Story of a 'Storyline Visualization' in High School Readings

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Abstract - **Storyline visualization, as a process of illustrating data that has a course of events via a visual medium, has been used in the area of film making for a very long time. Not so long ago, it has moved from the paper version to the digital word allowing for a wider usage. In this paper we propose its usage as a teaching tool in the area of literature reading for the Croatian class (primary language). We have conducted a preliminary research in five Croatian high schools of a different profile to see how storyline visualization, and visualization of school materials in general, affects students understanding of the material being studied. Each school participated with two groups of students where one group was exposed to the storyline visualization of a novel *Prokleta avlija* by Ivo Andrić [N=103 in total] during the reading period, and the other one was reading without the visualization [N=93 in total]. We will present our results taking into account students' gender and type of a school.**

I. INTRODUCTION

Many researchers agree that an eye is an important information receiver and that our brain does a good job in finding patterns in visual presentations of data [10], [2], [5], [3]. Thus, it is by no surprise that, in this information era that we live in, we are trying to find alternative ways to present information in a visually more understandable (comprehensive) way in order to absorb more information in a much faster manner. In the recent age, as we are surrounded with more and more data, and presence of Big Data is becoming overwhelming, this obsession of visual presentation of data has become more common, and surely even expected in business domain.

But, what about the arena of education? How can we help our students to better understand and better incorporate all the information that we are feeding them with in schools? Can we use visualization as a helping tool? Obviously, the answer is '*yes*'. Visualization is not a novel thing to education and different types of visualizations have been used for different lessons trying to convey the relevant information [5]. Some of the most widely used ones are geographical maps, periodical table of elements, Venn diagram, cyclic graphs, mind maps, UML diagrams, pie charts, bar charts, tree maps etc. and their usage depends mostly on the topic being taught.

And what about storyline visualization? Is it helpful in mastering the school curriculum? In what subjects can it help? Is it for everyone? These are just few of the questions that motivated us in this project. The main characteristic of this type of visualization is that it helps to demonstrate when and where did certain characters meet during the course of the story. So far, it has mainly been used to show movie character interactions. The professional illustrators would draw a board with characters moving through time and space to get an insight into the story flow. These lines where usually drawn by hand, but recently several software tools have been introduced that are able to draw the story line automatically after parameters like *characters, places* and *time* are provided as an input [17], [18].

In order to test our hypothesis that storyline visualization can be used in classrooms and can help in better understanding of a story, we have conducted a small scale research on 196 high school students. In the following sections, we will first provide some information on visualization giving a special attention to storyline visualization and its usage throughout history. Second, we will describe in more details how we designed a storyline visualization for a novel *Prokleta avlija* by Ivo Andrić and how we conducted our research. Before we conclude, we will present and discuss our results.

II. STORYLINE VISUALIZATION

A. Short History

Storytelling through visualization is not a novel approach to telling a story. It can be traced all the way back at the very beginnings of humanity. We can talk about visualizations when we talk about drawings in the old caves like Altamira or Lascaux, and later in the old Egyptian pyramids, and up to the more modern times in children story-books. Some of the most known visualizations are Galileo's sun spot map, Descarte's coordinates system, *New Chart of History* by J. Priestly, John Snow's map of cholera appearances in London, or Florence Nightingale's diagram of cause of death of soldiers fighting in Crimean war.

In spite the fact that most visualizations are understandable to different language groups, and that visualization can be regarded as a universal language, it is surprising that its usage was not always as popular or as widely spread as today. Although since 15th century it has been mostly on a raise, since the end of the 19th and up to the middle of the 20th century it had its modern dark age period when it showed a sudden decline, probably caused

by two Wars [8]. Speedy raise in science and technology, and production of immense quantities of data since the 2nd half of the 20th century made a fertile ground for the raise of visualizations as well.

This brings us to the modern age of computers which are almost unthinkable without different graphical presentations, from disc free/occupied space and disc defragmentation process, or schema of folders and documents to visualization of different social network happenings and phenomena. All of these examples use very large numbers of information and our brain is much better in finding patterns and making sense of those information if presented visually than via text or pure numbers [10], [13]. The main intention behind these visualizations lies thus in accentuating data's features, finding "patterns, and simultaneously showing features that exist across multiple dimensions" [2]. It is about informing in a fun manner in order to motivate an action.

