Construction kits for teachers: implications for design

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Abstract

This paper is about the ways constructionist software can shape and integrate design and the learning experiences. In particular, the experience of designing a constructionist kit is discussed and how it has been used to produce microworld instances. Based on the constructionist environment E-slate, a construction kit is produced relating geocoded components to historical facts. The kit, called Making Stories with Historical Facts (MaStoHF), presents synchronously spatial and temporal information together with other relevant information. It affords visualisation of historical facts of any kind, e.g. from creating art artefacts to local history, environmental innovations and scientific publications. The presentation of such information allows learners to visualise important events of a specific kind on a map and on a timeline not only realising its spatiotemporal dimensions but also accessing its context and learning to pose relevant questions. The paper identifies critical design decision parameters based on reflections from engaging teachers and pre-service teachers in the process of designing microworld instances.

Keywords

Constructionism in teacher education programs, Constructionist classroom experiences,

Introduction

When designing constructionist environments, it is of vital importance to provide learners with opportunities for examining their existing knowledge and structures that will enable them to reorganize their current models of thinking about the world and/or construct new models. It is also important for learners to develop competencies for communicating, exchanging, defending, proving, and justifying their ideas to the classroom. However, these types of tasks place a high cognitive demand on the learners.

Construction kits can provide useful tools for students to expand their understanding and make sense of new information. Students are given much more task management responsibility (Perkins, 1992) when they get engaged with construction kits, that is, prefabricated parts or processes they can use to ‘build things’ with. Interpretations of experience therefore become focal points and learners can elaborate and test those interpretations. Since learners are not expected to receive and store information, information banks become less central and are replaced by toolkits, sets of modular parts that students can use to generate new meanings and artifacts.

With constructionist kits, learners are empowered to take on more responsibility for task management than in conventional instruction. This shift of responsibility is necessary for students to become autonomous thinkers and learners. However, many students are not used to managing their own learning and so the teacher has to provide help and guidance to them in order to motivate and engage them in learning (Mulholland et al., 2012). Moreover, research in socio-constructionist perspectives and human and digital didactical support (Kynigos, 2007; Hoyles, Noss & Kent, 2004) suggests that working in groups can be of particular help to the students as opposed to individual learning experiences and supporting the whole classroom.

Essentially, a construction kit takes over some routine aspects of performing the task. It frees up processing resources that task performers can then use to perform the problem-solving aspects of the task (Norman, 1993). The most important considerations and theoretical notions have been incorporated in the construction kit, so that users do not have to deal with these issues themselves (Perkins, 1992). A construction kit should thus direct learners' attention to core aspects of the task and translate the routine aspects into prefabricated processes and parts. Furthermore, it should invite users to actually do things and not bother them with peripheral issues that can be dealt with later. Then, it provokes learning-by-doing and fosters inquiry based learning. For example, laying the facts on a map pinpoints to the geographical distribution of the scientific inventions or local environmental history, which could be elaborated further by queries expressing a personal standpoint.

A platform for designing construction kits

E-slate is an authoring environment which is not only based on the constructionist paradigm through building component configurations, but also on the connectivity metaphor, providing authors with multiple metaphors for connecting and thinking about component connections. E-slate projects are large – labor processes focusing on the idea of a custom desktop environment enabling users to hook up components and access their functionality in differing degrees.

Designing with the authoring environment E-slate follows a black and white box approach (Kynigos, 2004; 2007) in that it provides components as higher – order building blocks to construct software consisting of component configurations (black box). Components are black boxes in that the user cannot alter their main functionality and in that they are developed primarily to be technically efficient. These components are designed to be as generic as possible. On the other hand, it allows for specific components to be explored and manipulated, enabling inter-subjective exploration. Through the design of transparent (white-box) digital artifacts learners can construct and deconstruct objects and relations and have a deep structural access to the artifacts themselves (diSessa, 2000; Resnick et al, 2000). This white-box metaphor for construction and programming has generated a lot of creative thinking and involvement in learners mainly in informal educational settings.

The challenge is how this constructing – connecting combination can support creativity in building software. In designing construction kits, in particular, the challenge is where to draw the white box – black box line. This challenge, called 'principled deep structure access', involves decisions on where to draw the access line in favor of technical efficiency and higher – order functionality constructions. In essence it allows the designer to make decisions on what is important or not in the learning experience and to decide for the less important issues for the learner. The designer therefore breaks down into further constituent parts in order to gain higher order building blocks and learners can create interesting efficient software in a more focused way.

