Visual Storytelling – Knowledge and Understanding in Education

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ABSTRACT

This paper presents an ongoing research project of use and learning with geographic information visualization and Visual Storytelling (geovisual analytics) in education. The fully developed study will be applied in school settings in order to 1) customize the application for educational purpose, 2) improve the teaching in social science and 3) study teachers and students experiences and learning. - The application "Open Statistics eXplorer" will be used to improve the students knowledge and understanding of sophisticated statistical relations, - Teachers will be able to, individually and together, develop a dynamic teaching material through storytelling, through 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. Results from an usability study in this project are promising. Together with the associated science of perception in learning in relation to the use of multidimensional spatio-temporal statistical data this research will contribute to the research fields of geovisual analytics as well as educational science.

Keywords: Geovisual Analytics, Storytelling, Geographical Statistics, Interaction, Learning, Social 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 may help to improve and even change the terms and structures for learning about our society.

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 (SCB) [18] and international organisations such as the OECD [14] and the World Bank [22]. 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.

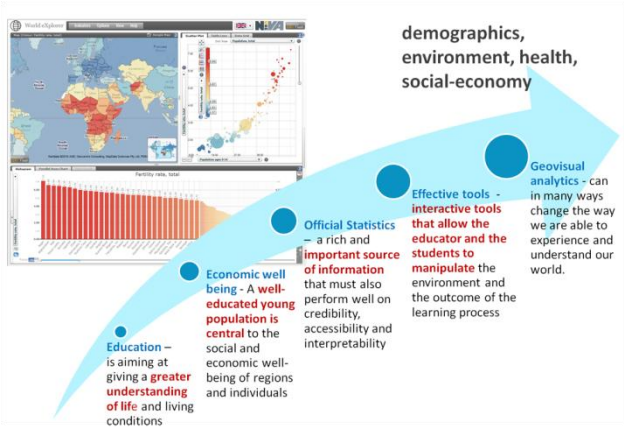

Figure 1 *The role official statistical data can play in education. World eXplorer showing fertility rates vs. population age 0-14 in three linked views map, scatter plot and histogram.*

We build upon previous research [8] including our web-enabled application *Open Statistics eXplorer* [9] a platform that is emerging as a de facto standard in the statistics community