B. From Visualization to Storyline Visualization

A new approach to storytelling through visualization is a method called storyline visualization. Although it shares a common 'DNA' with other visualizations [5], it differs in the number of details it can show, but also in the type of information we can learn from it. Its main task is to give us an overview of a number of events and/or people over a period of time. Tanahashi and Kwan-Liu [18] define it as "a technique that portrays the temporal dynamics of social interactions by projecting the timeline of the interaction onto an axis". Almost like a specialized timeline in which lines presenting characters converge where characters interact.

The storyline visualization strives to show the main structure of a story flow with the accent on interactions between characters without giving any sentiment or interpretation of a story. During the design process, it is important to refine the data and select only events and characters that are important for the story. Then follow the selection of a software for visualization, choice of colors, positions, sizes and intuitive symbols that will be used, and finally a legend where appropriate.

The most obvious application of a storyline visualization can be in the movie-making industry, where film directors, actors and script adapters can benefit from it [14]. However, that is not the only area that may find it informative. Visualization of linguistic shift [15], genealogical data [11], presentation of dynamic relationships of politicians over time or visual summary of events in informative context in data-driven journalism [14] have also been proposed. One of the most famous storyline visualizations is associated with the war related data, particularly Napoleon's troops marching toward Russia by Charles J. Minard and it dates back to 1862. A very thorough description of this visualization is provided by Sandberg [9] and with six different types of data it provides, it is well suited for both history and geography classes. But, as we are proposing in this paper, these two subjects are not the only ones where storyline visualization can find its place. Display of a historical or a fictitious story through storyline visualization should be the same since we have the same type of parameters

needed for this type of visualization. Thus, it is our strong belief that storyline visualization can find its place in portraying a story flow of a novel as well as in showing how different genres appeared throughout the time of literature, or how different theories in biology, chemistry and other sciences appeared with their main influencers interactions.

III.   BUILDING A STORYLINE VISUALIZATION FOR A NOVEL

The use of technology in class does not necessarily mean that students and teachers have to use computers or tablets during lectures. It can also include preparation for class such as making materials which will help students to understand the school subject in an easier way and later to help students review the subject matter before exams.

Until recently, it was only possible to draw storyline visualization either by hand or by using a simple drawing software like *Paint* or some other similar program. In recent years, several authors have either proposed software built specifically for the purposes of storyline visualizations [7] or have proposed some modifications towards improving the layout of a visualization [4], [16], [18]. Since the readability of a *storyline visualization* is of an extreme importance, it is not surprising that much thought needs to be put into ordering the characters among themselves and on the visual presentation as a whole.

We have tried to incorporate all the best practices in our visualization of a novel *Prokleta avlija* (Figure 1) in order to best show the flow of the main story and two additional stories that happen in the middle. In this, we have tried to follow the three main principles for constructing storyline visualization proposed in [18].
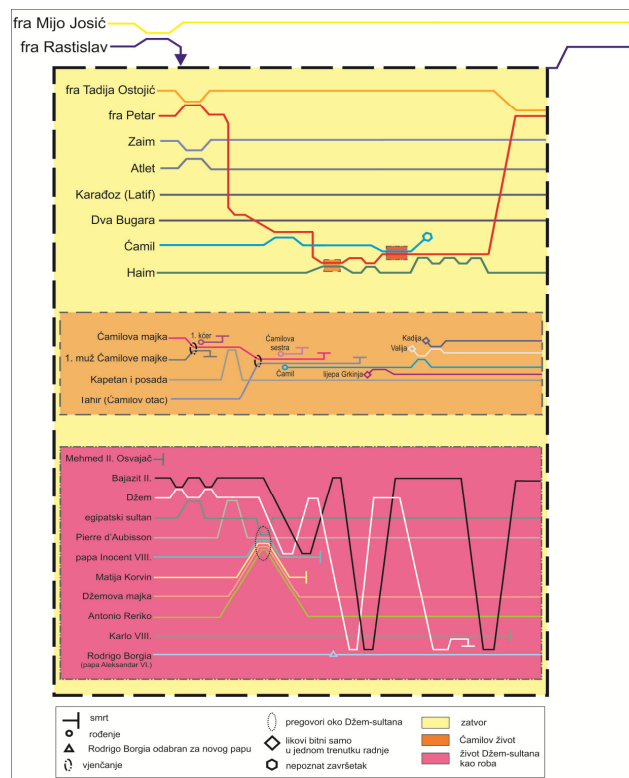