To address this challenge, a set of activities have been emerged that include:

- component architecture design and development, that is the generic E-slate environment
- software design and development of components

- secondary development of component configuration (authoring with E-slate)
- construction kits (e.g. MaStoHF)
- activity design and development (documented microworlds)
- collaboration with schools and school support
- teacher education
- research involving classroom and teacher seminar observation, tests and interviews

Focusing on the 3rd-5th set of activities, this paper discusses how secondary development of component configuration evolved to construction kits as well as activity design and development. In particular, the research team of ETL configured a set of components in order to relate geocoded data to historical facts. This configuration allowed the design of a construction kit that resulted in a number of instances of diverse educational content, e.g. history of art, place-based local history or scientific inventions. This configuration is considered a construction kit since it provides a set of components together with their connectors which teachers and learners can use to 'build things' with. They are also sets of modular parts that students can use to generate new meanings and artifacts. Some of these components can be omitted or extra can be added; new relationships can be created, each of these actions generates a new artefact (microworld) to play with.

Therefore, a new constructionist artifact is generated to be used by teachers and learners. For teachers to tailor the kit to their needs and those of their students, they should think of the theme of interest in new abstract ways that relate both to relevant information and the questions learners can pose. A critical issue here relates to the type of rules the kit affords: rules do not need to be logic-based but they can be value-labeled supporting reasoning beyond mathematical processes. Teachers, thus, not only need to collect information around a theme of interest but they should differentiate among rules of how this information can be used for meaning making. Learners, on the other hand, can visualize information in novel ways, generate questions and interpret answers that cultivate their reasoning, facilitate story-telling, and extend their understanding.

Why making stories with maps

Using space to structure problems, defining questions, finding answers, and expressing solutions (a skill called spatial thinking) requires a constructive combination of concepts of space, tools of representation, and processes of reasoning. By visualizing relationships within spatial structures, learners can perceive, remember, and analyze the static and dynamic properties of objects and the relationships between objects (Committee on the Support for the Thinking Spatially, Committee on Geography, 2005). Geospatial data can enable students and teachers to practice and apply spatial thinking in many areas of the curriculum and develop critical thinking skills that are central in science, the workplace, and everyday life (ibid). Therefore, spatial thinking plays a significant role in the information-based economy of the 21st-century.

Furthermore, geospatial understanding is developed greatly through narratives and there is a need to develop knowledge representation and reasoning techniques to help meaning and story making about a place – independent of its size (e.g. Europe or my neighbourhood). Creating stories out of geospatial data is rich in domain semantics and difficult for non-geography experts, like a primary teacher, to be expressed in formal language that a constructionist medium may require. Stories are usually expressed in everyday vocabulary with linguistic and cultural interpretations that need to be formalised into database descriptors, tables and queries. The research question therefore lies to the decisions that need to be made around the role of the technological tool in developing understanding, the elements to be discussed among learners and the activities to be designed by the teacher for the class.

Presenting the Construction kit

A construction kit called Making Stories with Historical Facts (MaStoHF) is being designed to address the need for developing spatial thinking skills as well as the ability to make stories out of a series of events. The construction kit consists of the following components and their connections:

- Map
- Timeline
- Database
- Other descriptive components, like photos, text, table etc.

These components allow the visualization of geocoded data, aiming to assist exploration and understanding. The visualization is specified both by temporal and spatial dimensions (Figure 1). The learner can zoom in and out of the timeline, choosing the period of interest, e.g. from 500 BC to 1700AC or from 1950-1975 AC or specific maps, e.g. Globe, Europe and Italy. Such visualization allows for exploring collocation and concurrency in the first instance.