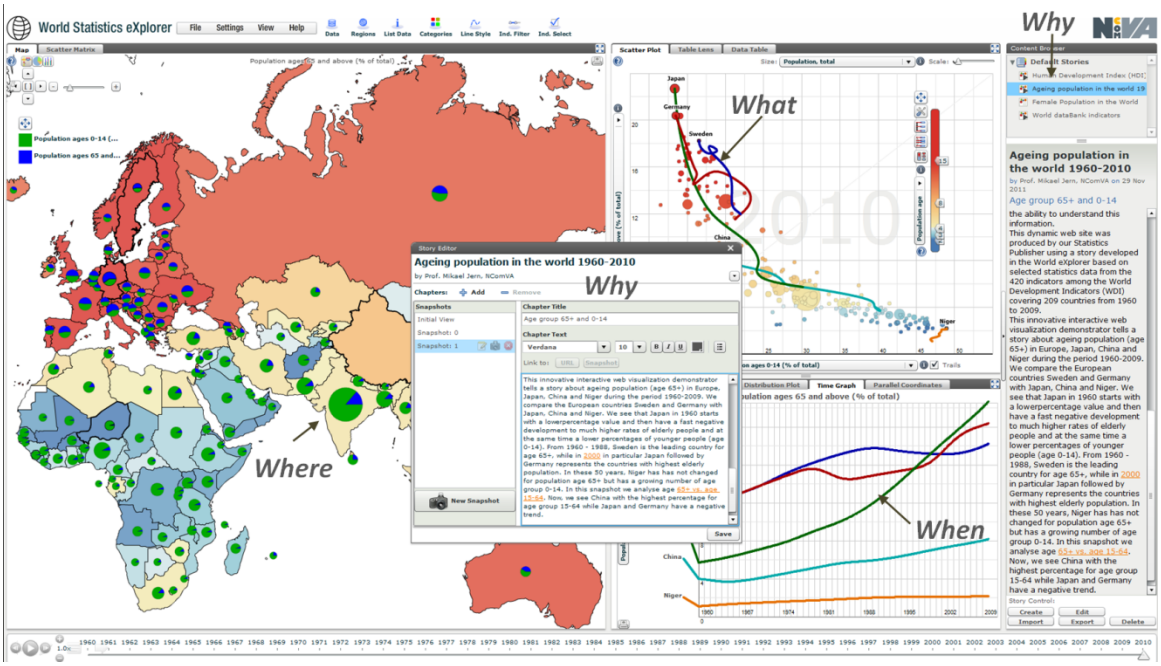

Figure 2 *http://www.ncomva.se/v4/world/alt.html#story=1; World eXplorer based on the geovisual analytics concept "Where-What-When-Why" based on 3 time-linked views showing a worldwide ageing population during 1960-2010; map (age 65+), scatter plot (age 65+ vs. age 0-14) and time chart (65+); comparing 4 countries Nigeria, South Africa, China and Italy. The story is published to the right side and includes linked snapshots. Users learn that central Africa maintains a high fertility rate (Nigeria), while South Africa starts in 1960 at the same level but then has a reduced trend. The users can interact and change indicators to discover reasons behind this trend and knowledge. Notice the Story Editor with the list of snapshots to the left and the associate metdata to the right.*

or exploring and communicating statistics data (figure 2). 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 region's development over time and shape the measure of economic growth and well-being. The storytelling gives opportunities to find 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.

A storytelling mechanism is initiated (figure 3) for the teacher to: 1) import statistical data; 2) explore and make discoveries through trends and patterns and derive insight - gained knowledge is the foundation for 3) create 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 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 [12]. The potential for educators to harvest theses powerful tools, to present and explore scientific data sets, ought to be offered and in focus for further investigation.

2. AIM

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 [17]. 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.

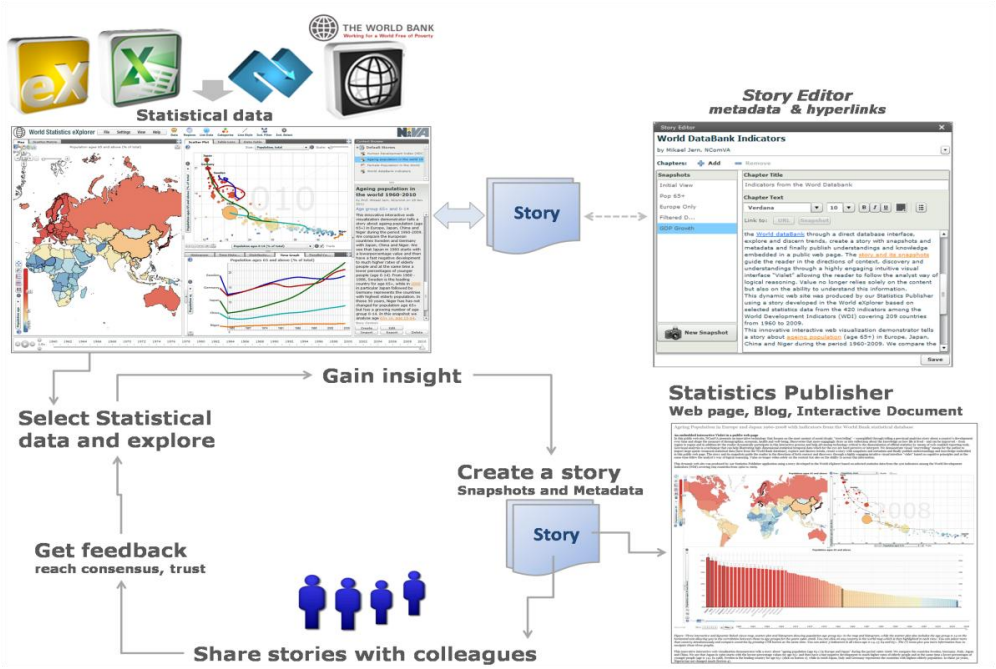

Figure 3 *The teacher is the author in this storytelling loop.*

3. RELATED WORK

Volumes of official national and regional statistical data are today generated by statistics offices all over the world and stored in public databases such as the OECD *Regional database* [13] but not used as effectively as one would wish. 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 uncover and specify factors that encourage or discourage deeper understanding or learning with multi external representational tools (MERs) like the geovisual analytics offer [1].

