VISUAL STORYTELLING APPLIED TO EDUCATIONAL
WORLD STATISTICS

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Abstract: The paper focuses on the most ancient of social rituals: “storytelling” – exemplified through telling a geovisual analytics story about a country’s development over time and shape the measure of economic growth and well-being, applied in an educational setting to 1) customize a geovisual analytics application for educational purpose, 2) improve the teaching in social science and 3) study teachers and students experiences and learning. Our tool “World Statistics eXplorer” with a database link to the public World dataBank with more than 400 indicators for 1960-2009 will help to improve the students knowledge and understanding of a variety in national demographics, healthcare, environment and economic structures and their performances over a longer time period. Teachers might be able to, individually and together, develop a dynamic teaching material about the progress in the world through storytelling accessed on the Web. Students will be able to, with help of powerful geographical statistics, explore statistical relations on their own. A better understanding of how educators and their students can elicit deeper user understanding and participation by exploiting dynamic web-enabled statistics visualization is of importance. Together with the associated science of perception and learning in relation to the use of multidimensional spatio-temporal statistical data this will contribute to the research fields of geovisual analytics as well as educational science.

1 INTRODUCTION

A well-educated young population is central to the social and economic well-being of regions and individuals. Education plays a key role in providing young people with the knowledge, skills and competencies needed to participate effectively in society. Official statistics is a rich and important source of information and have therefore an important role in education. Official statistics published with geovisual analytics (Andrienko, 2010) may help to improve and even change the terms and structures for learning about our society. What impacts will this have on the young generation?

Official statistics are statistics published by government agencies or other public bodies such as international organisations. They provide quantitative or qualitative information on all major areas of citizens’ lives, such as economic and social development, living conditions, health, education and the environment. Official statistics can be found on web sites of national statistical agencies such as Statistics Sweden (www.scb.se) and international organisations such as the OECD (www.oecd.org/statsportal) and the World Bank (www.worldbank.com). These are producing what is often called information overload. Statistics have often an unfortunate image of being boring – even though some of us know that they are in fact fascinating and exciting. Do teachers know about existing public statistics and its potential for a more engaging education? – Probably not sufficiently. Can they find them? – Not as easily as statisticians tend to think. And if they eventually get to them, do they actually understand them in such a way that they can use them in their educational activities? These are issues that are dealt with in this study. It concentrates on how to give our teachers innovative tools that can make national and regional statistics
interactive visually understandable and useable to students.

We build upon previous research (Jern, 2010a and 2010b) including our web-enabled application Statistics eXplorer a platform that is emerging as a de facto standard in the statistics community for exploring and communicating statistics data.

In this paper we introduce this innovative platform for integrated statistics geovisual analysis, collaboration and publication process facilitating storytelling aimed at producing statistical educational content in support of an automatic authoring process. The author, in this case a teacher, should simply press a button to publish the gained knowledge from a visual interactive discovery process to let the students then interact with the visualized content. We exploit our latest research focusing on the most ancient of social rituals “storytelling” - telling a story about a nation’s development over time and shape the measure of economic growth and well-being. Discoveries that more engagingly draw us into reflections about the knowledge on how life is lived - and can be improved – compare nations and local regions and in addition let the student dynamically participate in this process. The effectiveness of educations rests in many ways upon educators to empower their students to become effective learners and knowledge creators (figure 1). Therefore this paper also gives a report of an empirical study of implementing the tool into an educational setting for teachers and students use.

Figure 1: The role official statistical data can play in education. World eXplorer showing fertility rates vs. population age 0-14 in three linked views map, scatter plot and histogram.
The platform’s storytelling mechanism is initiated (figure 2) for teacher to: 1) access statistical data from the World dataBank database through a direct API interface; 2) explore and make discoveries through trends and patterns and derive insight - gained knowledge is the foundation for 3) creating a story that can be 4) shared with colleagues and reach consensus and trust. Visual discoveries are captured into snapshots together with descriptive metadata and hyperlinks in relation to the analytics reasoning. The teacher can get feedback from colleagues then adopts the story and 5) finally publishes “tell-a-story” using a “Vislet” that is embedded in educational blogs or HTML pages providing students with an interactive visual learning experience. With the ubiquitous availability of geovisual analytics the time has come to explore the possibilities for educators to incorporate these tools into a variety of subject courses and teaching practices (Kinzel & Wright, 2008). The potential for educators to harvest these powerful tools, to present and explore scientific data sets, ought to be offered and in focus for further investigation.

