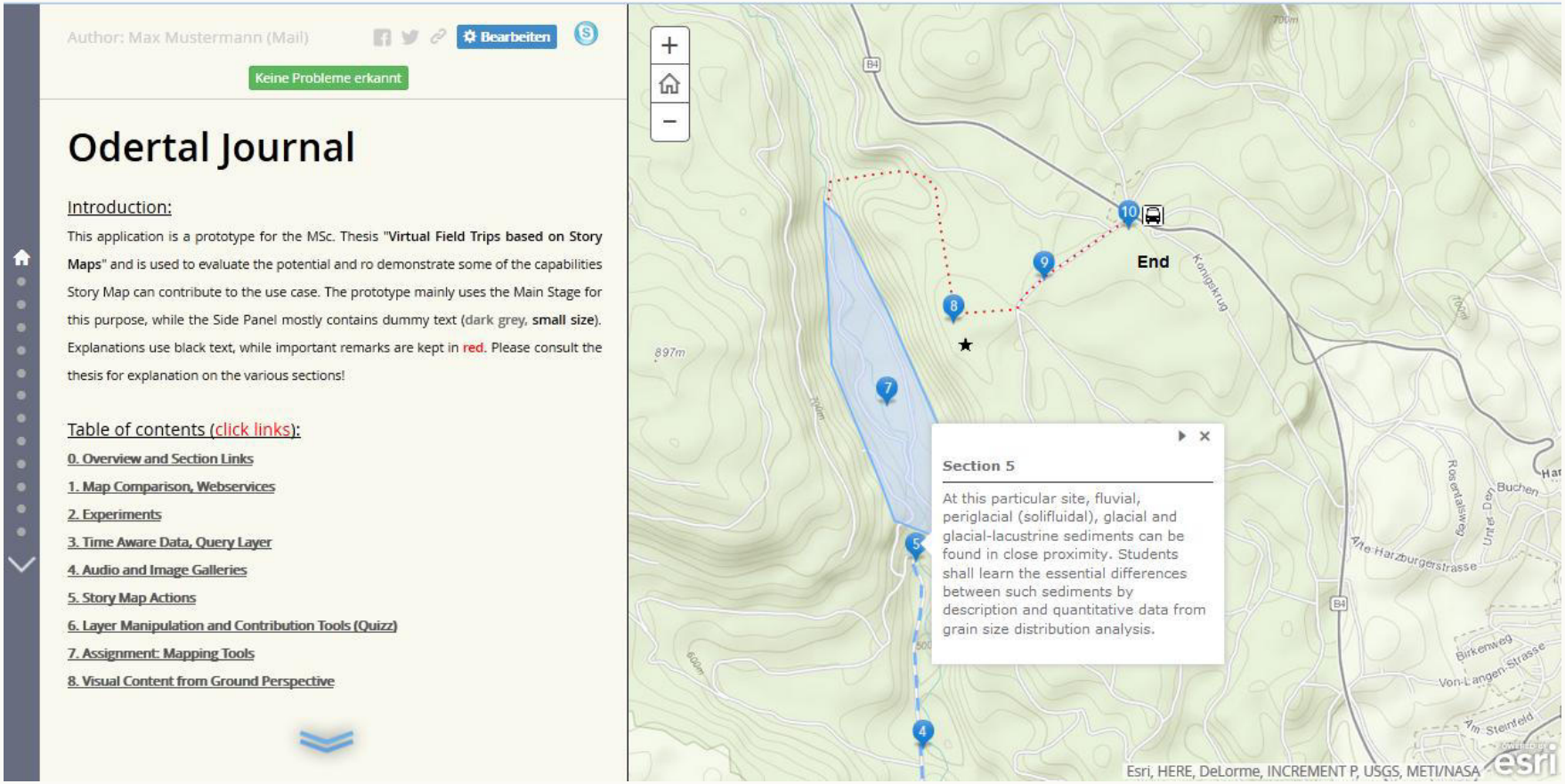
Architecture of the Map Journal template and interfaces to the AGOL framework.