Figure 1.   - Storyline visualization of a novel Prokleta avlija

A large amount of information can be obtained from just looking at the visualization and analyzing it, without even reading the book. So, for example, one can see how many plots exist in the book since every plot is positioned in its own rectangle in a different color, who are the characters and which of them meet, and finally where and when they meet in the book. The legend provided at the bottom of the visualization contains explanations of the symbols used in the visualization such as deaths, marriages and births of characters where this information is given through the novel.

IV.   PREPARATIONS AND SURVEY IMPLEMENTATION

Our research was conducted through five distinct phases. The first phase included a search for high schools that would be willing to participate. We asked each school that was willing to participate in the research to send us a list of readings they planned to do in the 1st half of the 2nd term in order to find the one book they had in common. Since it was important for us to have different profile of high schools, and that there are at least two classes in each school, we included those parameters as well while selecting our final five schools (one Natural Sciences High school, two Technical High schools and two Gymnasiums). One class from each school would receive the visualization with instructions on how to use it - test group, while the second class was to read the book without the visualization and would receive the visualization after they take the test – control group (in order to answer some questions from the questionnaire).

During the second phase we had to reread the novel and draw the visualization by hand trying to define all the character relations that we believed to be important for the story. The book that turned out to be in common for our schools was *Prokleta avlija*, a historical novel written by Ivo Andrić. This novel is also one of the mandatory books on the *matura* exam that Croatian students need to take in order to get their high school diploma. This was an additional bonus for choosing this particular book since we believed that students would be more willing to read it and participate in the research.

The third phase included the process of transferring the visualization from the paper version to its digital format using graphic design software *CorelDraw X7*. After the visualization was finalized we prepared two sets of test questions and two sets of questionnaires together with the visualizations for each student. Both tests consisted of 16 questions, 8 of which were linked to the visualization (could be answered with its help) and 8 were not. Although two variations of the test were made, the difference between them was in the ordering of questions and possible answers. However, we did add one extra question that was different for each group and required them to recall which two characters from the list we provided met during the story. Half of the students in each class received the test A and the other half received the test B. Two different sets of questionnaires were prepared in order to accommodate the two different groups of students: those who used the visualization during the reading time and those who were shown the visualization after they took the test. We used results of both groups in our research. However, since the questionnaires were

anonymous, we were not able to connect the test results with the types of answers provided in the questionnaires. All the materials, together with the instructions for the teacher on how to conduct the testing of each group were delivered to teachers of Croatian language in each of the schools.

In the fourth phase, 103 students who were reading with the visualization have been given the printed copies of the storyline visualization together with the instructions on how to use it. The other group of students (93) did not receive any information on the visualization or the research being conducted. Originally, 217 students were to participate in the research, but 21 student was absent from the school at the test day, so their tests were returned empty. On the test day, both groups of students were first given the tests. The test group received the questionnaires immediately after finishing the test. The control group was first given the visualization after finishing the test and then the questionnaires.

In the final phase, after tests and questionnaires were returned to us, we transferred the answers to our database and prepared them for further data analysis. Our findings with a short discussion are presented in the following section.

V.   RESULTS AND DISCUSSION

The main purpose behind this pilot research was to find out if storyline visualization can help students better understand and memorize the timeline of the story and movement of its characters throughout the novel than the conventional way of just reading a book and then analyzing its content in class. We also wanted to see if students of different gender and type of the high school would perform differently on the test. Additionally we were interested to learn how young people today react to an unconventional visual data representation, or in this case, to a storyline visualization of a novel and if they see some other subjects where its usage would be rewarding.

Our main hypothesis was that that the students who had the visualization while reading the novel would have better understanding of the story and its characters and would thus have better test results than the students who were reading without visualization. Also, we expected male students to perform better since research shows that they are better in visual-spatial thinking as well as the students of technical profile high schools who are more accustomed to visual presentations due to the nature of their studies.