We think that interactive tools for teaching such as GIS, visualization, computer models and animations that allow the educator and the student to manipulate the environment and the outcome of the learning process are effective for learning (Solem, et al. 2009). There are research and usability testing of geovisualization tools, but there is a lack of studies of young students learning processes. A better understanding of how educators and their students can learn by and elicit better user understanding and participation by exploiting these tools is of importance.
We are implementing these tools – geovisual analytics – applied in social science – to help and engage educators to communicate progress initiatives, measuring economic, social, educational, health and environmental developments to young students to

- Examine the students’ development of knowledge and understanding by using visual analytic storytelling methods in an educational setting
- Investigate teachers experiences when using those methods
- Contribute to further development of geovisual analytics for educational purposes according to the pedagogical findings.

The study is delimited to investigate this in all public junior high schools in one municipality in Sweden. The tool will be introduced to teachers and their students (age 13 – 15 years) in social science.

Volumes of official national and sub-national statistical data are today generated by statistics offices all over the world and stored in public databases such as the World dataBank but not used as effectively as one would wish for. Research has, up to now, focused on tools that explore statistical data while methods that communicate and educate understanding and knowledge with clarity, precision, and efficiency has not achieved the same attention.

Publishing official statistics through assisted content creation with emphasis on visualization and metadata represents a key advantage of our storytelling and probably has a potential to transform conditions and structures for learning.

Little focus has been given to make geovisual analytics technologies useful and accessible to educators and advance visual presentation to students. Nor has research in any greater extension yet, tried to on uncover and specify factors that encourage or discourage deeper understanding or learning with multi external representational tools (MERs) like the geovisual analytics offer (Ainsworth, 2006).

World eXplorer may promote the educator in the task to translate information to be learned into a format appropriate to the learner’s current state of understanding (figure 3). As far as instruction is concerned, eXplorer will support the educator to encourage the students to discover principles and consistency by themselves. The educator and students then might be supported by the tool to engage in an active dialog (i.e., Socratic learning). The content should be organized in a spiral manner so that the student continually builds upon what they have already learned (Bruner, 1966). This builds upon the idea of learning as an active process in
which learners communicate and construct new ideas or concepts based upon their current/past knowledge (Vygotsky, 1986). The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so. A cognitive structure (i.e., schema, mental models) provides meaning and organization to experiences and allows the individual to "go beyond the information given (Bruner, 1973) in order to accomplish this, geovisual analytics must try to make connections between knowledge the learner has and the knowledge being taught. An interdisciplinary research in cognition and geovisual analytics includes therefore pressing research questions and theoretical perspectives.

2 SYSTEM IMPLEMENTATION

Statistics eXplorer is based on our in-house developed component toolkit adapted for Adobe’s Flash basic graphics and does not require installation of any other software and will run anywhere. The toolkit facilitates innovative methods from information and geographical visualization such as the choropleth map, dynamic histogram, table lens, parallel axes plot “profile plot”, scatter plot, time graph, and pie and time glyphs, flow map (trade and migration) applied and customized for statistics data. Interactive features that support a spatial analytical reasoning process are applied such as tooltips, brushing, highlight, visual inquiry and conditioned statistics filter mechanisms that help detecting outliers. Data are normally preloaded with a set of basic indicators such as demographics, economic indicators, education statistics etc. but the user can also load external data through optional database interfaces such as SDMX, PC-AXIS or other API solutions to be mixed with preloaded data (figure 4). In order to detect complex patterns it is convenient to view statistics data through a number of different visual representations simultaneously (figure 3), each of which is best suited to highlight specific features. Any filtering, highlighting or colouring made in one of the linked views is transmitted to all the others.

Figure 4: Statistics eXplorer provides an open data architecture for flexibility. This data interface is based on a programmed API to the World databank.
The conceptual data model for our Statistics eXplorer platform can be seen as a data cube with three dimensions: space, time and indicators (figure 5). The spatial dimension is represented by the regions and the indicators are various indicators (GDP growth, elderly dependency rate, etc). Time is the period or point in time to which the data refer. The general method for finding a value in the cube is by its position (space; time; indicator) or (where; when; what) and fast access time is essential for motion graphs. Space-time-indicator awareness means that the data cube can be analysed and visualized across all three dimensions simultaneously.

### 3 STORYTELLING AND PUBLISHING

The use of geovisual analytics have in many ways revolutionized the way we are able to experience and explore our world. A primary target group for our storytelling is the educators and their students. By introducing the use of this tool in their process of learning and knowledge construction they got the opportunity to discover and take advantage of what this technology offer. Our geovisual analytics supplies possibilities for the educator to orchestrate the educational planning and teaching. The World eXplorer platform (World eXplorer, 2011) is customized from our Web-enabled GAV Flash class library (Quan, 2011), programmed in Adobe’s object-oriented language ActionScript and includes a collection of innovative geographic and information visualizations adapted to statistics data handling.

