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Map guide for botanical gardens: multidisciplinary and educational storytelling

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ABSTRACT

The article presents the authors' experiences in designing a storytelling map guide for the botanical gardens of Palacký University, Czech Republic, from a pedagogical point of view. The authors introduce a three-pillared original concept. The overall educational contribution is a combination of educational, thematic and technological knowledge which supports successful engagement in the storytelling process. In the Storytelling Map Guide for the Botanical Gardens and Greenhouse Collections, the first pillar represents the educational aspect. Botanical knowledge and familiarity with the study area, i.e. the Palacký University Botanical Gardens, represent the thematic pillar. The technological pillar is covered by knowledge of software, cartography and application design skills, including an overview of contemporary storytelling applications. Finally, the educational impact and benefits to students of geoinformatics are discussed.

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Introduction

Storytelling has been one of the most common communication methods to preserve memory since prehistoric times. Storytelling involves the narration of stories with certain themes, plots and characters, and the end of a story often illustrates a purpose. Storytelling is a narrator's task. In the past, stories were preserved in oral, written or cartoon form. With the advent of modern technology, sharing stories has moved online to the Internet and become significantly simpler (Fog et al., 2010). Almost daily, we encounter storytelling, either unknowingly or consciously. Many messages can be conveyed to a reader through stories which engage and draw the reader into the narrative (Caquard & Dimitrovas, 2017).

In the present paper, we describe the design and development of map guides which apply storytelling principles. We investigated the potential of field work and storytelling map design to increase the pedagogical benefit for both students and authors, as mentioned in the literature (Egiebor & Foster, 2019) (Mukherjee, 2019). According to Dickinson and Telford (2020), story mapping raises the reader's attention to visual elements. Dickinson and Telford define story mapping as a "more than visual form of

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representation of research." However, an awareness of the target group and the selected topic is a prerequisite.

The present paper discusses the unconventional approach of our Botanical Gardens Map Guide for botany and geoinformatics students. Young students need to be addressed with alternative methods of education through digital media. Lee (Lee, 2019) points out that story maps improve awareness in geography education. Story mapping involves a form which is more than visual through a combination of mobile device platforms, multimedia content and maps as the basis for stories. Mobile devices are frequently used to support geographical field trips (Medzini et al., 2015).

Several methods and ideas have been applied in geography lectures concerning field classes. Virtually all lecturers in geography understand the importance of field work as a vital mode of teaching in the subject (Kent et al., 1997). Bradbeer (1996) recommended the use of problem-based learning to prepare geography students for field classes. Regarding field lectures, researchers from Indiana University concluded that field trips had long-term benefits for students in ecological and environmental knowledge (Farmer et al., 2007). Undergraduate students were likely to gain the most benefit from research in terms of depth of learning and understanding when they were actively involved, especially through various forms of inquiry-based learning (Healey, 2005).

Teachers have also emphasised preparatory and planning stages in collaborative projects followed by collaborative learning and the integration of classroom knowledge into field research (Hefferan et al., 2002). The literature also mentions the use of field trip notebooks by students to reflect on and capture their experiences during international field work in Barcelona, Spain (Simm & Marvell, 2015). Dummer et al. (2008) stated that the assessment of student learning from field work can be problematic. Farmer and Wott (1995) suggested that related follow-up activities reinforced some of the concepts presented during a field trip to a public garden.

Geographers (Falk & Chatel, 2017) confirmed that not only does mobile computing support traditional lecture-style teaching, but through convenient information gathering and sharing, it can also promote innovative teaching methods in geography education with applications such as SMARTGEO. Ralston et al. (2019) established how student engagement and exploratory learning through remote field activities could be conducted outside the classroom. For students preparing maps during field classes, a source of inspiration is the book "Rethinking maps", which offers a contemporary assessment of diverse forms of mapping (Dodge et al., 2009). Telling the story of how maps are created and how they come to life has become a new challenge for mapmakers (Caquard & Cartwright, 2014).

In the case of student research projects, maps are designed effectively when quantitative data collection in the field is combined with data visualisation, manipulation and analysis in a GIS (Favier & Van Der Schee, 2009). It is sufficient to cover only the technical aspects of the application of GIS software; however, the context of spatial problems is also important. The teaching of critical spatial thinking in higher education empowers graduates to engage effectively with spatial data (Bearman et al., 2016).

Drawing on several years of experience, the authors of the present paper define the educational benefits of story maps as a triangle which comprises educational, thematic and technological pillars. The authors examine the educational benefits during the process of developing story map guides and present a case study of the Botanical

Gardens and Greenhouse Collections map guide. The benefits are also examined from a visitor perspective.