There is research on learning with MERs which has shown that when learners can interact with an appropriate representation their performance is enhanced. The issue is not anymore if a multiple external representation is effective or not, but about the circumstances that influence the effectiveness of MERs [6]. There are a number of design factors that should be considered when addressing aspects of learning with MERs, not only including the focus on the form of the representational system. A deeper understanding of learning environments with multiple external representations can best be reached by also considering the functions, the cognitive tasks as well as the learner itself [2].

Geovisual analytics 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. As far as instruction is concerned, the tool 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 [3]. 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 [21]. 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" [4]. 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.

4. THE OPEN STATISICS EXPLORER PLATFORM

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 will have 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 Open Statistics eXplorer platform [10] is customized from our Web-enabled GAV Flash class library, programmed in Adobe's object-oriented language ActionScript and includes a collection of innovative geographic and information visualizations adapted to statistics data handling. Figure 4 shows a seamless integration of a teacher authoring tool, storytelling and publishing interactive education documents for official statistics and it is based on:

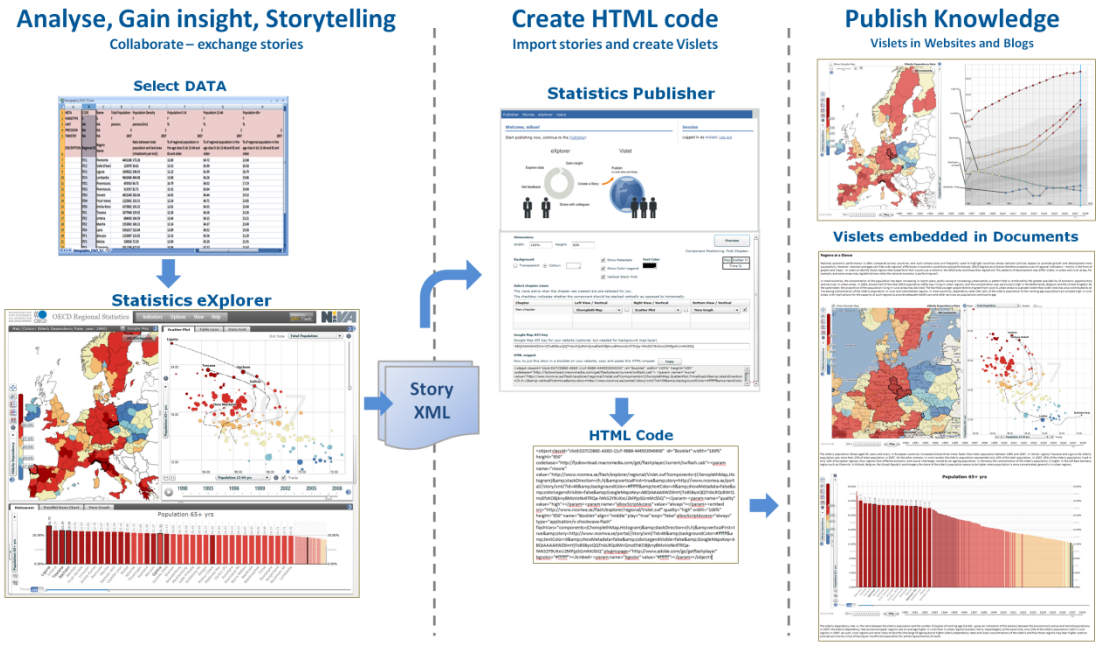

Figure 4 *The teacher (author) uses Statistics eXplorer to first import statistical data, explore and make discoveries through trends and patterns and derive insight. A teachers understanding is then the foundation for creating a story where visual discoveries are captured into snapshots together with 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.*

- ***Authoring***: data provider (spreadsheet and database); data manager; visualization methods (choropleth map, scatter plot, table lens, histogram, parallel axes plot, time graph, data table); coordinated and linked views; map layers; analytic tools (dynamic query, filter operation); regional categorization; profile plot; highlight regions; motion charts; dynamic colour scale and legend.

