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Abstract visual notations as an aid for historical problem solving

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Abstract: Historical problem-solving normally involves textual answers with students using various primary and secondary sources to solve historical problems. This study used abstract visual notations on the lines of unified modeling language (UML) to aid the visualisation of historical events and concepts and thus recreate the "explanation space" diagrammatically. These diagrams are then translated into text to create richer explanations. The feedback from participants guided the development of a software called the History-Maker, which addressed the difficulties faced by the pencil-paper approach.

Keywords: historical problem-solving; history; thinking skills; historical thinking

1. Introduction

This study aims to support the cognitive task of historical problem solving by using abstract notations as a form of external representation. In conventional problem solving, we are given a question and we use a set of procedures or processes to find a solution. In history, we are given a question of which we already know the outcome and the learner has to reconstruct the objective and state of the system by engaging with the "explanation space"(Wineburg, 1991a). According to the National Center for History in Schools(NCHS) framework, there are several sub-skills that constitute historical thinking of which historical problem solving is considered a higher cognitive skill(Nash, 1997). First, the learning strategies used to develop historical problem solving and its sub-skills were identified and evaluated. Next, abstract notations that represented historical events and concepts were provided to first year undergraduate students along with historical sources and they were asked to answer a historical question. The history specific abstract notations consisted of individual identity, class identity, community identity, group or collective identity, religion-caste, trade, profession, war and artifact. Generic notations consisted of event, concept, process, activity, actor, condition, destruction, document, idea, note, start and stop. It was hypothesised that the use of abstract visual notations to create diagrammatic explanations would improve historical problem solving over simple text only explanations. The notations would aid a novice learner to better visualise the “explanation space”. Once combined into a larger diagram, the notations would allow the learner to construct, deconstruct and reconstruct their solutions to historical problems. A paper-based two-group experiment post-test only randomized design was conducted using the notations. The data showed that while there was improved learning the results were not statistically significant. Based on the feedback from the participants, a software tool called the History-Maker was developed that would allow the learner to easily create and manipulate the diagrams. Future studies will evaluate the use of the notations through the History-Maker.

2. Background

2.1 Use of historical events and conceptual history to learn historical problem solving

Throughout the papers surveyed related to historical thinking, the focus of the content has been on specific instances of history like American history (Stahl, Hynd, Britton, McNish, & Bosquet, 1996), world history(Vansledright & Frankes, 2000), medieval history(Wineburg, 1991b), Indian history and so on. Thus, there is always a question of whether some technique used in teaching world history

would be relevant in, say, American history and this makes generalisation difficult. In order to make better generalisation for learning historical thinking, we chose two basic abstractions of history – historical event and conceptual history. It should be noted that history can be abstracted in several ways like historical process, historical theory, historical structures, historical themes and so on. The terms 'event' and 'concept' in history are so fundamental that it was difficult to find a standardised definition of what the terms mean. Mathews describes historical event as a mental construction which has a beginning, a middle and an end(Matthews, 1937). He further elaborates that all historical events have their basis from a historical process and thus are arbitrary units that are extracted for convenience. An example for a historical event would be the first war of Indian independence. However, this could broken up into smaller events such as 'causes of the revolt', 'stages of the revolt', 'aftermath of the revolt' and so on.

It is suggested that it is better to teach conceptual history to students in order to reduce the memorisation of historical facts as this would help learners "structure and organise" historical data to make sense of it(Vansledright & Frankes, 2000). Working examples of historical concepts, also called foreground concepts(Vansledright & Frankes, 2000), are 'culture', 'democracy', 'freedom', 'the state', etc. From the examples of historical event, 'revolt', 'independence' and 'war' would also be considered historical concepts. We would like to differentiate them from other concepts of history, also called background concepts(Vansledright & Frankes, 2000), such as "evidence, assertion, point of view, source validity, reliability, evidence, change, continuity"(Nash, 1995). Thus, with these two abstractions, the effort is to make the learning strategy content-independent.

2.2 Pedagogical interventions to support learning historical problem solving

Of the papers surveyed for historical problem solving six of the solutions were based on paper-based activities and three were based on the use of technological tools to support learning of the required sub-skills. The non-technological approach required active involvement of the teacher with the students. The strategies included reading multiple documents and writing opinion pieces(Stahl et al., 1996), thinking aloud(Kucan & Beck, 1997), providing an authoritative entity to guide the learners(Paxton, 2002), the use of annotations, highlighting, marking and notes with a combination of individual and group work(Donovan & Bransford, 2004) and providing learners with documents that contradict each other(Nash & Symcox, 1991). These strategies were identified as they would form the control for future studies.