4. Prototype

Virtual Field Trips based on Story Maps

Virtual Field Trips based on Story Maps

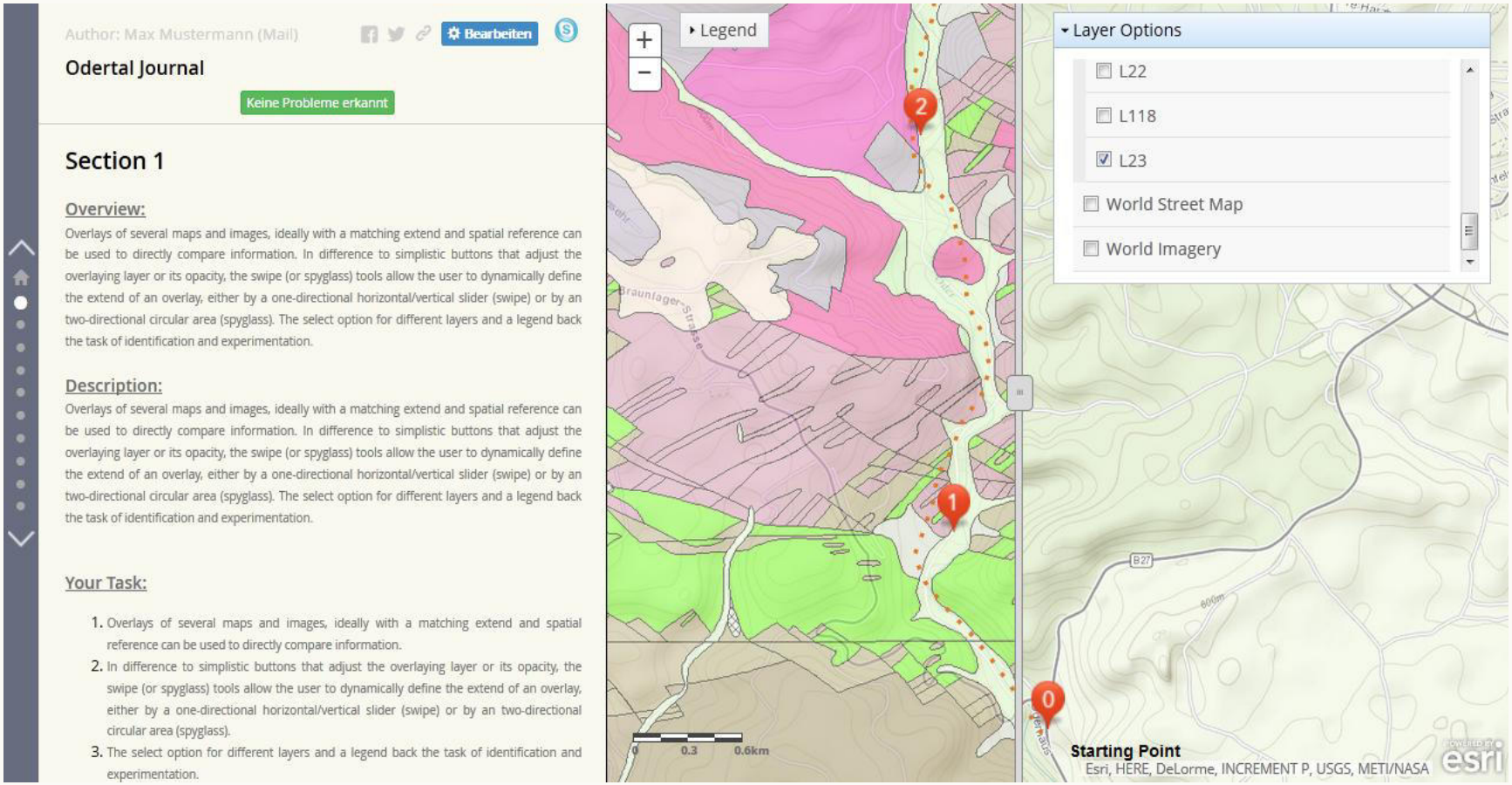
Prototype Field Trip:



Web map designed as an overview for the Odertal Virtual Field Trip. Numbered icons reference stages in the table of content and can be selected to open a popup window.

Virtual Field Trips based on Story Maps

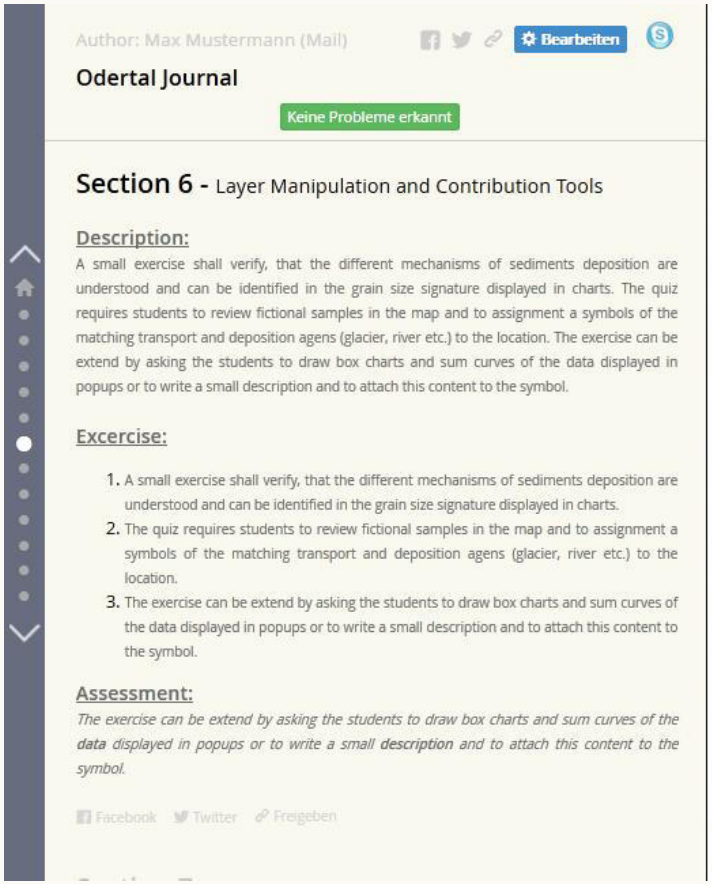
Prototype Field Trip:

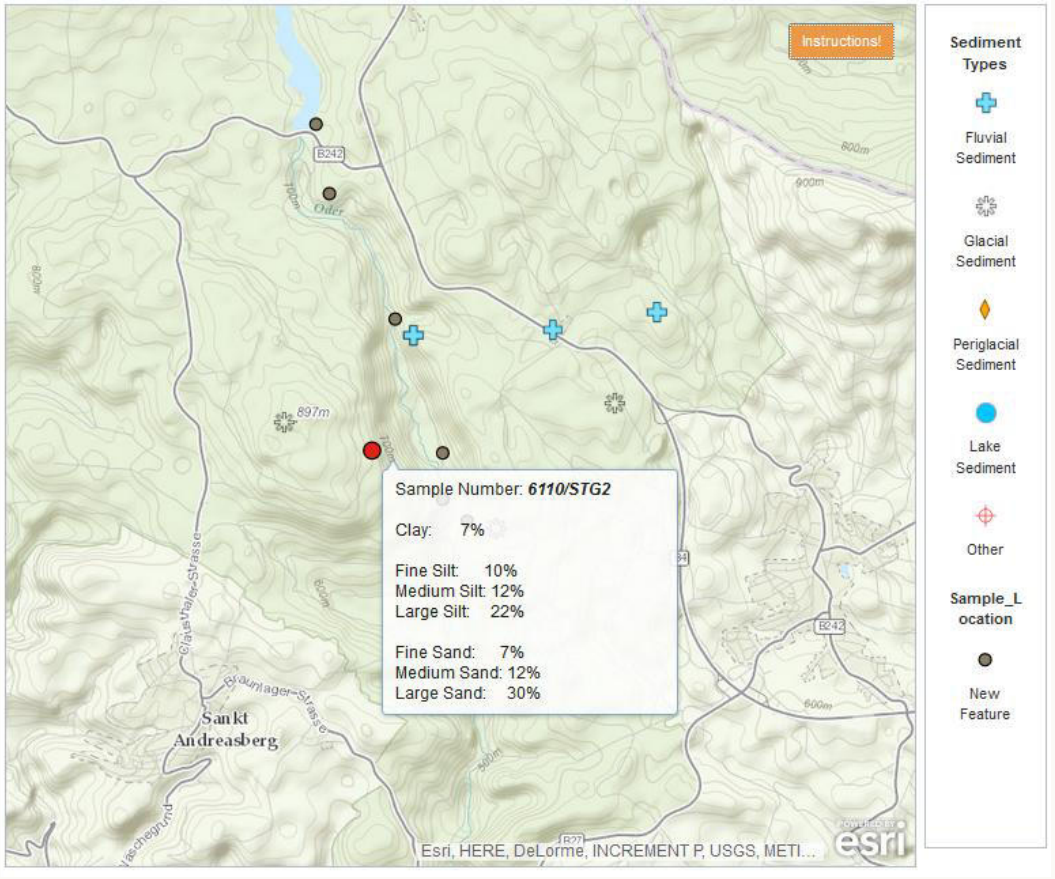


Web application of section 1 features a slider to display data from a webserver as overlay of basemap content from AGOL. Data can be toggled with "layer options" and "legend" drop down menus.

Virtual Field Trips based on Story Maps

Prototype Field Trip:

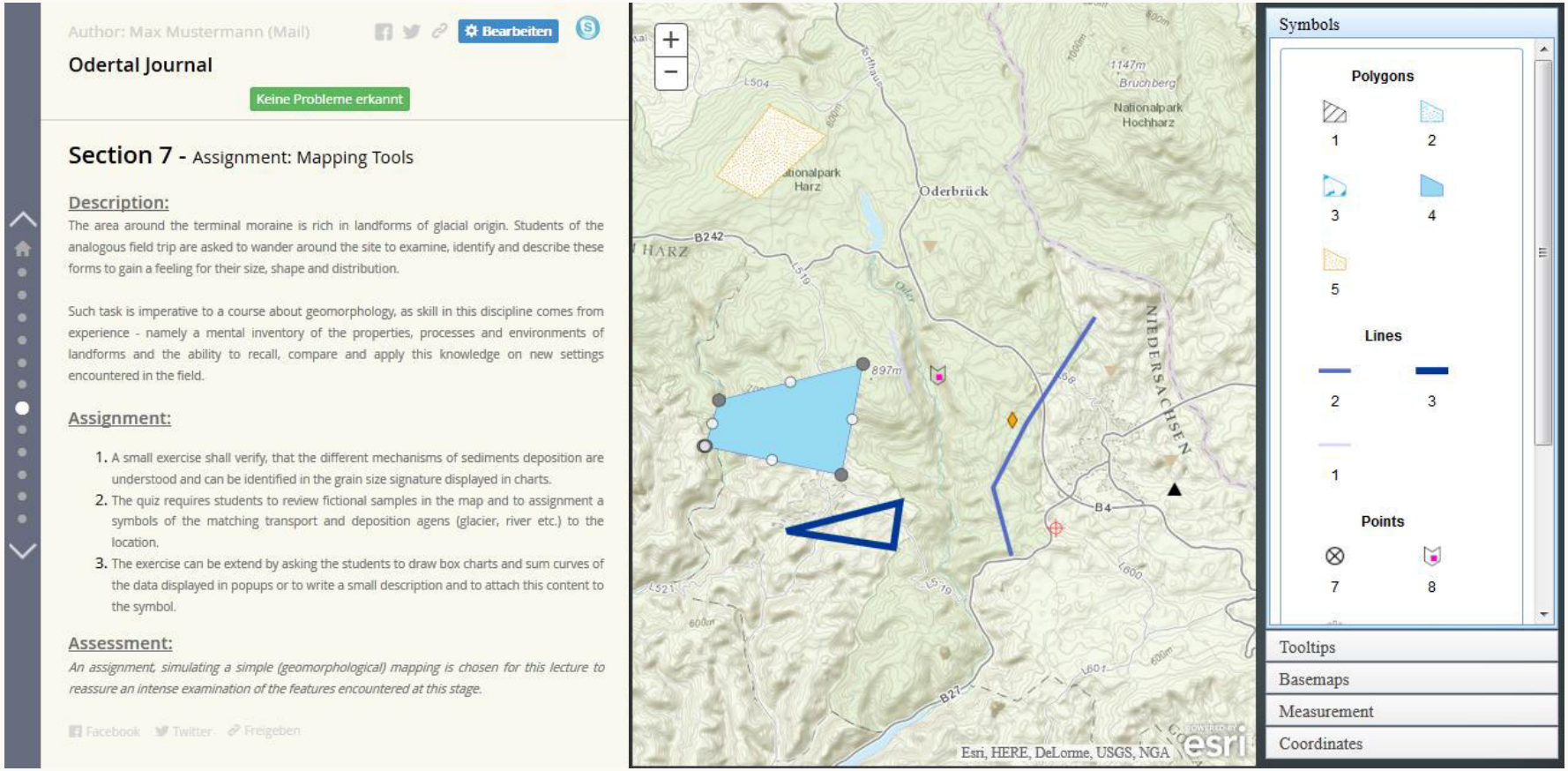




Web application of section 6 displays various sample points and an icon toolbar on the right. Symbols of the latter can be placed on the map while their dialogue window accepts input of metadata and attachments. Sample points can be accessed by hovering over the icon (brown dots).

Virtual Field Trips based on Story Maps

Prototype Field Trip:



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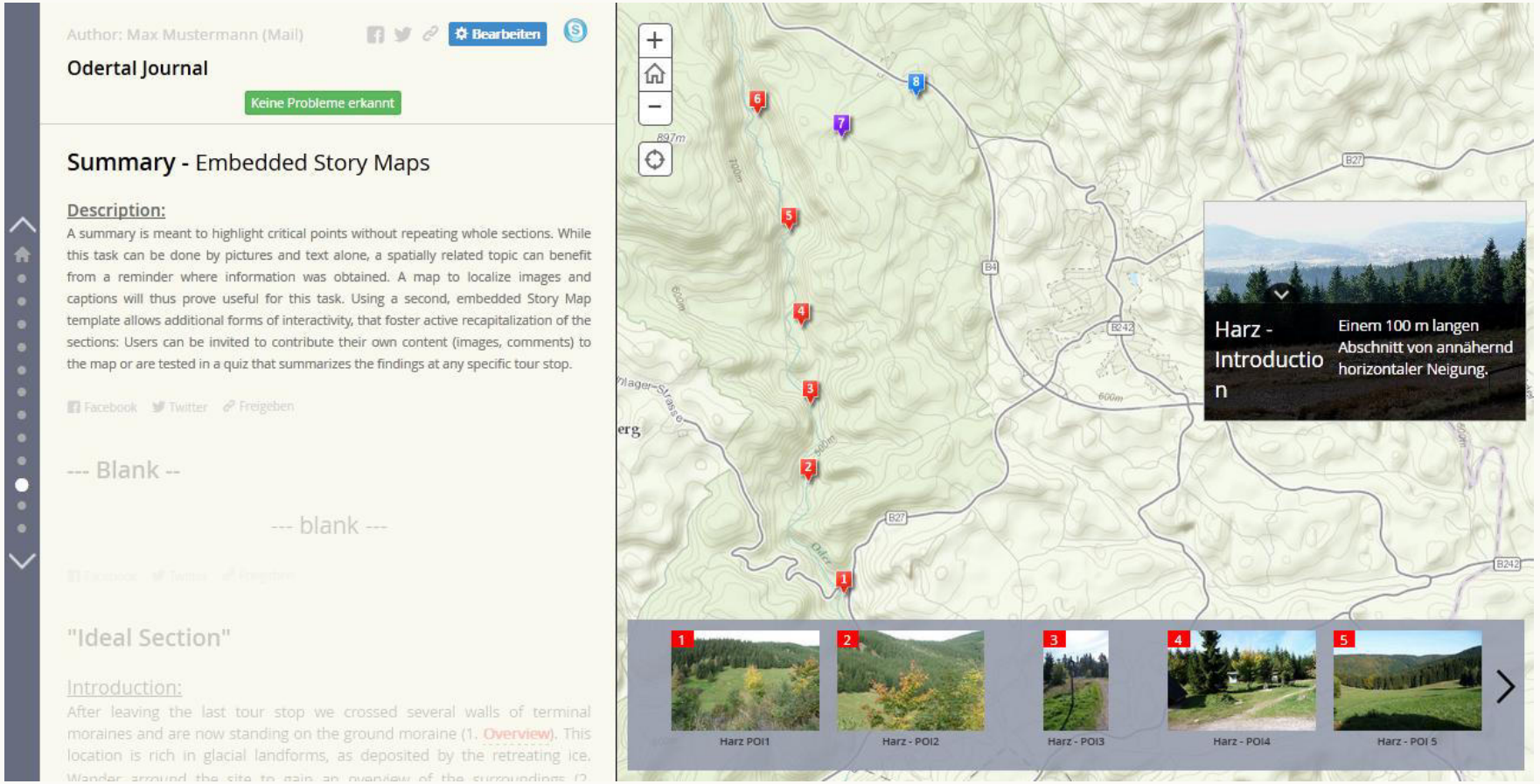
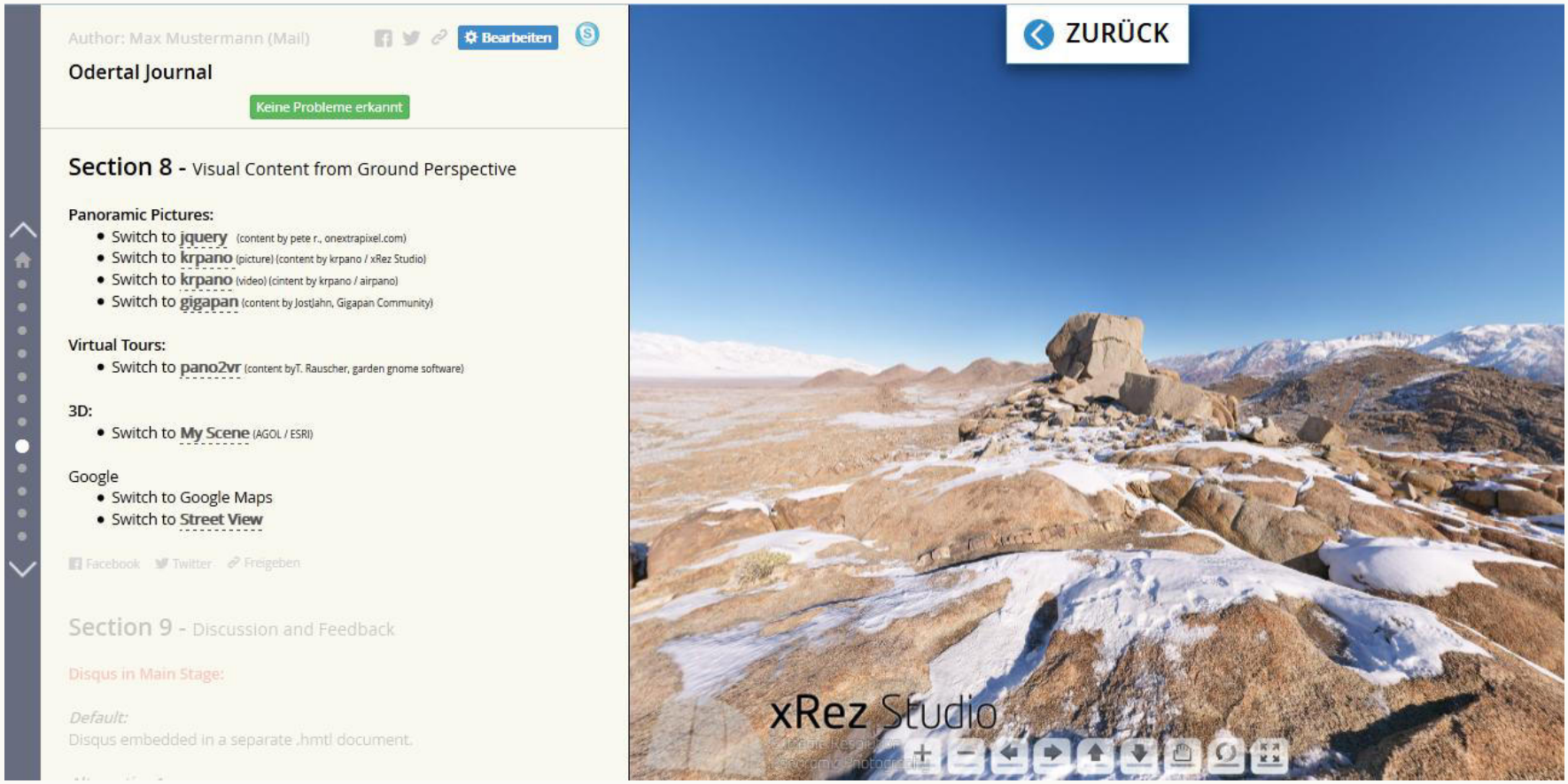