- ***Storytelling***: snapshots capture mechanism; story editor; metadata with hyperlinks for analytical reasoning; import and export a story.

- ***Publisher***: create Vislet (widget); generate HTML code of selected visualizations used in a story (map, scatter plot histogram etc; embed HTML code in web pages, wikis or blogs.

The methodological concept offers the educator to:

- ***Choose educational content***: According to what content the teaching deals with statistical indicators and related geographical regions (countries, counties, municipalities etc) are uploaded to the platform.

- ***Use the multiple linked views*** to simultaneously explore the content and highlight trends and knowledge through:
  - An interactive map: possibilities to different interactive features that support a spatial analytical reasoning process such as tooltips, brushing, highlight visual inquiry and conditioned statistics filter mechanisms.
  - A motion chart: also offer the interactive possibilities to find patterns, connection and discover outliers among the indicators as well as show time series.
  - Time series: give opportunity to dynamically show indicators development over time.

- ***Produce an educational document***: the educator can express (in her own language) a descriptive text and point out important spotlights of the content/indicators or even provide questions for students.

- ***Create snapshots: in the educational text*** *the educator is able to* highlight different content and a link is created to the interactive map or motion chart.

5. THE EDUCATIONAL DOCUMENT

The educational text constitutes an interactive document embedded as a web document based on a wider storytelling concept where the Vislets, play the role of images and figures. This concept adds another depth to an education book by making diagrams interactive, allowing the student to reach a deeper understanding and further explore the subject. Readers can play animations, change indicators and view more details on specific interactive views. One such publication where an interactive document has supplemented the normal paper version is OECD Regions at a Glance (RaG). This report now has an interactive version where selected chapters have been transferred from the static publication into an interactive state and published on the web (figure 5). The author created stories and snapshots from the RaG data, wrote new or edited existing text and collected interesting links. The stories where used to create chapters in the interactive document, where visualizations reside together with the text, relevant links, the corresponding chapter in the publication as a pdf and access to the source data. The main benefit of making the educational material interactive is that it enables the reader to interact directly with the data that is of interest, and also see the variation over time using animation. The teacher can choose snapshots that are of particular interest, but the student can still interact with the visualization and change the indicators and select what they find interesting, and thus enhance the user experience. Another example is SCB's interactive Statistic atlas, http://www.scb.se/statistikatlasen. This is visualizations of official statistical data from SCB:s database on a national level.