Three studies used 'inquiry based learning'(Vansledright & Frankes, 2000)(Prangsma, Kanselaar, & Boxtel, 2008)(Regist, 2011) and one used 'authentic learning'(Hillis, 2008). Incidentally, the NCHS framework chosen for this research work is based on 'inquiry based learning'. In all these cases, a historical question, which was to be answered, along with related historical documents were provided to the learners. The setting for seven of the studies was the classroom, one was in the library and one in the laboratory. Homework was given to the students in all the studies quoted. All, save one experimental study, were long term studies spanning a whole semester or a whole year.

The use of representations was explored for chronological thinking(Prangsma, Kanselaar, & Boxtel, 2008). Chronological thinking is the first skill-set that students need to develop as a part of the historical thinking framework by NCHS. Based on the classifications set forth(Lohse, Rueter, Biolsi, Walker, & Arbor, 1990), Prangsma developed a set of visual notations to help history students learn 'chronological thinking' coupled with the skills of identifying causation in historical events. Her work used "concrete representations of abstract phenomena and abstract relations" and specifically visual-textual representations integrated into a timeline. The visual representations included 1. process diagram, 2. network chart, 3. structure diagram, 4. cartograms. This has two disadvantages: First, as stated by the author, concrete representations are more useful to aid memorisation rather than conceptual knowledge construction. Second, it is difficult to construct concrete representations for every single use-case that is historically relevant. Thus, abstract notations which can be used in different contexts are proposed as a solution.

2.3 Theoretical basis for notation-based intervention

The representations used to visualise history such as maps, graphs, pictures, cartograms, multimedia and timelines can be classified as multimodal representations(Lohse et al., 1990). It was shown that the learners are able to make deeper connections with the concepts they are working with when using multimodal representations due to visual linking(Ainsworth, 1999). A study conducted by Prangsma on the effects of collaborative construction of multimodal representations in history shows that the use of multimodal representations helps the students to easily remember historical data because they are actively constructing visual-textual representations of the historical data. However, the appropriateness of the external representations could play an important role. External representations not only support memory but also offloads certain critical cognitive tasks into the physical realm (Zhang, 1997)(Kirsh, 2010). Prangsma claimed that the type of notations used could affect the learning process.

3. Methodology

3.1 Experiment to check effectiveness of the notations for historical problem solving

The research question of the study is, "Given a set of abstract visual notations, how effective were they in helping novice learners learn historical problem solving?" Sixty first-year undergraduate history students were selected through purposive sampling. The participants had no prior exposure to historical thinking though they did study history in school. The division of the sixty participants into control and experimental group was done randomly. The experimental design was two-group post-test only. The duration of the session was 50 minutes with both group being briefed about historical thinking for the first ten minutes. The experimental group was then given a ten minute treatment on the use of notations along with a few simple examples from the chapter on "First war of Indian independence". The examples covered both conceptual history and event-based history to ensure that both abstractions of history were present. The post-test for both groups was from the chapter "Totalitarianism – Case study: Stalinist Russia". The question to be answered by both groups textually was:" How would your life change if you lived in a totalitarian state?" Both groups were given a sheet containing the relevant sources required to answer the question. The test was a pencil-paper test.

3.2 Results and discussion

The Shapiro-Wilk test was used to check normality of their internal scores in history. The internal scores were based on the sum of two tests and one mid-term exam. For the control group, it was found that the scores were normal p-value=0.47, alpha=0.05, mean= 38.23, standard error= 0.895 For the experimental group the scores were not normal with p-value=0.04, alpha=0.05, mean=38.6, standard error=1.006. Thus, the Mann-Whitney test for two independent samples was conducted. One-tail: alpha=0.05, p-value=0.320, not significant. The null hypothesis (h0) for Mann-Whitney test is the group means are equal i.e. p>alpha indicates that the probability of that happening is not by chance and hence one cannot reject h0.