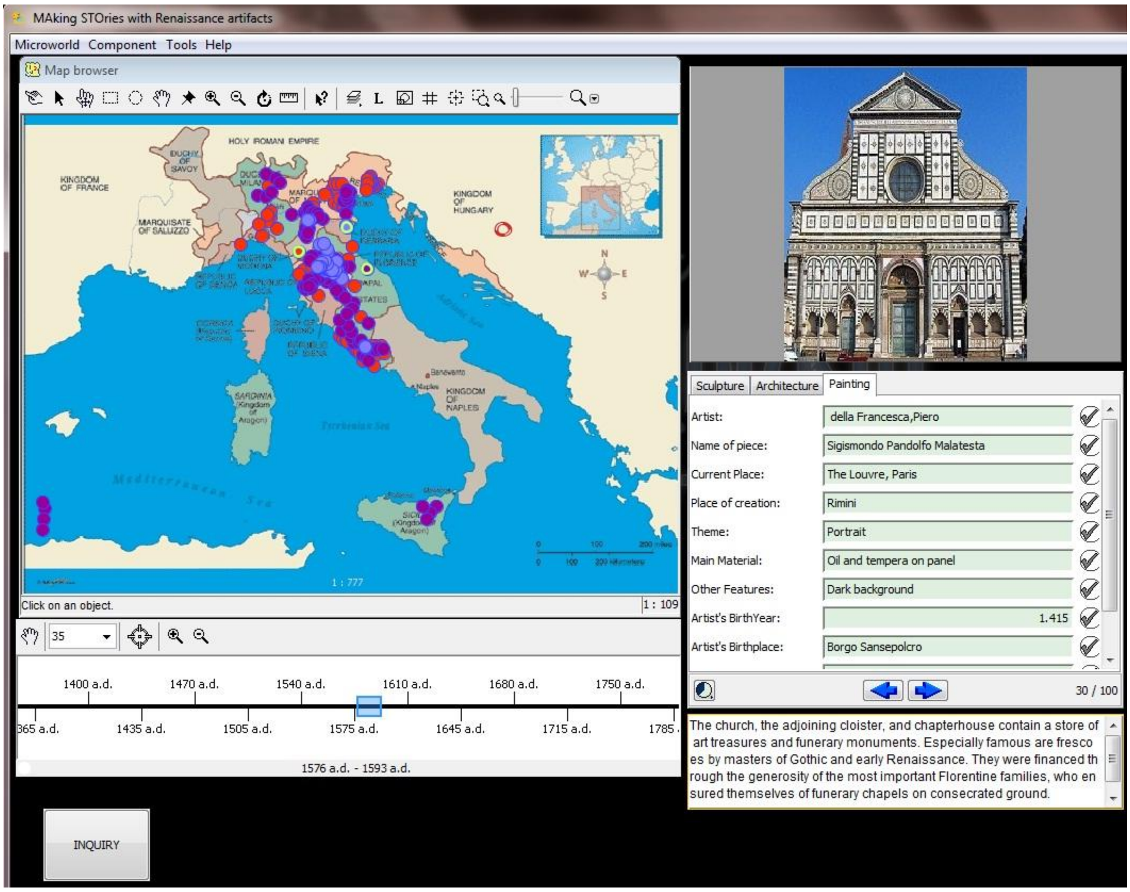

Figure 1: A screenshot of a MaStoHF instance relevant to Renaissance artefacts. This view shows the visualisation of geocoded data with temporal and other complimentary information.

Furthermore, MaStoHF allows the learner to explore the dataset based on queries with logical operators (Figure 2). With such queries the learner can question, express and test hypotheses, allowing for rapid inquiries either planned by the teacher or spontaneously occurred by learners. Such queries provide learners with a powerful tool of dataset exploration that facilitate the ability to ask relevant questions and engage in problem solving processes.