A.   *Test results*

There were 16 test questions, eight of which have been shown through the visualization. We will discuss only them. Five of these questions were multiple choice (MC) questions, two were true/false (TF), and one required a short answer (SA).

The results for the first MC question (*Which Pope was in the historic part of the novel?*) were better for the students from the test group (pink sections = left sections). Also, male (M) students (54.14%) performed better on this question than female (F) colleagues (45.86%) (Figure

2). In the visualization, we have used a special symbol showing a change of the pope to mark this occurance.

Which Pope was in the historic part of the novel

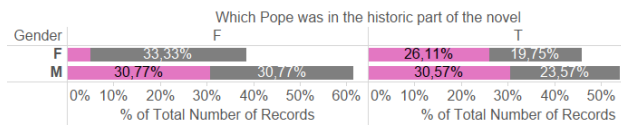| Gender	F		T	
F	33,33%		26,11%	19,75%
M	30,77%	30,77%	30,57%	23,57%

Figure 2. - Distribution of results for the 1st MC question where gender (F/M) and group type (test/control) is taken into account

The second MC question (*How many times did Camil's mother got married and how many children did she have*) gave similar results: test group performed better and male students performed better (Figure 3). A special symbol was also used to show a wedding of a character.

How many marriages and children

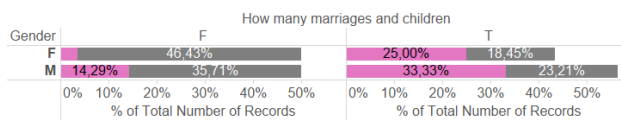| Gender	F		T	
F	46,43%		25,00%	18,45%
M	14,29%	35,71%	33,33%	23,21%

Figure 3. - Distribution of results for the 2nd MC question where gender (F/M) and group type (test/control) is taken into account

The third MC question was about Cem Sultan, the son of Sultan Mehmed II. His fate was a tragic one and at one point in his life he had been sold to the enemies of the Ottoman Empire. The final three MC questions are about his first owner (*Who is the first owner of Cem Sultan*), the number of people who wanted to buy him (*How many people want to buy Cem Sultan*) and what happened to him in the story (*What happens to Cem Sultan*). The graphs (Figure 4, Figure 5 and Figure 6) show the results for these three questions in the same order as afore-mentioned.
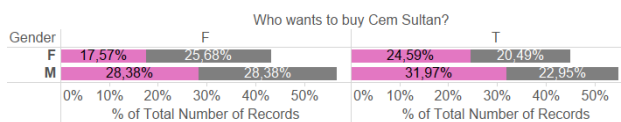
Who wants to buy Cem Sultan?

Gender	F		T	
F	17,57%	25,68%	24,59%	20,49%
M	28,38%	28,38%	31,97%	22,95%

Figure 4. - Distribution of results for the 3rd MC question where gender (F/M) and group type (test/control) is taken into account

How many people want to buy Cem Sultan?

Gender	F		T	
F	15,22%	28,26%	27,88%	17,31%
M	26,09%	30,43%	34,62%	20,19%

Figure 5. - Distribution of results for the 4th MC question where gender (F/M) and group type (test/control) is taken into account

What happens to Cem Sultan?

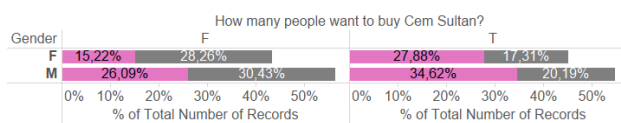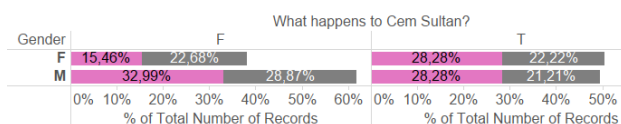| Gender	F		T	
F	15,46%	22,68%	28,28%	22,22%
M	32,99%	28,87%	28,28%	21,21%

Figure 6. - Distribution of results for the 5th MC question where gender (F/M) and group type (test/control) is taken into account

There are two TF type of questions. The first one was used to find out if there are characters in the story whose fate was not revealed to us (a special symbol was used to show this in the storyline visualization) (Figure 7).

Are there characters whose fate remains unknown in the story?