Post test scores - Control group: Mean=3.067, SD=1.172, p-value=0.005, alpha=0.05, normal=no; Experimental group: Mean=3.233, SD=1.318, p-value=0.018, alpha=0.05, normal=no
Mann-Whitney test for two independent samples for one tail where alpha=0.05, p-value=0.264, significant=no. Since p>alpha, the null hypothesis (there is no relation between a and b) cannot be rejected.

Inter-rater reliability: Fleiss' Kappa for m Raters (exact value) - Subjects = 24; Raters = 3; Kappa = 0.653. The kappa value is on the borderline. However, this could be because the number of parameters of the evaluation rubric were several. The data for the inter-rater reliability was obtained from the pilots and was discarded after the the inter-rater reliability.

Hypothesis: The use of abstract visual notations improves historical problem solving over simple text only solutions. While there is an improvement in learning with the notations as treatment, there is no statistical significance in the paper-pencil based test.

4. Discussion and future work

Some of the experimental group members opinioned that they were not completely familiar with the notations and many were using notations to solve problems for the first time and hence it was difficult to use them in problem solving. The papers that were discarded used the abstract notations without textual explanation or labels to contextualise them. A longer treatment to familiarise the participants would have been more beneficial. Pencil-paper approach had several disadvantages. Participants expressed "*some of the notations are difficult to draw*" and "*how would I use the symbols if I do not have a copy?*" Further, paper based solutions have inherent problems like it is difficult to resize drawings, move around elements, display complexity within the 2D paper unless one is an expert, not possible to insert meta-data for analysis, difficult to sort and search through the diagram and so on. Initially, the concept map(cmap tool) and UML drawing tools like yEd and Umbrello were used but they did not have history specific notations.

The feedback from the participants in the experiment informed the design of a software based tool. The user interface (UI) consists of the 'canvas', where the history-maker map is created, and the 'elements' panel, where the elements of the historical thinking notation can be selected, a question box and an answer box. The links between the elements are created by clicking on an element and dragging the link from one element to another. When creating either nodes or connectors, the user is prompted to enter the name of the element, the type of connector and some meta data. A sample use-case has been provided below in figure. The question being answered is "How would your life change if you lived in a totalitarian state?" Further studies based on abstract notations using the tool will be performed.

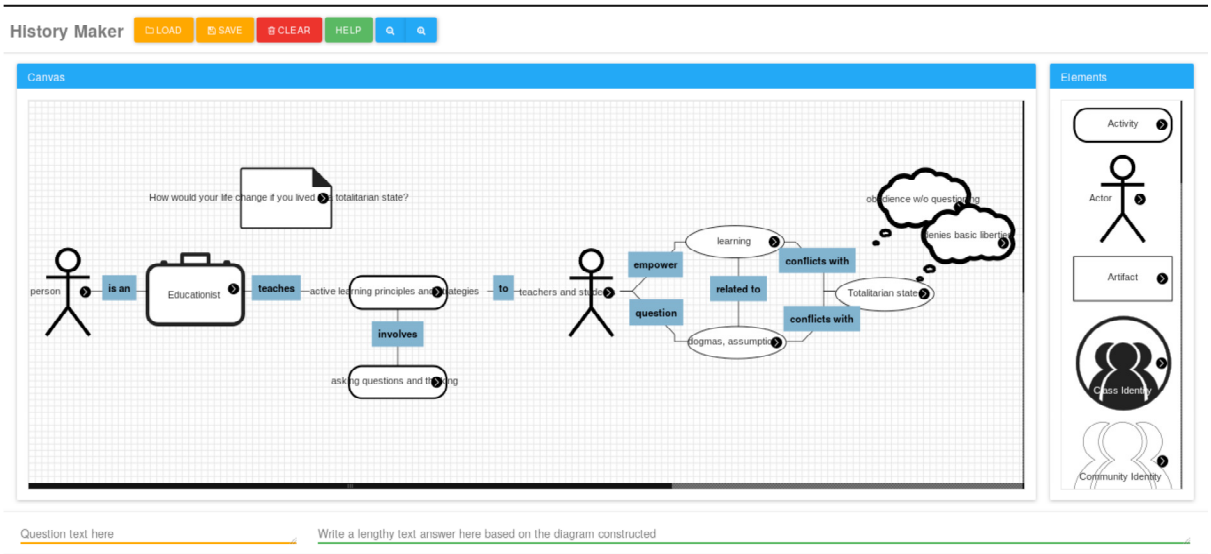

Figure2: Use case of how notations and history-maker map will help answering questions

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