The first chapter explains and defines the map guide project as a triangle of educational, thematic and technological pillars. The chapter reflects the personal experience of teachers in practical courses which led to the creation of the Botanical Gardens Map Guide as a storytelling map. The courses and students involved represent the educational pillar. The following section describes the Botanical Gardens and Greenhouse Collections as a study area, representing the thematic pillar. The final section contains an overview of the available software for producing map guides, representing the technological pillar. The concluding chapter describes the benefits which arise from the design and application of map guides as storytelling maps for students, teachers and public visitors.

Three-pillars concept

Creating a map guide for the botanical gardens was a complex process which required expert thematic knowledge across different disciplines, interdisciplinary cooperation and a combination of technical and educational skills. The overall educational contribution could therefore be defined as a triangle of educational, thematic and technological knowledge. In the present study, this three-pillar concept is based on participating disciplines (Figure 1):

- Educational pillar = skills required for presenting topics to a target group, communication skills in student groups and communication with botanical specialists as added value to the project,

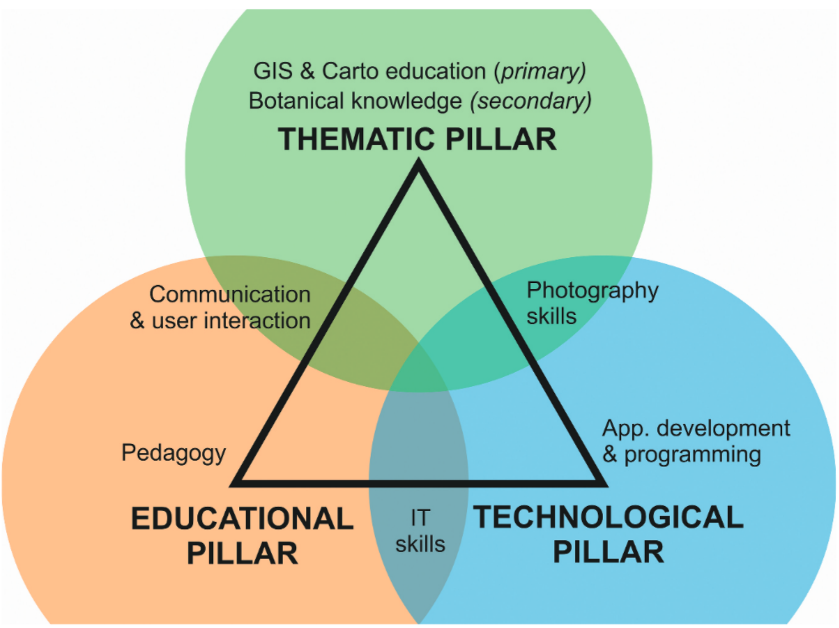

Figure 1. Three-pillar concept.

- Thematic (domain) pillar = professional thematic knowledge and previous learning in primary (geoinformatics, cartography) and secondary fields (botany, zoology, ecology, etc.),
- Technological pillar = professional technical knowledge in programming, application development, photography, computer science.

In the present study, we aim to demonstrate and verify the triangle of educational, thematic and technological pillars at the individual stages of creation of the map guide. This concept was defined according to numerous completed student and academic projects. In a long-term teaching collaboration with the botanical gardens, a sequence of several essential steps was established. These steps mirrored the three-pillar concept. In each of these steps, partial goals were achieved, supporting one of the respective pillars:

Educational Pillar

- Aim – concept design for the guide,
- Includes – data preparation, concept design, determination of the tone of communication and interaction, formulation of the concepts for guides which educate using non-conventional and more attractive forms,
- Requires – general knowledge from bachelor's studies, communication skills,
- Improves – pedagogical and educational skills.

Thematic Pillar

- Aim – Fieldwork at – field work in study area,
- Includes – long-term practice or short-term field exercises in the Botanical garden-botanical gardens, primary data collection in the field,
- Requires – thematic courses from bachelor studybachelor's studies (Cartography, GIS),
- Improves – knowledge in primary and secondary fields.

Technological Pillar

- Aim – development of storytelling maps,
- Includes – process of development, testing and launch of applications,
- Requires – specific courses from bachelor's studies (Programming, Web Technologies, etc.),
- Improves – knowledge in application development and programming.

In addition to the three main pillars, some skills obtained are complementary due to the intersection of pillars. The main concept is extended on the edges of the three pillars:

Edge of the Educational and Thematic Pillars

- Aim – design a comprehensible output,
- Includes – comprehending a topic, the ability to communicate knowledge further,
- Improves – communication skills and user interaction (soft-skills).

Edge of the Thematic and Technological Pillars

- Aim – extend a map using multimedia technology,
- Includes – comprehensive and detailed orientation in the study area,
- Improves – photography skills.

Edge of the Technological and Educational Pillars

- Aim – preparation and progression of the project in steps,
- Includes – orientation in the IT environment,
- Improves – general IT skills (hard-skills).