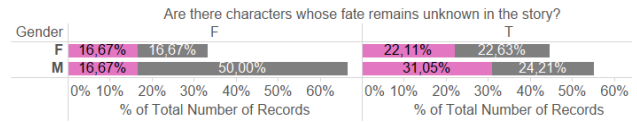| Gender	F		T	
F	16,67%	16,67%	22,11%	22,63%
M	16,67%	50,00%	31,05%	24,21%

Figure 7. - Distribution of results for the TF question where gender (F/M) and group type (test/control) is taken into account

In the 2nd TF question, a set of five statements was given that needed to be marked as true or false. These five statements, marked 11.a through 11.e, tested if two characters met in the story or not, and if they have met after a specified event. Results are shown in Figure 8.

11.a Camil was arrested AFTER meeting beautiful Greek lady.

Gender	F		T	
F	27,10%	26,17%	15,73%	17,98%
M	25,23%	21,50%	37,08%	29,21%

11.b Egyptan Sultan has never crossed path with Cem Sultan.

Gender	F		T	
F	23,94%	29,58%	20,80%	18,40%
M	19,72%	26,76%	36,80%	24,00%

11.c Bajazit and Cem Sultan met immidately after the death of Mehmed II. C...

Gender	F		T	
F	22,99%	14,94%	26,44%	35,63%
M	22,02%	17,43%	33,03%	27,52%

11.d Karlo VIII and Camil's sister are in the same story.

Gender	F		T	
F	25,81%	16,13%	21,21%	23,64%
M	35,48%	22,58%	29,70%	25,45%

11.e Fra Tadija Ostojic met Zaim.

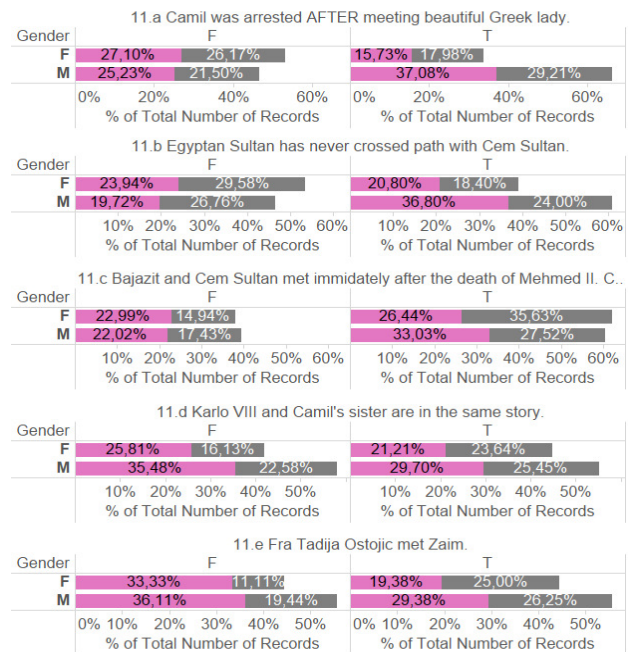| Gender	F		T	
F	33,33%	11,11%	19,38%	25,00%
M	36,11%	19,44%	29,38%	26,25%

Figure 8. - Distribution of results for the set of TF questions where gender (F/M) and group type (test/control) is taken into account

In the SA category of questions there was only one question where students were asked to write how many stories there were inside the main story. In this historical novel there is one main story inside which three other stories appear. Each story in the visualization was marked with another color. We used white background for the main story, yellow for the jail story inside which two more stories occurred (orange was used for story about Camil and dark pink for Cem Sultan's story). Although a high percentage of students without visualization performed well on this question, still there were more students with the visualization with the correct answer and among them, more male students (Figure 9).

How many stories are in the main story?

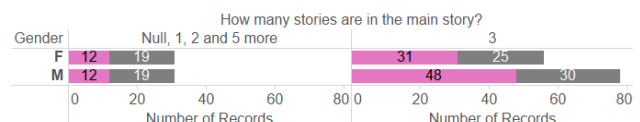| Gender	Null, 1, 2 and 5 more		3	
F	12	19	31	25
M	12	19	48	30

Figure 9. - Distribution of results for the SA question where gender (F/M) and group type (test/control) is taken into account

Our results show that we have been right to assume that students with visualization would perform better on the test and also that male students would perform better

than female ones. However, overall test scores show that technical school students did not perform better on the test, as we have expected them to.