Storytelling, in our context, is about telling a story on a subject, based on statistics, and related analytics reasoning about how gained knowledge and understanding was achieved. Storytelling is supported by an innovative mechanism in the visualization toolkit that supports the capture and storage of interactive events through “memorized interactive visualization views” or “snapshots” that can be captured at any time during the explorative data analysis process in World eXplorer and represents an important task of the authoring analytical reasoning process. Publisher is the application tool that imports a story produced by Statistics eXplorer and generates the HTML code that represents the story with selected regions and associated indicators. The HTML code is then inserted into a blog or web page (figure 6).
Figure 6: The teacher (author) uses Statistics eXplorer to first import statistical data, explore and make discoveries through trends and patterns and derive insight. A teacher's understanding is then the foundation for creating a story where visual discoveries are captured into snapshots together with descriptive text and finally publishes "tell-a-story" to the students using a “Vislet” that is embedded in a web document that now becomes an interactive learning experience.

3.1 Storytelling

Storytelling within a participative web context, could more engagingly draw the user into exciting reflections and sometimes change a perspective altogether. The story is placed in the hands of the students as an interactive guided learning experience with attached descriptive metadata. For example, the teacher can attach external web links to relevant information important to achieve a more complete understanding of the lecture. Visual storytelling is in this scenario an approach of telling more vital and engaging stories to the students through interactive web-enabled visualizations (figure 7).

Figure 7: Visualization components available for composing a Vislet.
3.2 Snapshots

Exploring and making sense of comprehensive statistics data requires a coherent cognitive workspace where our discoveries for organizing and navigating can be maintained. The GAV Flash toolkit includes such means by capturing, saving and packaging the results of a World eXplorer “gain insight” process in a series of “snapshots” that could help the analyst to highlight views of particular interest and subsequently guide other analysts to follow important discoveries (figure 2). The snapshot tool creates a continuous series of visualization captures during the exploration process that form the foundation for a story (figure 8). In a typical scenario the teacher selects relevant attributes for a snapshot, e.g. time step, highlighted regions for comparisons, class values for colour legend, filter inquiry conditions for selected attributes and finally highlights the “discoveries” in the world map view from a certain angle.

![Diagram of GAV Flash Visualization Components](image)

Figure 8: The snapshot tool creates series of visualization captures during the exploration process that form the story.

The teacher requests a snapshot with the Capture function in the Story Editor (figure 2) that results in a snapshot class operation scanning through all active connected views for properties to be captured. Each of these properties will then be parsed into XML and written to a file that also contains details on which data (indicators, time and geographical regions) was used and a unique name for each component. When a snapshot is activated, the saved state of the snapshot class will then be read from the XML file and parse its nodes back into component properties again. The previously marked properties will be applied and set the state of the application (figure 9).

![Example of two snapshots embedded in the story metadata](image)

Figure 9: Example of two snapshots embedded in the story metadata.
3.3 Publisher and Vislets

Publisher is the application tool that imports a story and generates the HTML code that represents the story and metadata that the teacher selected using appropriate visual representations for the story e.g. map, scatter plot, histogram, time graph etc. (figure 7). This HTML code can manually be copied and finally pasted into a web page or blog. The story is then transformed into a Vislet and can be opened in the reader’s Web browser and dynamically communicate the story. A Publisher server maintains the Vislet flash (swf) files together with a story repository, statistical data and regional shape maps.

A Vislet is a standalone Flash application (widget) assembled from our low-level toolkit represented by, for example, a single map view or a composite time-linked map, scatter plot view and histogram view (figure 10). The Vislets run locally in the client’s Flash Player and can thus achieve dynamic interactive performance. A Vislet facilitates the transition of selected statistics into communicative sense-making news entities with integrated metadata and interactive time animated visualization that could engage the student. The innovative storytelling technology could advance research critical to education using digital media and enable a leap in understanding by the students, so as to enhance the overall learning progress.

Figure 10: Example of an interactive educational document based on public World dataBank indicators with educational text, map, motion chart, snapshots and time series – the methodological concept. For an interactive experience of the educational tool and teaching material click on the link; http://visletblog.blogspot.com/2011/01/ageing-population-in-europe-and-japan.html.
4 EMPIRICAL STUDY AT PUBLIC JUNIOR IN SOCIAL SCIENCE CLASSES

With a major interest in studying human understanding and learning within complex technology mediated learning environments our paper builds on a number of analytical concerns and assumptions. The study has a socio-cultural perspective on learning (Vygotsky, 1986) together with perspectives on the significance of visual aspects on learning (Gibson, 1969). Three concurrent factors ought to be considered when studying a learning process in a socio-cultural perspective; 1) how do intellectual tools develop, 2) how do the use of physical artefacts develop and 3) what does communication and cooperation look like in human collective contexts (Säljö, 2008). The methodological position of the study is therefore also connected to the growing body of video based studies of social interaction in contexts where technologies are used (Heath & Luff, 2000).