Educational pillar

According to De Fina (2016) "storytelling is usually regarded as a cooperative environment". The author primarily described the impact of a cooperative and competitive environment on the educational process. It is based on the relocation from "traditional" (indoor courses, individual learning processes, specific and narrow topics) to "non-conventional" (outdoor/field courses, in groups, multidisciplinary) educational processes within university courses. The authors illustrated that for suitably selected topics in certain university courses, the "non-conventional" approach could be beneficial.

Alterio (2002) confirmed that students who learn through storytelling and reflective processing of their own stories "develop skills that allow them to connect subjective and objective perspectives". Pilot studies conducted by students at Palacký University verified the effect of both subjective and objective elements. While the objective aspects covered botanical taxonomy and geographical location, the graphical design and technical implementation was affected significantly by individual skills. Bouchner (2016) argued that cognitive, psychomotor and affective goals can be achieved through storytelling. The highest level of Bloom's revised taxonomy of cognitive goals (Krathwohl, 2002; see Figure 2) is "create". This means composing elements into continuous and functional units. In the educational process, this must include all previous levels. When students perceive a story map, they recall previous knowledge to place it into context and apply it

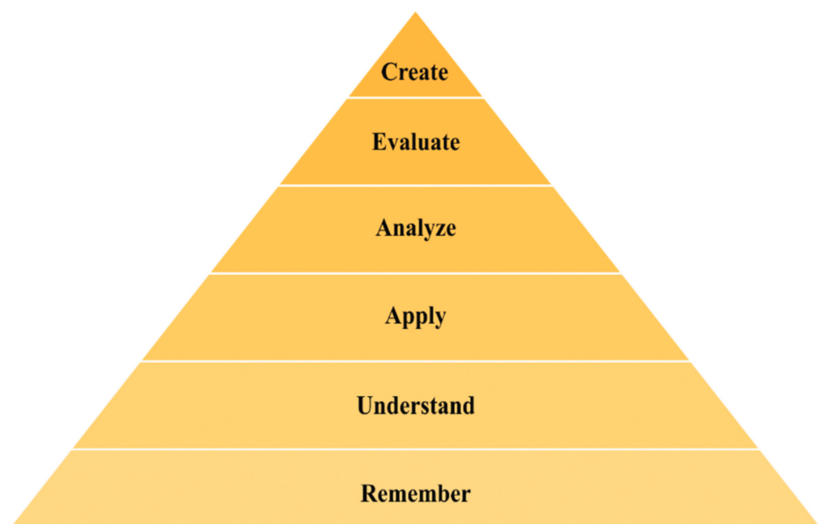

Figure 2. The story map concept covers all levels of Bloom's revised taxonomy of cognitive goals (Krathwohl, 2002).

appropriately. To master the task of creating a story map, they must understand not only the given story and topic but also be able to apply and analyse knowledge in the correct context.

Following the educational effect of the cooperative process (De Fina, 2016), the benefit of collaboration can be understood in two ways. First, collaboration between students groups is a fundamental educational tool. Competition between group members and between groups positively improves the quality of the study process. In their study, Bikse et al. (2013) motivated students through competition "to develop their skills and emphasise the practical side of the study process". A collaborative relationship was also established between the students and the botanical garden employees.

Students involved in the programme

The Department of Geoinformatics and Palacký University Botanical Gardens collaborate closely at several levels: both staff and students work on the BotanGIS project, academics have issued over ten academic publications, Geoinformatics students can develop semester projects, practice their field work in the botanical gardens or write their thesis on interdisciplinary topics (Hradečný, 2018). The findings described in the present article are based on student experiences of semester projects in the Web Cartography (KGI/WEKAR) course. The course is a full semester (13 weeks) and combines field work and web map application development on specific topics such as botanical gardens for the master's degree programme.

The educational pillar requires thematic courses from bachelor's studies. During a bachelor's degree, students acquire knowledge of GIS, cartography and databases, including map design and web application development. Experience in developing and creating GIS are not only applied to thematic courses (e.g., botany) but also several courses in geoinformatics and geography. The following list of sources are prerequisites for successful map guide creation: Thematic Cartography I, II (KGI/KART1 and KGI/KART2) are conducted as fundamentals in the first year and benefit students with experience in terrain measurement and drawing and creating themed garden layouts and greenhouses (Dobesova, 2012; Dobesova, 2017). Field exercises which focus on surveying also give students useful practical experience. The database's design, including the entity-relational model, is explained in the Database Systems course (KGI/DATAS) in the second year of the bachelor's degree (Dobesova, 2016). Computer science skills are acquired, for example, in Programming I (KGI/PRG1) and Web Technologies (KGI/WEBOT) in the same bachelor's degree. While bachelor's studies depend more theoretical courses, master's degree programmes focus on practical skills. Master's students therefore already know the methodology for map guide creation, and in Web Cartography, they combine field work with the development of real applications. The present article summarises the authors' experiences and pedagogical feedback from graduates over the three years of the Web Cartography course. Qualitative feedback was based on written evaluations of the course from 12–15 students each year.