A second, "child" Story Map of the "Map Tour" type can be nested within the main application. In comparison to a stand alone app. Selecting a POI will lead to an update of the corresponding picture and vice versa.

Virtual Field Trips based on Story Maps

Prototype Field Trip:



Story Map Journal can feature immersive content in the Main Stage, like panoramic pictures, virtual tours and 3D scenes. (Image courtesy of krpano / xRez Studio)

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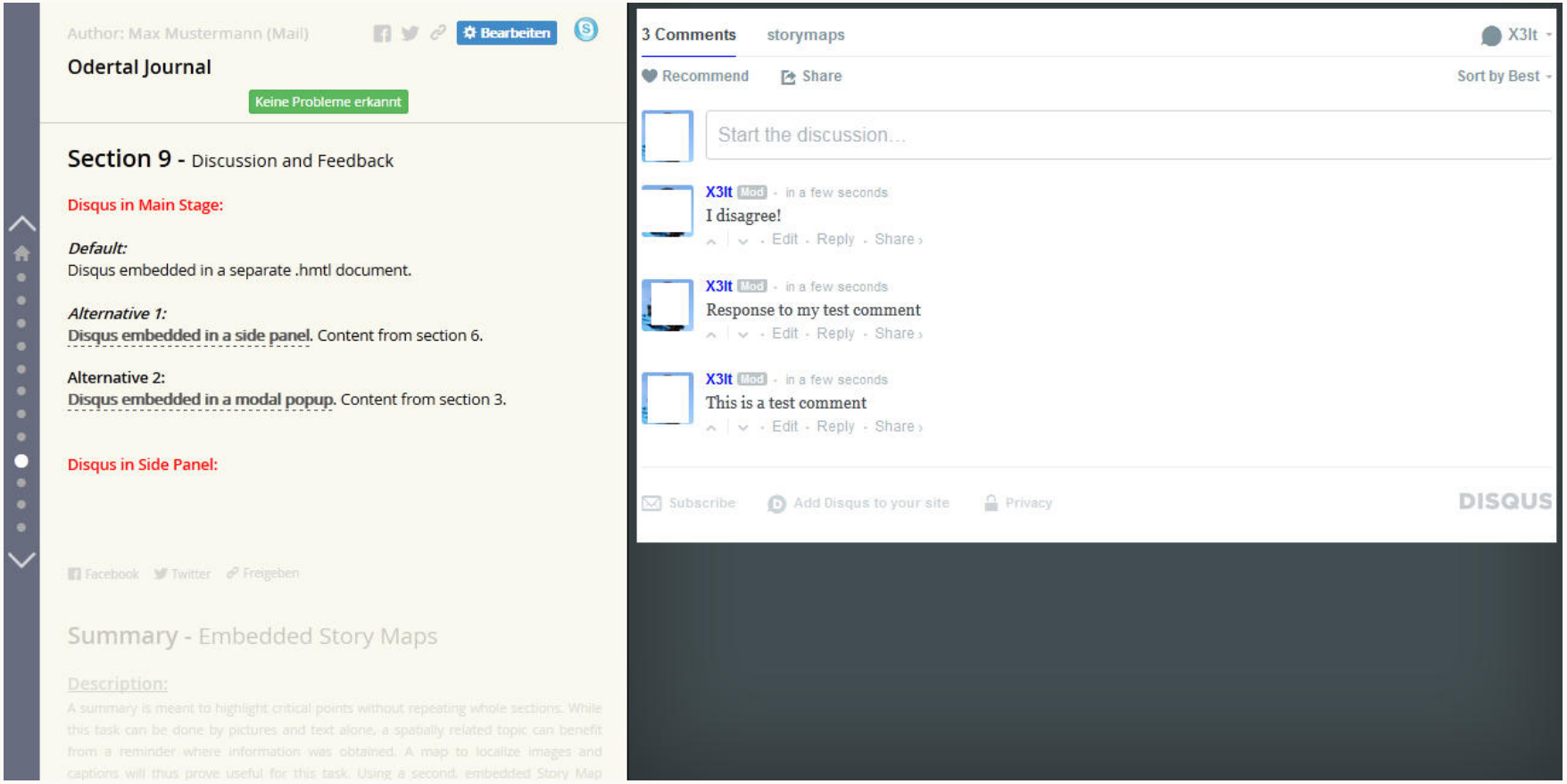
Prototype Field Trip:



Using “Disqus” (https://disqus.com) as a commenting platform in the Main Stage of a Story Map application.

5. Results

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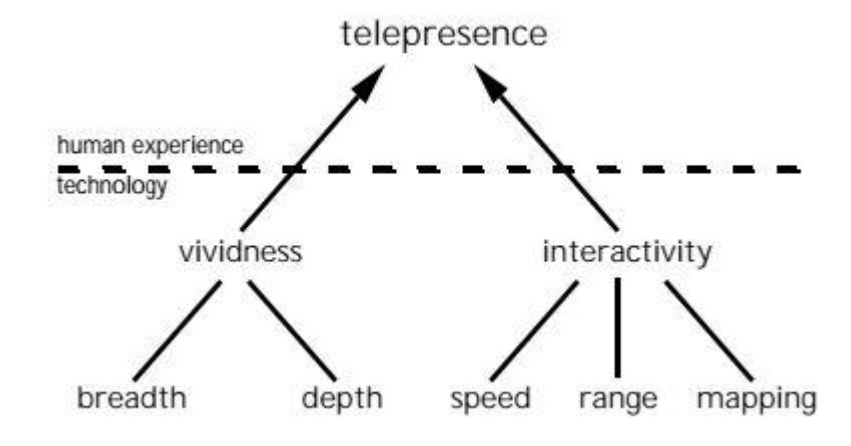
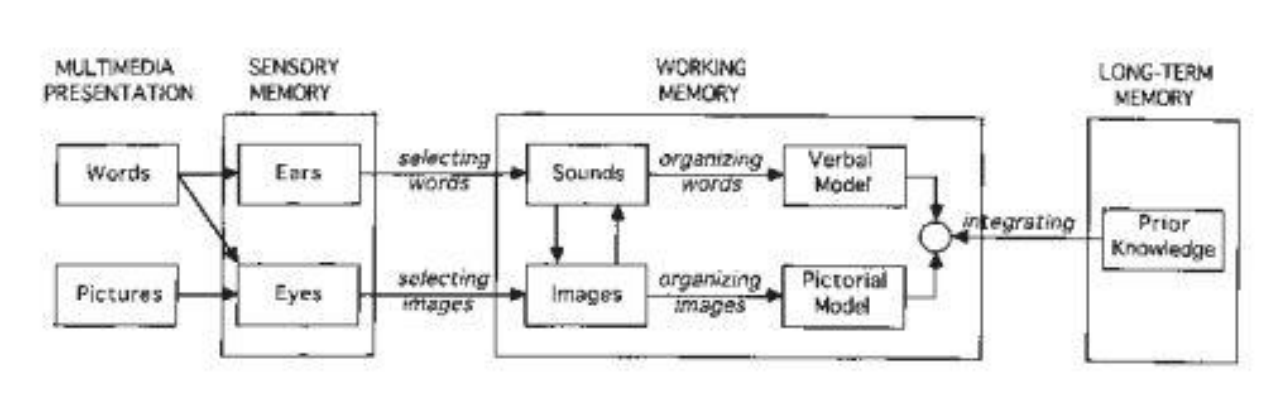
Immersion:



Technological factors for telepresence by Steuer (1992). Immersion is determined by breadth and width of vividness (left side).



"Cognitive theory of multimedia learning" by Mayer and Moreno (2003). Arrows indicate cognitive processing, labeled arrows active processes.