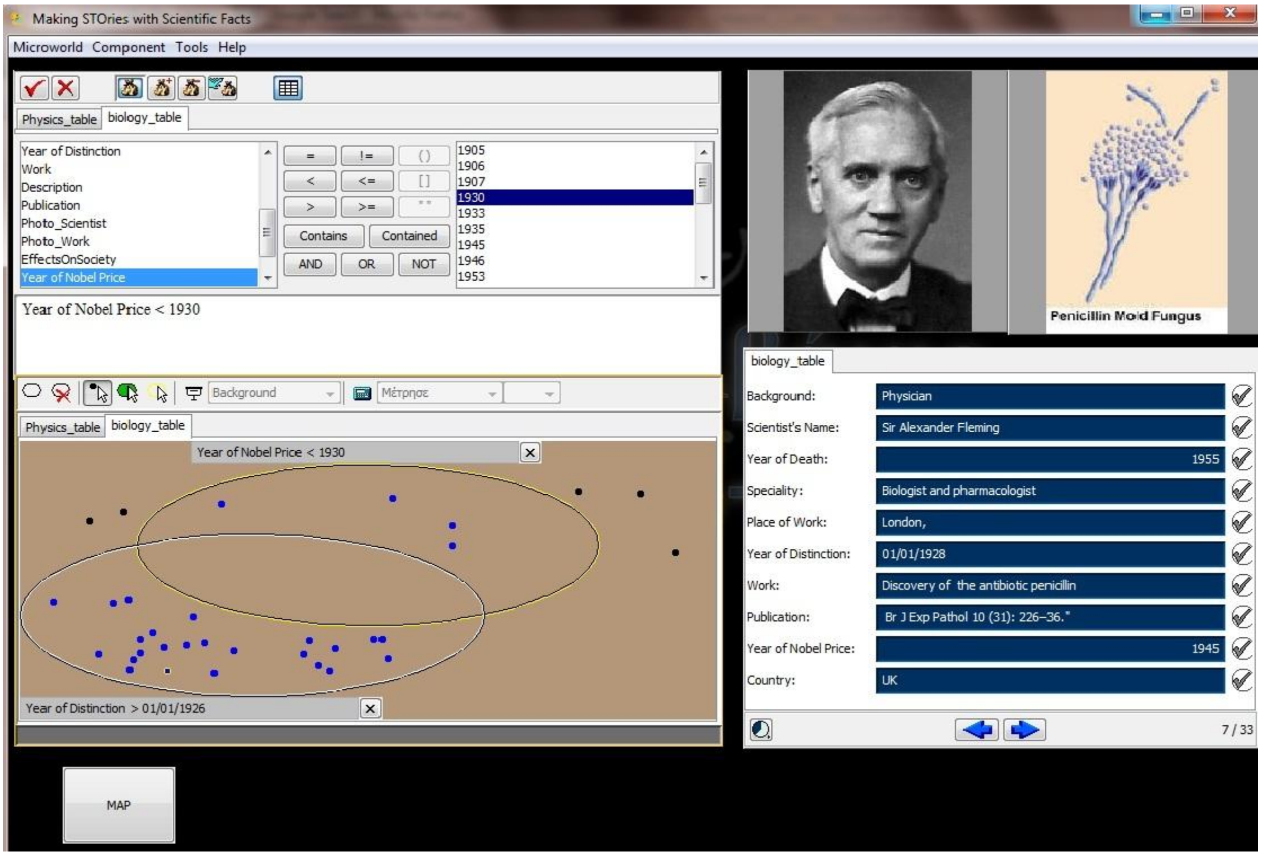

Figure 2: A screenshot of a MaStoHF instance related to Scientific Innovative Facts. This view shows how inquiries can be carried out by learners.

Designing with MaStoHF

Our aim was to explore how such a construction kit would enable teachers and prospective teachers in developing curricula based on active explorations of geocoded datasets. Having developed a template where the basic components are already available, the teacher needed to tailor the template to their particular curriculum needs. Three in-service teachers devoted time and effort as part of their postgraduate training. Based on our experience of supporting those teachers, we identified critical design decision parameters that influence the process of designing MaStoHF microworld instances (Table 1).

These parameters are closely related and they are going through iterative phases. For example, fields may specify how the facts will be told but at a later phase, and facts may notate which fields need to emerge. Below, we analyze each parameter by relating MaStoHF design decisions to questions related to scenario design.

Designing the database

A fact is an entity that is represented by information in a database. Depending on the specific context, a fact may be specified through text, images, audio, mind maps or videos.

All facts are gathered in a database directly associated to the map. The database should contain information relevant to the fact that is chosen to be of significance. Therefore specifying the database fields is of paramount importance. Fields specify the information that adequately describes a fact. They categorize the semantic information and specify the type of queries the learner will be able to ask at a later phase. Therefore an important question that the teacher-designer should address is 'What elements (descriptors) of the story are important?'.