Students at the Department of Geoinformatics do not have any mandatory botany courses in their study programmes. Generally, they would be considered typical public visitors to the botanical gardens and are probably the first visitors who use and evaluate the storytelling guides. Before our students graduate from the Web Cartography course, they are considered at the same relationship level as regular visitors. The present article primarily explores the educational benefits of the map guide development process. However, educational benefits can also be understood from a purely visitor's perspective.

Designing the guide's concept

The guide's design process falls under the educational pillar. Students are required to collect, process and combine different types of data appropriately to create a storytelling map. The main advantage of the story map concept is the combination of textual, multimedia and spatial information (Mukherjee, 2019). The map guide explores this concept to a deeper level. The author must also consider spatial and thematic continuity and thereby fulfil the general principle of storytelling. Selection of data and integration into the axis of the story requires communication skills and a respect for basic pedagogical rules such that the resulting application is comprehensible and intuitive to visitors. The target group includes novice botany students who are commencing studies at university, and the map guide is the first introduction to the botanical gardens. The map guide must convey information to a reader attractively, i.e. communicate with users and relate a story. Finally, the application must provide information which is relevant and correct (Egiebor & Foster, 2019).

Many communication aspects which ultimately affect the interpretation and educational role of the guide must already be taken into account during the design stage, i.e. graphic forms (warm vs. cool colours, saturated vs. muted colours, contrast), photo characteristics (detail vs. overview, quality), text and multimedia information (crowded text vs. blank text), composition and layout of individual features (map, legend, pictures, story axis), map background (inappropriate contrast), etc. This concept directly affects the communicative tone of the guide. Compared to other platforms, web solutions offer a unique communications relationship, i.e. interaction or two-way communication. While the guide conveys information to visitors for the purpose of education, the user can change the guide's behaviour and therefore educational experience through certain commands. Its general principle is also an awareness of fundamental pedagogical requirements. Students are confronted with linguistic issues such as language correctness, language style, effectiveness in conveying information and explaining the topic to readers, support for spatial imagination, support for basic geographical rules and information literacy. All the issues were discussed in student groups followed by discussion with instructors at each partial step during the creation of map guide prototypes.

Thematic pillar

A fundamental step in any multidisciplinary project is to become familiar with the issues, positions and secondary topics of interdisciplinary research. Following the concept of digital participation defined by Panek and Netek (2019) and increasing expertise in secondary disciplines beyond the minimum level is essential. Geography and geoinformatics students generally have a poor awareness of botanical knowledge, having only encountered biology in high school. In primary disciplines which are technically oriented, such as geoinformatics, informatics or cartography, establishing a basic knowledge of botanical garden and some aspects of botany is important. Specifically, this involves acquiring a fundamental knowledge of basic climate zones and greenhouse categories (tropical, subtropical, etc.), principles of plant naming (Latin taxonomy), botanical nomenclature (family, species, genus), awareness of the schemes and principles of descriptive information, and essentials of plant photography (habitus, detail, leaves, flowers, fruits). This type of information is not only essential in understanding the passport scheme mentioned in professional materials (as a source for further work) but also the BotanGIS database (described in the next chapter). Personal visits, field work, knowledge of the target groups and direct contact with a thematic expert especially are irreplaceable in the thematic pillar. Understanding the topic is a prerequisite in creating all the subsequent steps. Improving knowledge and skills in both primary (Geoinformatics) and secondary (Botany) thematic fields, therefore, is a key process in producing maps and directly affects the design of outputs, the process of communication between map and the reader, and interpretation and ease of use for the user.

From the point of interdisciplinary perspectives, a GIS integrates information from different disciplines. A GIS has the potential of being a mainstay cross-disciplinary educational tool such as the calculator or word processor (National Research Council, 2006). According to Hubbard et al. (2002), interdisciplinarity "helped foster better methods of thinking geographically and how to research geographic questions across the discipline – from human to physical geography". Rickles et al. (2017) argued that student knowledge can be fostered "through understanding disciplinary practices that govern the creation, validation, representation, interpretation and critique of geographical knowledge" which may be applied to specific domains and topics. Geography-oriented students have a clear idea about the spatial characteristics of data, but they lack a thematic consideration of complex comprehension. According to Albrecht (1998), a GIS can support interdisciplinary research since it "is able to integrate a variety of different data sources" and thus support researchers across disciplines in general. Kuhn (2012) and Rickles et al. (2017) illustrated spatially located information as essential across several scientific disciplines (e.g., climate change, cultural heritage, energy, water, natural hazards, health etc.). Interdisciplinary methods could improve both the student learning experiences and map outputs. Interdisciplinary projects enrich all source disciplines with new opportunities. Geoinformatics and botany are both enriched as source disciplines in the presented case.