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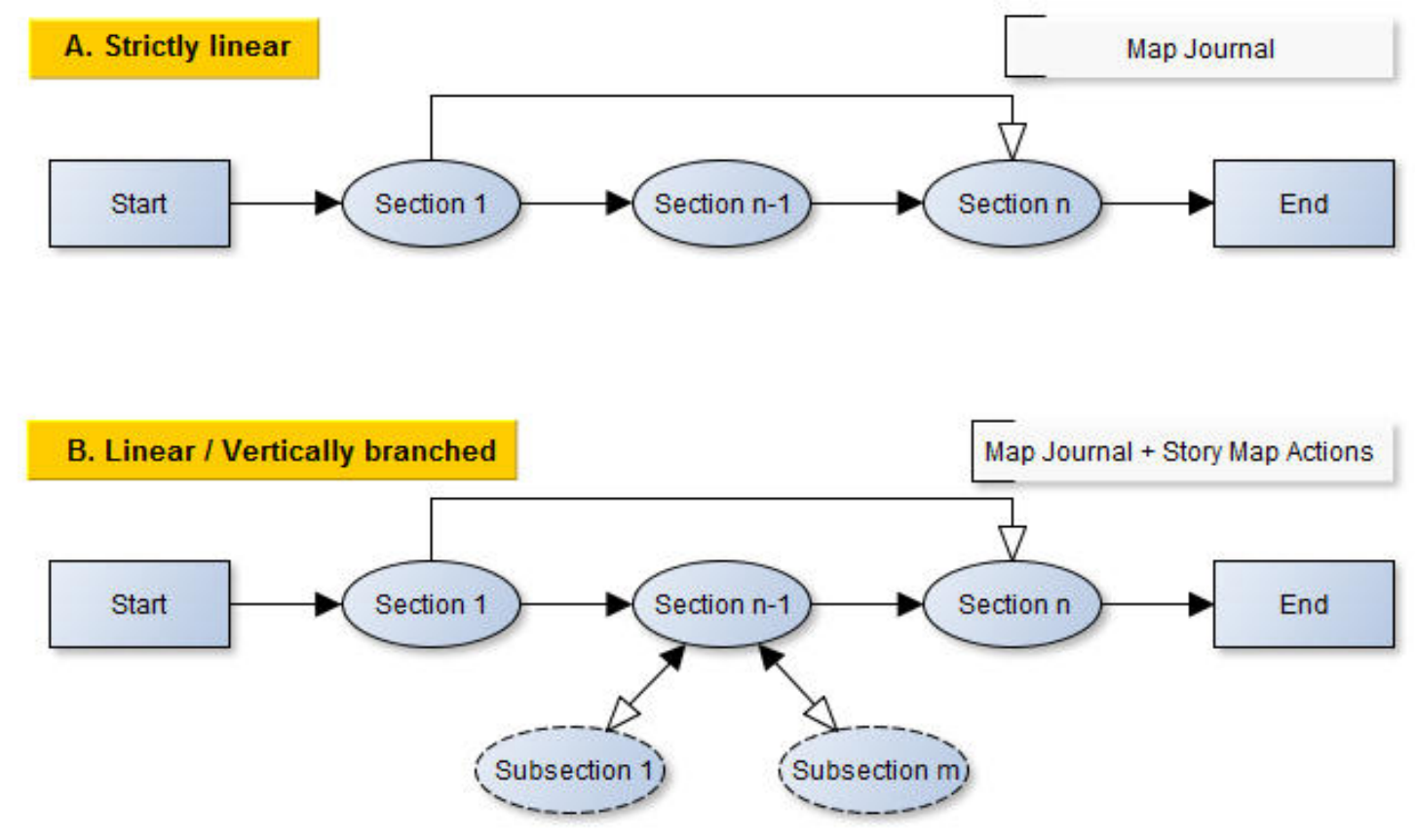
Navigational interactivity:



Types of navigational interactivity. A. is the default, "re-active" and linear type of the Map Journal, B. its alternative if Story Map Actions are used. Required movement indicated by black, optional by white arrows. Non-required topics with dashed lines.

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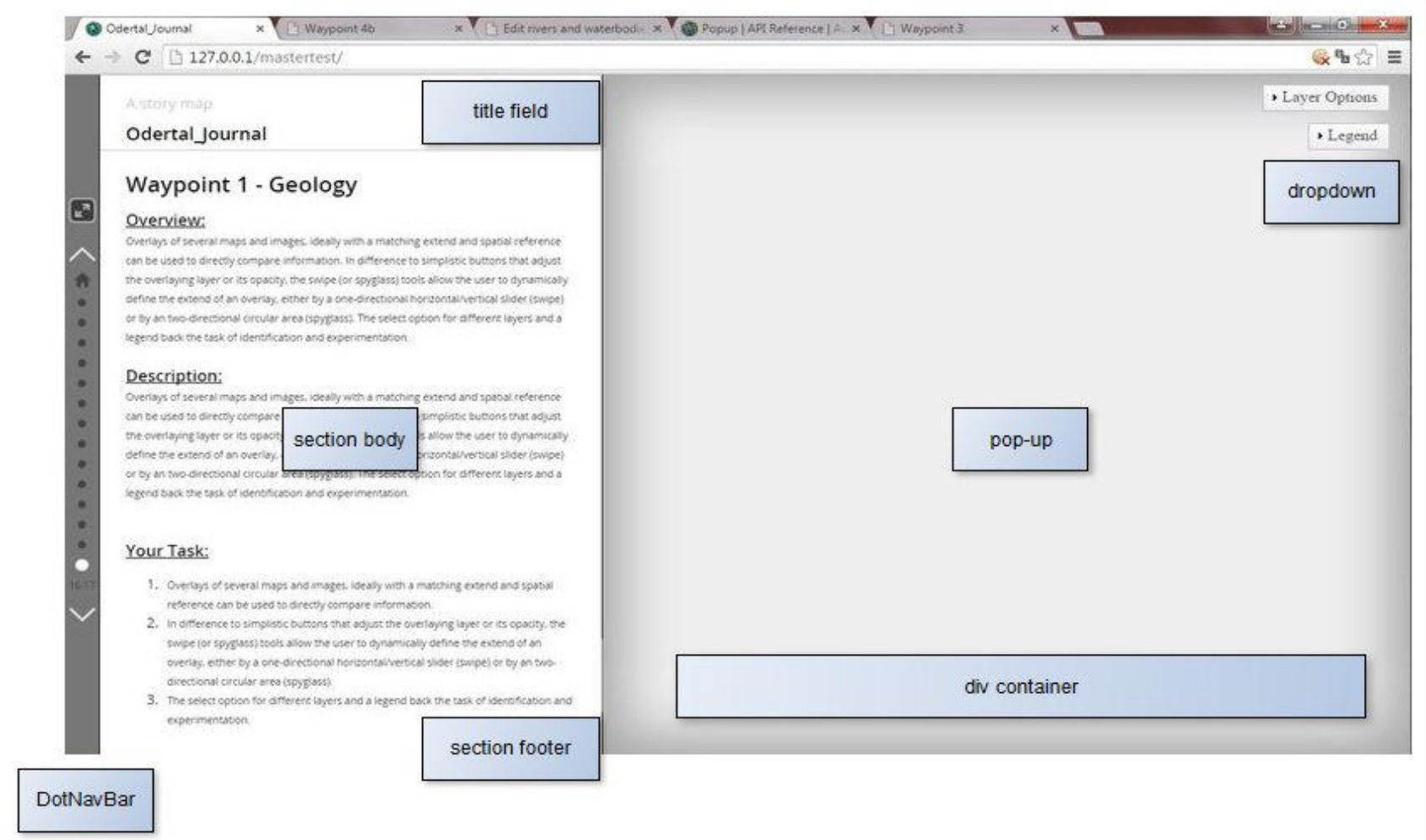
Communication:



Joints for the implementation of communication tools in a Map Journal application

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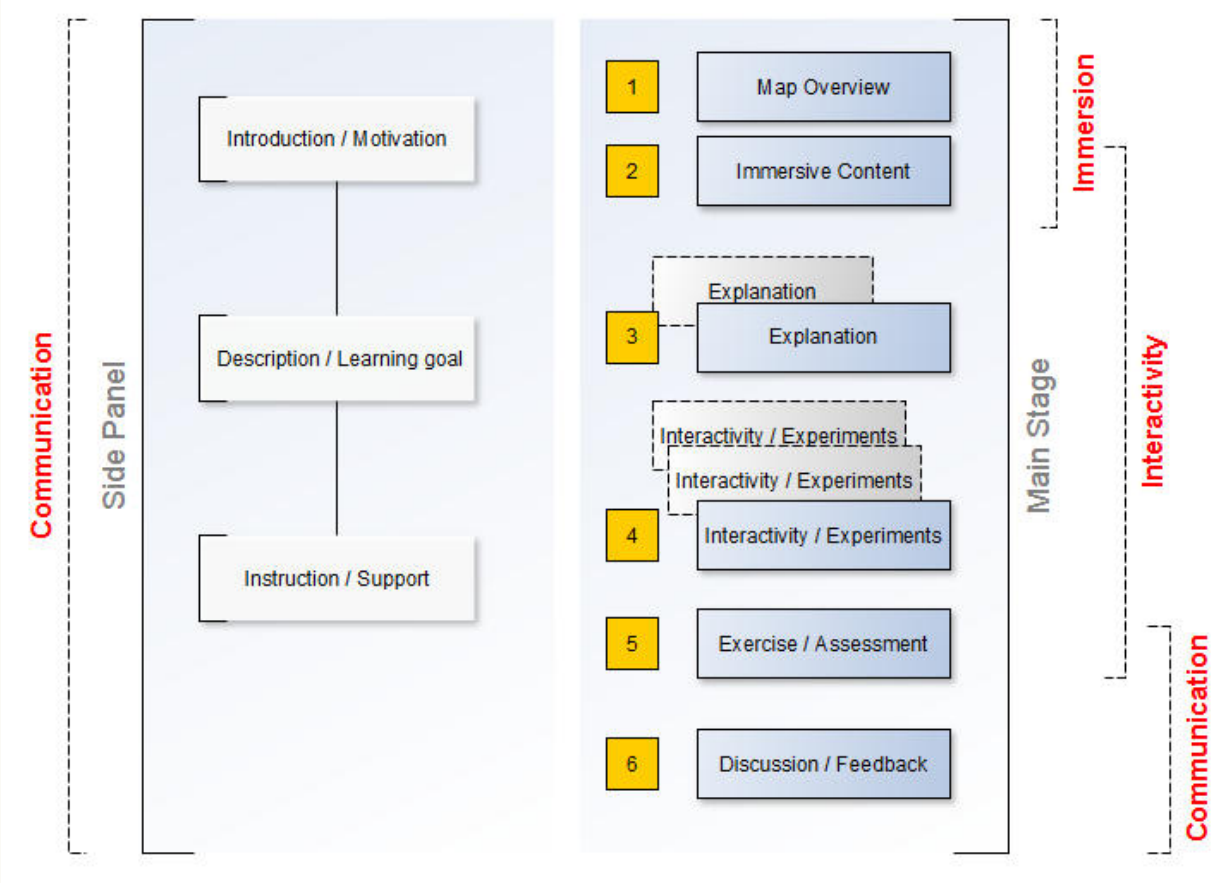
Design proposal for an "ideal section":



A self-contained unit within a Story Map VFT: The Side Panel contains a single text body with various types of instructive content, while the sections course consist of several stages from introduction to discussion. Related principles in red.