B. Questionnaire results

We prepared two sets of questionnaires: one for the test group and the other for the control group. The main goal was the same – to find out how students feel about presenting data from a novel through storyline visualization and what other subject areas they feel it could be useful for. The test group questionnaire also had questions about the visualization (if it was presented in a clear manner, if they find it helpful for preparing for the test, during the reading of a novel and for better understanding of relations between characters). Since the control group was given storyline visualization only after they took the test, their distinctive questions were whether they think it would have helped them during the reading and in better understanding of relations between characters. First, we will present our findings from the selection of questions common to both groups, and then the questions present only in the test group followed by the questions distinctive of the control group.

It is important to say that 82.49% of all tested students believe to be visual types, or to be more precise 94.52% of gymnasium students, 80.39% natural science students and 75.82% of technical students. If we take a look at their overall test grades per school type (Figure 10), than gymnasium and natural sciences students performed accordingly. However, there is a discrepancy between the declaration of technical students and their test scores since the students from the control group performed better than their colleagues from the test group. This came as a surprise to us since 75.82% of these students declared to be visual type and 64.83% believe that visualizations could help better understand other subjects as well.

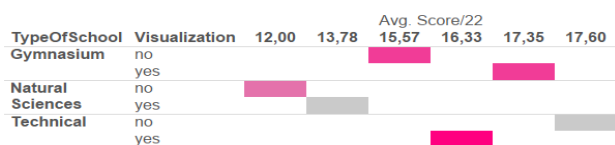| TypeOfSchool	Visualization	12,00	13,78	Avg. Score/22 15,57	16,33	17,35	17,60
Gymnasium	no						
	yes						
Natural Sciences	no						
	yes						
Technical	no						
	yes						

Figure 10. – Distribution of average scores per school type and their declaration about being visual types

If we take gender into account, than more male (45.16%) then female students (37.33%) declare themselves as visual types. This is in contradiction with their test results since overall grade for male students (15.45) is lower than for female students (15.69). However, both male and female students from the test groups had outperformed their colleagues from the control groups.

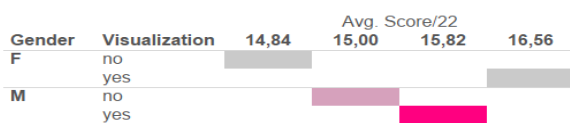| Gender	Visualization	14,84	15,00	Avg. Score/22 15,82	16,56
F	no				
	yes				
M	no				
	yes				

Figure 11. - Distribution of average scores per gender and their declaration about being visual types

When asked if a storyline visualization would help them when reviewing for a test, 78.03% students answered affirmative, and 7.94% of them are students who originally declared themselves not to be visual types. There are also 13.08% of visual type students who do not find such a visualization as a good tool for test reviews.

There are 86.92% of students (10.28% of nonvisual type) who believe that storyline visualization would be helpful in better understanding even the more complex novels and 73.96% of students (6.98% of nonvisual type) who believe that it would help them in some other subjects as well. When asked in which subjects they could find such a visualization as a helping tool to better understanding of the material being studied 50 listed history, 23 listed biology, 18 listed chemistry, 15 listed physics, 15 listed mathematics and 36 of them stated that it could be useful in all subjects. There were up to 9 students that also listed one or at least one of the following subjects: sociology, geography, technical subjects, psychology, logics, art of music, visual arts and philosophy.

A larger portion (81%) of test group students found the storyline visualization to be presented in a clear manner. Among them, there are more male (60%) than female students and more students from technical schools (41%) than other types of school.

When asked about the down sides of the visualization their answers ranged from '*too little of the context was given*' and '*exact years and locations would be useful*' to '*did not like the symbols and/or colors used*' and '*more details about characters*'. But, as mentioned earlier, storyline visualization, just like other types of visualizations, can be used to present only some types of data – not all.

If we cross reference test students' answers, we find some discrepancies. For example, there are students who find the visualization to be presented clearly, to have helped them better understand the relations between characters and was helpful to have during the reading time. However, they did not find it helpful for answering the test questions. This may have something to do with their test scores. Unfortunately, since the questionnaire was anonymous, we do not have means to test this assumption. All the other combinations of their results are presented in Figure 12.