Palacký University botanical gardens as the study area

The presented map guide covers the Palacký University Botanical Gardens and Greenhouse Collections at the Flora exhibition grounds in the city centre of Olomouc, Czech Republic. The botanical gardens are divided into several sections interwoven with paths. More than twenty flowerbeds are cultivated for various herbs and woody plants. The park area contains mature trees and two rockeries and ponds with vegetation. The botanical gardens are directly adjacent to the greenhouses.

The greenhouse complex is composed of palm, tropical and subtropical greenhouses which house tropical and subtropical plant species from around the world. The greenhouses are one of the top greenhouse collections in the Czech Republic. The palm greenhouse currently contains around 50 individual species of palm, and

160 other plants (Dancak et al., 2013). The foliage of some plants extends into the paths to give visitors the impression that they really are in the tropics. The plants in tropical greenhouse require either high humidity or a root system directly in contact with water. Almost half of the greenhouse area consists of ponds. The tropical greenhouse houses around 140 important tropical plants. A special showcase in this greenhouse displays rare species of orchid which require specialised care. The subtropical greenhouse contains 75 different plant species. Several plants in the greenhouse are considered productive citrus trees which fruit with either lemons, tangerines, persimmons or kiwis. The most significant exposition along the greenhouse route is a collection of carnivorous plants borrowed from Palacký University in the summer.

Both the gardens and greenhouses are available to university students for experiments and field work in botany. The area is also open to the public throughout the year, except in winter. Over the last fifteen years, teachers from the Department of Geoinformatics have collaborated to support the area with a geographical information system, digital plans and a plant database. The collaboration has produced a set of useful digital products, one being the botanical portal BotanGIS.

BotanGIS educational portal

The BotanGIS (Botanical Geographical Information System) is a unique botanical portal comprising an interactive database of the plants extended with geographical and spatial features (Figure 3). It has been in development since 2011 through the collaboration of botanical and geoinformatics specialists and lecturers at Palacký University in Olomouc. The BotanGIS can be found at the URL www.botangis.upol.cz.

The BotanGIS portal supports the specialised botanical education of university students. The database contains a detailed taxonomical categorisation and morphological description of over 1500 plants. Over 3500 photos supplement the information about these plants, depicting both the habitus and parts of plants such as flowers, leaves, fruit and trunks in different stages of growth throughout the year. BotanGIS is freely available to all students and not limited to botany students at the university. BotanGIS is designed especially for specialists, students and administrators in botanical fields. BotanGIS is listed as a source for map guide creation.

For the public, a presentation as a condensed story map is a more attractive and suitable option (Netek, 2014) which can also be used for botany students as an introduction before they commence field work in the first stage of botanical studies. Only some of the most interesting plants are therefore described in the map tour and accompanied only by a single photo. Finally, four separate story maps were created: three for the greenhouses and one for the botanical gardens.

Technological pillar

The development process covers programming and cartographic/geoinformatics skills. From a geoinformatics point of view, field work involving mapping spatial relationships and producing photographs supports the technological pillar, while botanical relationships (taxonomy etc.) support the thematic pillar. Only field research can instruct

Figure 3. The BotanGIS interface – plant database (left) and details of the plant (right).

students on the overall positioning of greenhouses and their individual sections, pathways and garden areas. A combination of direct (primary) and remote (secondary) mapping procedures can be applied to self-targeting and mapping for use in geoinformatics and cartographic outputs. Secondary mapping involves collating map sources, such as older map plans or aerial photographs.

Although the botanical gardens already contain detailed information from previous work with the Department of Geoinformatics, students conducting internships at the university are required to perform a three-week field exercise at the botany campus. This period has proved sufficient for students to become acquainted with the environment and learn essential knowledge. Students also concentrate on updating the digital data for missing or new plants and correct the base plan through field measurements (Figure 4). Primary data is recorded using a specialised GPS-based application which allows spatial data to be collected on portable devices such as tablets. Updates are recorded and stored directly in the spatial GIS database. An indisputable benefit of field mapping is the process of obtaining original photographs. These serve students both as a foundation for professional botanical studies and as multimedia components for improving the attractiveness of the map guide. Although captions to photographs are a minor step in the entire process, this task falls under and combines basic technological skills (how to capture a photograph) and an overview of botany (what to display in a photograph). The three-week internship conducted directly at the greenhouse collections has been described by students as “an ideal way to understand the functioning of the entire greenhouse system, their distribution, interconnections and significance.”