Design parameters	Related questions
Designing the database	What elements of the story are important?
Choosing the fact	What is the main element that the story will be based on?
Specifying the story	What parts of the story should be stressed through the system? What parts of the story is to be discussed in class? What parts of the story are to be explored by the learners?
Setting and testing hypothesis (Inquiring)	

Table 1: The main design parameters

Choosing the fact

The collection of facts specifies the wealth of the dataset. When choosing the way to describe a fact, the teacher designer should focus on the unique element around which the story will evolve. For the history of Science, for example, the fact can be the innovation that was awarded with a Nobel price. This unique element and its characteristics influence the fields of the database within an iterative process where the story descriptors denote the unique fact and then the fact specifies the descriptors.

When deciding on the unique element of the story, the teacher-designer decides on the perspective of the story as well as the significance of some events against some others. For the place-based local history scenario, for example, the fact could be for example the erection of specific buildings in a civic environment (Anastopoulou et al., 2012). Such a fact focuses on particular uses and the effect of citizens' related social needs not only on the image of the city but also on its overall function, ecological balance, and perceived quality of life. Such a decision denotes that facts around changes in the landscape or disturbances of the flora and fauna become less relevant. Therefore an important question that the teacher-designer should address is: 'What is the main element that the story will be based on?'

Specifying the story

The narrative construction starts from the decisions of teacher-designer but with MaStoHF, it is going to be extended or further specified by the students. In particular, the teacher-designer can decide on the following questions that also specify the degree of students' freedom.

- What parts of the story should be stressed through the system?
- What parts of the story is to be discussed in class?

- What parts of the story are to be explored by the learners?

Setting and testing hypothesis (Inquiring)

The narrative construction is further developed when learners enter a query into the system. Queries are formal statements of information needs, in order for example to find which facts are collocated or happening concurrently. For the query to make sense, it should not identify only a single object in the collection. Instead, several objects may match the query, perhaps with different degrees of relevancy. Queries are matched against the database information so that learners can explore elements of the dataset. The matching facts are presented as dots in different colors. Learners can identify which fact refers to the dot by clicking on it- pre-defined information is made available to inform them.

Learners can structure the similarities and differences between concrete concepts through a Venn diagram. A Venn Diagram is a visual organizer used to compare and contrast concrete concepts. Venn Diagrams are made up of two or more overlapping circles that sometimes interlap. One circle is for comparing, the other circle is for contrasting and the overlap is for the similarities. Learners can inquire around descriptors of each fact, visualizing similarities, differences and other comparisons. For example, in a scenario around scientific facts, learners could run queries around the time elapsed between publishing scientific innovations and receiving the Nobel price (Figure 2).

Critical questions for the teacher-designer refer to the activities that would facilitate students to try out meaningful comparisons that would engage them in fruitful interactions and debates with their peers.

Conclusions

For learners to be responsible for communicating their ideas to the classroom, they need to create and respond to opportunities to make sense of the information at hand. Construction kits can empower learners to take on more responsibility for task management by directing their attention to core aspects of the task and translate the routine aspects into prefabricated processes and parts. In designing construction kits, however, the challenge is where to draw the white box – black box line, in other words, for the teacher-designer to make decisions on what is important or not in the learning experience and to decide for the less important issues for the learner.

This paper discussed how secondary development of component configuration of a constructionist platform evolved to construction kits as well as activity design and development. By designing MaStoHF, a set of components were configured in order to relate geocoded data to facts with a temporal dimension. In essence, it related spatial thinking skills to narrative construction based on geo-temporal data. It challenged teacher-designers to think of stories usually expressed in everyday vocabulary but formalise them into database descriptors, tables and queries. This challenge led to design decisions on their behalf around the role of the technological tool in developing understanding, the elements to be discussed among learners and the activities to be designed by the teacher for the class.

Based on the experience gained from supporting in-service teachers develop MaStoHF instances of diverse educational content, we proposed a set of design decision parameters. These parameters are in particular: designing the database, choosing the fact, specifying the story, setting and testing a hypothesis. These design decision parameters relate directly to questions for the teacher-designer around the ways to facilitate and engage students in fruitful interactions and debates with their peers.

In the future, we are interested in finding out how students in real settings engage in active explorations of geo-temporal datasets based on the curricula that their teachers developed. We envisage that visualizations that allow exploration of collocation and concurrency as well as setting and testing hypothesis, provide learners with a powerful tool of dataset exploration that facilitate the ability to ask relevant questions and problem solving.

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