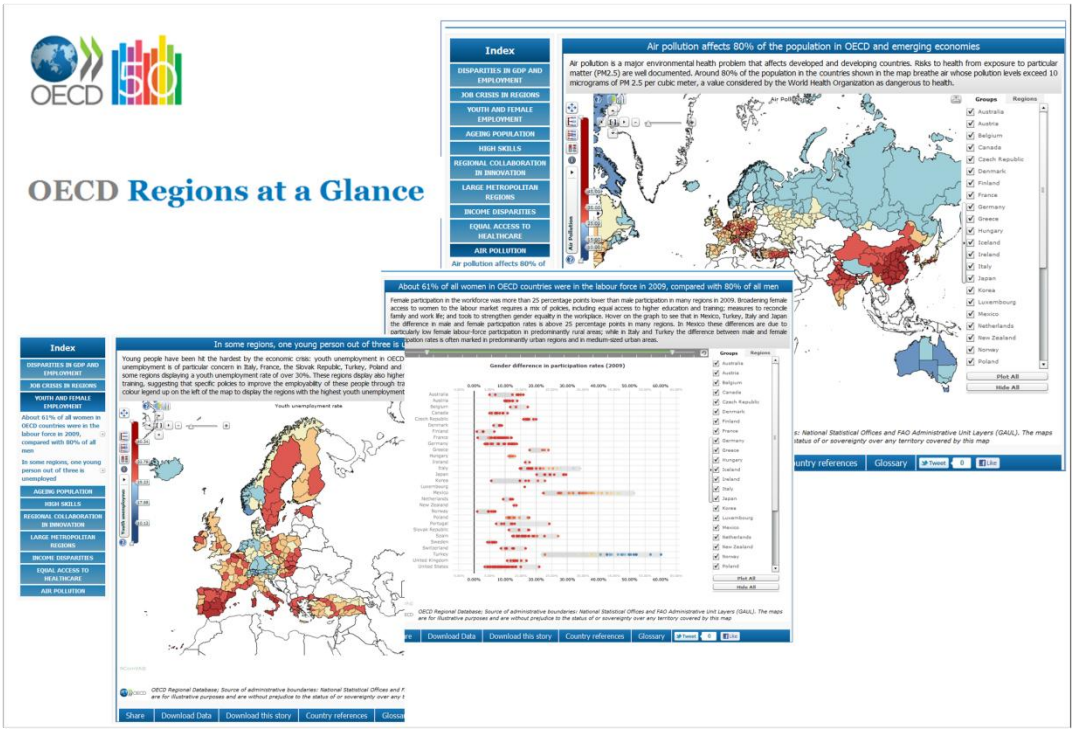

Figure 5 *Example of an interactive educational document based on public OECD data with educational text, map, motion chart, snapshots and time series – the methodological concept. For an interactive example of the educational tool or teaching material click on the link; http://rag.oecd.org/*

6. METHOD

This research project is interdisciplinary and includes several different studies. There are two different main research areas contributing, the technological development of the tool and the research of using the tool in an educational context.

Theoretical starting points

With a major interest in studying human understanding and learning within complex technology mediated learning environments the research builds on a number of analytical concerns and assumptions. The research has a socio-cultural perspective on learning [21] together with perspectives on the significance of visual aspects on learning [5]. To study a learning process in a socio cultural perspective three concurrent factors ought to be considered; how do intellectual tools develop, how do the use of physical artifacts develop and what does communication and cooperation look like in human collective contexts [19], [20]. The methodological position of the study is connected to the growing body of video based studies of social interaction in a context where technologies are used [7].

Design

The studies within the educational research context are all applied in school settings. The research methods are mainly qualitative. The projects status: 1) a pilot- and a usability study of the tool have been accomplished and were carried out in one single class in an elementary school. 2) a study of students' learning with geographic information visualization and Visual Storytelling has been conducted in three different primary schools, this study is in its analytical phase. 3) right now a study at all public junior high schools in a municipality in Sweden have been set up, in order to 1) customize the application for educational purpose, 2) improve the teaching in social science and 3) study teachers and students experiences and learning.

Procedure

To address the aims and issues outlined above, the ongoing study have been introduced to teachers in the participating schools, educating students at the age 13 – 15 (grade 6 – 9) in social science. They have been invited to take part in the study together with their students. The study is divided in two different phases, where phase one is completed. In this phase the teachers have been introduced to the tool and they have by the storytelling functions, the Open Statistics eXplorer offer, been able to produce educational material. The stories have been published on the teachers own educational blogs on the internet as Vislets. The students are, in the ongoing phase two, working with these interactive Vislets. At this stage a group of 4 – 6 teachers and their students have been randomly selected for participation in a detailed oriented research phase. Within this group 1) Questionnaires will be used to measure the student's performance 2) Video observations will be done to follow the students work 3) Speak aloud interviews will be carried out to investigate the student's understanding and learning. The teachers in the group will be interviewed both individually and in group and they will be asked to do notes in a log.

Ethical considerations

In all the different studies, the ethical issues are taken into account by asking for consent to realize the data collection by the participating teachers, the students and their parents. They are all informed about the study, the voluntariness of the participation and that the involvement could at any time be terminated.

Implementation and lingering effects

To control and implement the study initial seminars and workshops have been held. Development of education, training-courses and support has been arranged. Support for implementation in the educational setting as well as technical support has been offered to all teachers using the tool. The study's purpose in itself is to function as a catalyst for developing the use of interactive information communication technology in schools. The object is also to develop and customize the geovisual analytics in order to the demands of the educational settings and the students learning process. NCVA, Linköping University will after the study give The Educational Department of the participating municipality free authorization and license without charge for teacher's continuing use of the eXplorer Statistics. In turn the Educational Department is committed to the responsibility of running the eXplorer Statistics for supplying the maintenance of the teachers use. In this way the mission of long term conducting will be strengthen.