Development of storytelling maps

Storytelling maps are effective tools for communicating and visualising complicated ideas and large amounts of information in an organised, user-friendly interface which target a specific audience or lesson (Cope et al., 2018). Teaching with storytelling maps can enhance spatial thinking, which is anticipated as a pathway to success in many scientific, technological, engineering, and mathematics careers (Kerski, 2015). A modern GIS allows the creation of interactive map applications with various features. Storytelling maps combine modern web technologies and cartography with geographically-based data for education and communication (Dodge et al., 2009). These types of map are tools for creating, customising and sharing web maps with custom content. Unlike other map applications, these tools emphasise intuitive means of expression and effective methods of conveying information to the reader. This allows the use of multimedia (photos, graphs, videos, animations) and attractive graphic presentations. Users can combine their textual content with multimedia components for an enhanced experience (Netek et al., 2013). The main benefit is in geographically localising all descriptive and multimedia information on the map (Mukherjee, 2019). Storytelling maps also support visualisations for time components. This allows the researched area to be imagined effectively and the topic to be presented attractively; simply, this method is based on proven methods in school learning. Storytelling maps also support visualisations for time components.

Storytelling maps are used to create and publish interesting stories concerning specific areas of interest. A map describes an area of interest and is therefore the combination of

Figure 4. Students surveying to create a base plan.

a story and a map. One of the most common applications of a storytelling map is presenting a route from point A to point B, with several stops along the way; for example, a vacation route augmented with photographs of specific locations. This type of example can be used as a guide for other travellers (Evans & Esri'sStoryMapsTeam, 2020). Another example is a map which details the spread of large forests fires over time. A specific example describes the volcanic history and artefacts found on the Methana peninsula (Antoniou et al., 2018).

Several tools are available for creating storytelling maps. Each tool differs graphically, functionally and in its use in teaching. Significant storytelling map tools are listed in Table 1. The described pilot study was developed under the Esri Story Maps environment.

The development process was preceded by an equally important step in selecting a technical solution for creating the storytelling maps. The currently available platforms which support storytelling map creation are described in the previous chapter in Table 1. The comparison in the study verifies that all the solutions possess the same default properties, i.e. display of a story in the form of a timeline or route and a series of stops or chapters linked to a map field. They differ in how individual stops, background maps and graphic designs are presented, especially in functionality. The choice of a suitable solution is limited by several aspects which primarily relate to educational and thematic aspects: the size and character of the displayed area, graphic design and the integration of individual map data. The technological aspect is limited by the abilities and skills of the

Table 1. Comparison of storytelling map solutions.

Application	Technology	Data format	Functions
ArcGIS StoryMaps	ArcGIS online	Each format supported by ArcGIS online	Single story-builder, flexible layout
Esri Story Maps	ArcGIS online	Each format supported by ArcGIS online	Six display styles: Map Tour Map Journal Cascade Map Swipe/Spyglass Basic
StoryMapJS	JavaScript or template editor	Cannot upload spatial data	Four storytelling styles: Juxtapose Soundcite Story map Timeline
Odyssey.js	JavaScript API	Cannot upload spatial data	Three map styles: Scroll Slides Torque
Google Tour Builder	Google maps	KML and KMZ files	Multimedia data, images and videos can be uploaded into Google Photos, YouTube or directly from a computer
TimeMapper	TimeMapper editor and Google spreadsheet	Google spreadsheet	Three display styles: Time map Timeline Map

developer, which can, however, be subsequently eliminated (through tutorials and help files, self-education, and developer exchange).

The main concern in the present case study was the limit on scale and zooming. Because the greenhouses cover a small area, the storytelling guide had to be displayed at maximum zoom. The combination of the requirement to build a large-scale wizard and the integration of our own data could only be addressed using Esri Story Maps. The other applications are more suitable for medium and small scales, typically for storytelling at the level of cities, countries or continents. The choice of technical solution is affected by the objective parameters of the educational and thematic pillars, while the technological pillar is directly affected by the knowledge, skills and experience of the author involved in the development stage. These individual aspects may be limited by the maximum potential use of the selected solution.

Pilot study

For the pilot study, four guides were created from pre-prepared map layers, descriptions and photographs: Palm Greenhouse, Tropical Greenhouse, Subtropical Greenhouse, and Palacký University Botanical Gardens. The application is available online and follows a responsive design. Optimisation for display on mobile phones and tablets is a fundamental aspect of the user experience (Netek et al., 2015). The webpage entrance "Map Guide for the Greenhouse Collections and Botanical Gardens" contains links to each sub-guide (Figure 5) and can be found at the URL http://botangis.upol.cz/storytelling/.

The virtual tour route and stop numbers of the map guide correspond to the real route along which visitors are guided during a walk through the greenhouse. The plants for the guide in our case study were selected by an expert botanist. In other cases (e.g., arboreta, zoos or botanical gardens where tour routes are not fixed), interdisciplinary collaboration between geoinformatics and botanical specialists is important in determining optimal routes. Plants were selected carefully in cooperation with the greenhouse manager before the map guide was designed. Plants and objects that would hold greater interest to visitors were emphasised. A suitable number of stops was considered to ensure visitor attention was not overloaded.