Was StoryVis presented in a clear fashion?	Did StoryVis help in better understand.	Was StoryVis helpful during the reading time?	Was StoryVis helpful for answearing test questions?	
no	no	no	no	2,97%
			yes	0,99%
		yes	no	6,93%
			yes	3,96%
		yes	no	1,98%
			yes	1,98%
yes	no	yes	yes	3,96%
	yes	no	yes	8,91%
		yes	no	4,95%
			yes	63,37%

10% 20% 30% 40% 50% 60% 70%
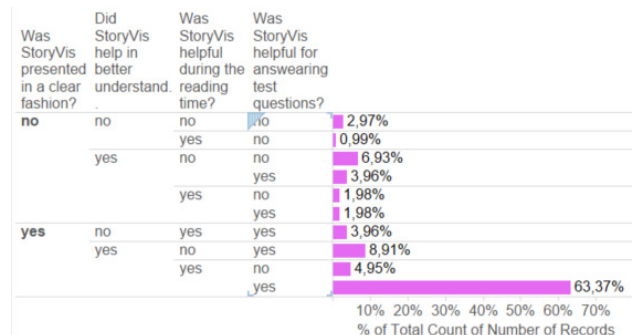% of Total Count of Number of Records

Figure 12. Distribution of Test group results

After control group was introduced to the storyline visualization 71.55% of them responded that it would have helped them during the reading time. More male students (53.01%) than female students (46.99%) were in

favor of this belief as well as the most gymnasium students. Their distribution regarding the school type and gender is given in Figure 13.
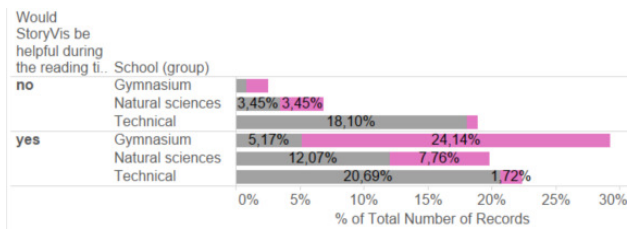

Figure 13. Distribution of Control group answers about helpfulness of storyline visualization during the reading time

Even more control group students (80.17%) believe that the storyline visualization would have helped them with understanding of relations between characters. Again, more male (56.99%) than female students (43.01%), but more technical school students than others. Their distribution regarding the school type and gender is given in Figure 14.
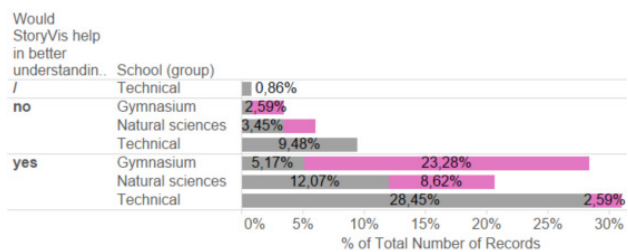

Figure 14. Distribution of Control group answers about helpfulness of storyline visualization in uderstanding of relations between characters

VI. CONLUSION

The main purpose of this paper is to test if *storyline visualization* can be introduced as a legitimate educational tool for presenting information that includes a type of narration where the characters and their interaction over a period of time is important to convey. Our preliminary research results show that students would benefit from such presentation and would use it during the study period but also as a revision tool. Since the majority of people rely greatly on eyes as an information receiver, *storyline visualization* comes as a perfect tool that can be used not only for research and business, but in teaching and learning as well. The research has shown that students from Gymnasia and Natural Sciences Highschools that used the storyline visualization while reading the novel scored better on the exam than the students without visualization. Also, opposite to our expectations, students from Technical Highschools without visualization performed better on the test than their colleagues with visualization during the reading time. Considering only gender, our female participants using visualization while reading achieved better results than male participants with the visualization. This was also in contradiction with the stereotype and our questionnaire results where more male students declared themselves to be visual learning types that female ones. The one-tailed Fisher's exact test value (P=0.0172) show statistical significance between gender and helpfulness of storyline visualization in understanding

while χ^2 test value (P=0.0006) for the association between school type and helpfulness of storyline visualization show high statistical significance.

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