7. RESULTS

The usability study was carried out to examine the effectiveness, efficiency and user satisfaction of the geovisual analytics. This case-study was carried thorough in the school setting and the participants were 12 years old. Altogether 28 students were participating. Three methods for evaluation were used; 1) Questionnaires to measure the student's performance 2) Observations to follow the student's efficiency when working 3) Interviews to investigate the student's satisfaction of using the Vislet. The results show that the storytelling methods are usable within the school. The tool seems to be understandable and useful even for young students. It is for the students easy to understand and adjust the interactive functions and indicators. As many as 96 % percent of the students were able to understand and control the interactive tools correctly, as zooming, opacity and different kinds of transparency of the map. All of the students were able to understand the possibilities of finding, choosing and adjust the indicators at different places. 93 % of them were also able to at all times exact control the indicators. 85 % of the students were able to fully understand the concept of the linked views. The results also show that the tool is efficient to students in supporting their searching and apprehension of connections between different kinds of statistical data. Here meaning that they understood connection between a region/country at the map and the corresponding bubble in the scatter-plot and correct read and analyze the information. The user satisfaction among the students was extensive, at least used as brand new tool – the long lasting effects are however unknown [16].

The study of primary students learning has been carried out in three Swedish elementary schools, in grade four up to grade six. The aim was to investigate:

- 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?

Altogether 100 students have been involved. The teachers of the participating students' have been introduced to the tool; they have made educational plans according to the curricula, organized the content and the tasks by involving use of "the eXplorer platform". The students work has been followed by qualitative methods. Interaction analysis [11] and the DeFT framework [1] are now used for the analytical concerns, to clarify the pedagogical functions that multi external representations (MERs) serve, in this case the geovisual analytics and in so doing, consider the ways that a multi-representational system has in impact upon the process of learning and comprehension.

As presented in the method chapter, the major study is ongoing at junior high schools. At the moment the empirical material is collected http://ncva.itn.liu.se/vise?l=en.

8. CONCLUSION

Within an international perspective our research builds on collaborating work with OECD since 2008 and we have supplied advanced statistics visualization technology to this organization [13]. We have also been involved in the development of the PISA2009 profiles [15]. Another partner 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 in this research field, focuses on how learning is influenced by the form of representation that learners study. The field considers all forms of representations 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.

All together the results of this study will give valuable contributions to the development of these research fields. The geovisual analytics technology introduced in this paper allows the teacher to communicate with student through interesting and important discoveries captured into snapshots together with descriptive text. Selected indicators and visual representations can be published together with their metadata, thus facilitating the comprehension of statistical information for educational purpose. We believe that this innovative storytelling technology can be useful for a next-generation of educational dynamic books for learning about different phenomena in the world. The Vislet technique helps developing agile on-line educational publications, which draw the attention on recent trends and inequalities, as examples demonstrated in this paper.

The primary objective of the introduction of visualization is to avoid boring statistics data. Instead we want to use them to tell interesting and urgent facts about our world. We want statistics to be exciting to both teachers and students so that they invade the minds and help them in their creation of knowledge, thus allowing students to apply new insights as a basis for understanding. The world is rapidly changing but the chances often bypass and are not observed. We have to be able to track direction, pace, and patterns in the shifts that take place and gradually but totally reshape the world. In order to do this the visualization should highlight structures and patterns in the data and allow the students to play around and test their own

hypotheses and ideas. It is well known that interactive web based maps speak to the minds of many people. In addition to maps showing the data, we want to highlight interesting correlations through our snapshot mechanism between several indicators across the geographic areas, as well as dynamics over time. If teachers are to devote interest to statistics data and use the information for educational purposes, the statistics must clearly convey a message. The visual analytics storytelling technique applied to statistics visualization therefore is essential.

9. ACKNOWLEDGEMENTS

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