The map guide includes 52 of the most important and attractive plants. Eighteen records were selected from the palm greenhouse and include *Phoenix Canariensis*, the largest palm in the greenhouse, *Beaucarnea recurvata*, known as an elephant's foot or ponytail palm because of its thick trunk, and a *Ficus Religios*, known as a Bhodi tree. More than 35 plants were considered on first inspection in the tropical greenhouse, but only 15 plants were recorded on the map. The tropical greenhouse is undoubtedly dominated by the *Victoria cruziana* plant, which is a water lily with giant leaves resembling enormous trays. Younger visitors especially may find the banana tree *Musa acuminata* at the end of the greenhouse fascinating. Also interesting are the distinct species of vine which form several lobes directly above the visitors. Nineteen plants were selected from the subtropical greenhouse for the guide and are evenly distributed throughout the tour.

A preview photo, the relevant continent as a map icon, Latin and Czech taxonomy, accompanying text, and a link to details in the BotanGIS database were assigned to each

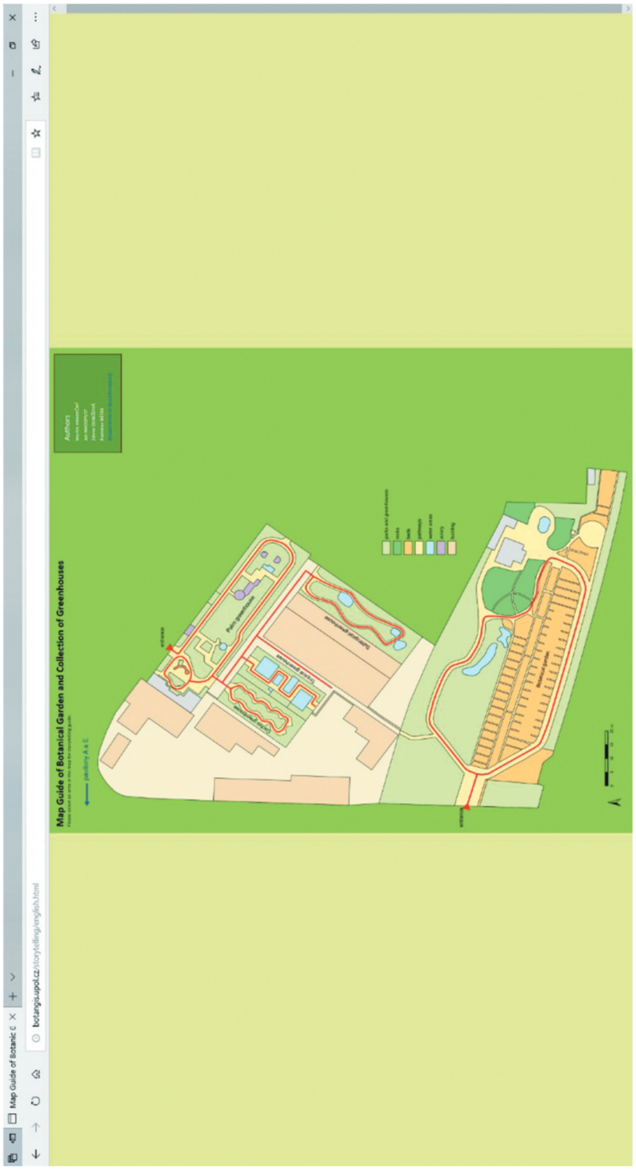

Figure 5. Online webpage entry to the four map guides.

Figure 6. Storytelling maps of the Palacký university botanical gardens in one of the four guides.

plant in the guide (Figure 6). The numeric labels on points are highlighted with colour which represent a cartographic aspect. Plants from Africa are displayed with a red icon on the map, green represents European plants, blue represents American vegetation, and Asian & Australian species are indicated in violet. In a specially determined workflow, the students must already be acquainted with the topic and locations according to the thematic pillar, ideally from the field research mentioned in the previous chapter.

The botanical gardens differ from the greenhouses in two aspects. The first aspect is the absence of fixed visitor routes, and the second aspect is the much larger range due to the presence of buildings, ponds, trees, rocks, benches and other specific objects such as insect hotels. The original proposal to include the most interesting plants would have required selecting hundreds of specimens (stops). The notion was rejected since the guide would have become unnecessarily complex and lost its educational significance to the target group (visitors) and may, in fact, have discouraged users. Fourteen stops were selected in the botanical gardens. These stops include the most attractive trees, such as the *Tilia cordata* near the entrance, some bushes, the central plant beds, the rock garden, two ponds populated with vegetation, and the wooden insect hotel. The final selection was discussed at an interdisciplinary level with the administrator of the botanical gardens.