The empirical study was according to the theoretical starting points carried out in the actual school context of public junior high schools in a municipality in Sweden. Altogether 100 students at the age 13 – 15 years (grade 6 – 9) were involved. The study was divided in two different phases. In phase one, the teachers were introduced to the tool and made educational plans according to the curricula, organizing the content and the task by involving use of the Statistics eXplorer platform and its storytelling methods for exploring demographics indicators. This means that educational plans - Vislets were produced based on indicators from the World dataBank concerning the period from 1960 – 2009. The Vislets were published at the teachers own educational blogs on the internet. In phase two the students worked with the interactive Vislets reading the stories and interacted with a map and scatter plot (figure 6), (figure 11), (figure 3).

Figure 11: The educator’s creation of educational plan starts with choosing data from the World dataBank according to content concerning the educational goals. The selected data are possible to import directly into the Statistics eXplorer platform. The educator can orchestrate the data/indicators by using the platform’s storytelling functions to produce a story. This story can enclose different representations as, text, snapshots and hyperlinks to the dynamic linked views or to other blogs or websites. The educator creates and prepares in this stage her own educational material. To publish this material the educator uses the publisher tool. This tool transforms the educational material into a Vislet (HTML-code) that with a copy and paste function is possible to publish on a blog or a web page. Now the student can interact with the Vislet which is accessible from any computer. The student has a customized learning opportunity and can start the learning process and knowledge creation.

During these two different phases the aim was to investigate following research tasks:

- How do conceptual and perceptual factors interact in learning with different representations?
- How does learning differ with presented or constructed representations?
- What are the costs and benefits of learning with interactive or dynamic representations?
- What are the conditions under which learning is enhanced by combining textual and graphical representations?
Our interdisciplinary case study was built upon two different main research areas “technological development of the geovisual analytics tool” and the “educational context of students learning process” when using this tool. Within the later context a Usability study has earlier been carried out to examine the effectiveness, efficiency and user satisfaction. The results from this research show that the storytelling methods are usable within the school. The tool seems to be exiting, understandable and useful even for young students. It is efficient to students, it support their searching and the apprehension of connections between different kinds of statistical indicators. The user satisfaction among students was extensive at least used as brand new tool – the long lasting effects are however unknown (Stenliden & Jern, 2010).

Interaction analysis (Jordan & Henderson, 1995) and the DeFT framework (Ainsworth, 2006) will be used for the analytical concerns in the case study presented here, this to clarify the pedagogical functions that a multi external representations (MERs) like this tool serve and in so doing, consider the ways that a multi-representational system has in impact upon the process of learning and comprehension. The results from the case study here presented will hopefully give some of the unknown answers.

5 CONCLUSION

Within an international perspective our research builds on collaborating work with OECD since 2008 and we have supplied advanced and innovative statistics geovisual analytics technology to this organization http://stats.oecd.org/OECDregionalstatistics/. We have also been involved in the development of the PISA 2009 profiles: http://stats.oecd.org/PISA2009Profiles/ and Vislet at: http://www.ncomva.com/?page_id=873. The national Italian bureau ISTAT provides another very interesting and sophisticated learning material http://noi-italia.istat.it/ produced with our Statistics Publisher about the development and progress in Italian regions in (figure 12).

Another user is the European Commission that have used Statistics eXplorer for internal analysis of data from Eurostat.

The research concerning the learning perspective as presented in this study is highly requested from the international research field of learning and instruction (for example European Association Research of Learning and Instruction). The special interest group (SIG2) of comprehension of text and graphics inside this research field, focuses on how learning is influenced by the form of representation that learners study.

Figure 12: ISTAT – the Italian national statistical bureau has developed this innovative web site Statistics Publisher providing an interesting example of a sophisticated learning material.

Focus has historically been on text and picture comprehension but given the explosion of representations made available since the introduction of graphical interfaces, the field now considers all forms of representation including but not limited to, text, pictures, graphs, diagrams, concept maps, animations, equations, virtual reality, information and scientific visualization, haptics, multimedia, hypermedia, and simulations.

Research on learning, when using these aids, is essential. There is research of learning with multimedia environments in different experimental studies but there is hardly any research done of this in real school contexts i.e. in a socio cultural perspective. In Sweden there are hardly any studies considering didactic within social science education in schools.
The educational application presented in this paper can be evaluated at: http://www.ncomva.se/flash/explorer/wbapi/#

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