Educational benefits to authors and visitors

Storytelling maps are a modern alternative tool for conveying information about conventional topics. According to De Fina (2016), storytelling in general is based on two roles: the narrator and the audience. Since the educational impacts of the narrator and audience are completely different, their educational contribution can be seen on two levels. The first level is the benefit to the application's authors. The second level is the benefit to the application's users, i.e. the audience. A three-pillar concept can be applied to both groups, and both cases involve a multidisciplinary overlap, but each group needs to be viewed separately.

Students as authors

Egiebor and Foster (2019) defined four methods of engagement: generating inquiries, visualising information, mapping interactively and cycling topics in stories. As mentioned above, the overall educational contribution according to the present study is based on three pillars which combine thematic, educational and technological knowledge as described by Egiebor and Foster. The workflow described requires following a specific sequence of steps. While respecting the proposed workflow, students increase their level in each pillar by working through the individual stages.

The field work stage primarily involves the acquisition of knowledge in secondary fields, in this case, botany. Students can navigate botanical nomenclature and selected plants and become personally familiar with the greenhouses and botanical gardens. We cannot discuss increasing primary expertise in cartography and geoinformatics since it is usually a routine GIS operation. However, interdisciplinary collaboration, in this case between juniors and seniors, can certainly be considered another benefit. A secondary benefit is the acquisition of knowledge in producing botanical photographs. The main communication and pedagogical effect can be observed in the conceptual stage. The student is confronted with the question of how to comprehensibly explain professional topics outside their primary interest. Determining a communication strategy and respecting basic pedagogical rules undoubtedly raise pedagogical quality, especially for students from non-pedagogical disciplines. An effect on soft skills can also be observed (presentation, communication, grammar), which are often marginal in technical fields. The technological pillar is based on hard skills, such as general IT skills, but especially on specific development and programming knowledge.

Qualitatively, the overall educational effect on the author of storytelling applications may be assessed as high. The novelty of creative methodology and an enjoyable social context produces great enthusiasm in students. In a mapping study which engaged playfulness, Pánek and Pászto (Pánek et al., 2018) confirmed that "an exploration of processes incorporated into a more playful pedagogy are a testimony to authors and students in multidisciplinary fields". However, it should be mentioned that from the point of view of quantity, the value is debatable. The number of students involved are only a few units per year, and the resulting educational effect is also significantly affected by the ratio of mental skill in each pillar. In practice, the authors of the study identified an inclination towards one or two workflow stages, according to the individual preferences of students. However, the ideal assumes a balance of all stages. Determining a balanced workflow presents a challenging task to teachers.

Students as visitors & public visitors

The strategy in thematic, educational and technological knowledge for visitors must be specified. In the technological pillar, strategy is limited to passive use of technologies, such as tablets and mobile phones. Leaving aside interaction with the map, we cannot discuss the active role of the user in this pillar. It is assumed that the primary thematic impact should be to raise awareness of botanical topics. In non-botanical disciplines, students appreciated more the aspects of mobile device platforms, identified plants according to images, and connected with GPS or story maps in attractive formats, all which indicates the suitability of a multidisciplinary approach. By contrast, botany students appreciated the BotanGIS system as an alternative to teaching materials in paper form. A complete taxonomy and passport in combination with the photo gallery was considered the direct pedagogical effect of the entire survey. Generally, for younger students, the secondary pedagogical aspect was support for spatial imagination, geographical rules and information literacy.

Conclusion

Story mapping as a "more than visual" form is based on a combination of interdisciplinary fields (e.g., geoinformatics and botany) and combination of different media types (text, multimedia, maps) to increase user attention. The aim of the present research was to verify the potential of storytelling concepts for educational purposes. The present article described map guide design and development in a case study of the Palacký University Botanical Gardens and Greenhouse Collections in Olomouc. The concept can be used retrospectively by map creators to act as either narrator in describing situations that have already happened or directly as a teacher who guides students through unexplored territory. The process of creating a map guide and the experience gained from teaching allowed the authors to compile a more general view of the issue of practical teaching. Drawing on several years of experience in interdisciplinary courses at Palacký University in Olomouc, Czechia, we defined the educational benefit of story maps in terms of a triangle of thematic, technological and educational pillars. The thematic pillar represents field work in botany, the educational pillar represents the design of the guide's concept, and the technological pillar represents software application development. Collaboration in all three pillars was essential for the successful creation of an attractive storytelling map for the botanical gardens. The output of our case study is available online as a group of four public map guides built according to the storytelling concept. As each pillar increases student knowledge and awareness in a specific field, the combination of three pillars has an overall educational impact. Supported by student feedback, our experiences call to mind the use of more attractive educational methods than conventional methods for young people, such as storytelling. These methods can aid students to understand research at deeper, more complex, and individual levels.

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