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DESIGNING A NON-LINEAR STORYTELLING PLATFORM

Dissertação no âmbito do Mestrado em Design e Multimédia, orientada pelo Professor Doutor Licínio Gomes Roque e apresentada ao Departamento de Engenharia Informática da Faculdade de Ciências e Tecnologia da Universidade de Coimbra.

Setembro de 2021

CAVEAT: A WRITING PLATFORM LIKE "MEDIUM" BUT YOU ANNOTATE EVERY SENTENCE YOU WRITE WITH CONTEXT, HEDGING, EXCEPTIONS - IT'S NOT THAT SIMPLE.

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DESIGNING A NON-LINEAR STORYTELLING PLATFORM

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Abstract

In the context of accumulating scientific research, educational material and ever growing demand for clarity in scientific communication there is a need for fast and efficient learning and comprehension. With the rise of social media, decrease of attention span, journalism has to redefine itself finding new interactive forms for communication to catch the attention of its readers. In these two separate contexts we identify a common problem - inefficiency of linear form in which information are written and exchanged. Inspired by Nick Sousanis' Unflattening, in this work we explore how could we redefine reading and writing through the use of hypermedia. We do challenge preconceived visual and interactive notions of communicating information through the digital medium by proposing less constrained spatio-temporal form of writing and its potential enabling new non-linear forms of comprehension. We utilize research through design method to explore and invent an interface that objective is to identify key generative concepts which were design-tested and eventually aim to make comprehension of knowledge and information faster and more efficient. Similarly, following transition design framework we seek to propose a transitional change in which we could affect the perception of linear text which is seen as the most rigorous and convenient form of knowledge exchange, proposing new forms of interactive writing as more efficient in the communication and preservation of knowledge.

Contents

In gratitude to my supervisor, doctor Licinio Roque for his patience, supervision and guidance in the research process of writing of this master thesis as well as to professors and assistants of department of informatics engineering for their approachability, kindness and help thorough my master studies at the University of Coimbra.

1. Introduction

1.1. Context & Motivation

A personal motivation of this pursuit dates back to my childhood. I fondly remember times of reading and browsing through wonderful illustrated encyclopedias. This way I learned a lot already in a young age. I remember these illustrated encyclopedias ranging all across the fields of chemistry, music, history to astronomy and physics. I can't emphasize enough how this helped me to develop mental models of thinking, learning which later reflected in school where most of the topics I was already somehow familiar with. This childish curiosity has been greatly present in my early age, yet as I grew older, books changed as well. They transformed from these wonderful illustrated encyclopedias full of diagrams, maps, stories and short readable columns into bundles of neverending planes of text. Rebelious as I am, I couldn't merely accept that and the desire to learn transformed itself into desire to make it easy, efficient and memorable for everyone else to read, learn and explore.

One of the characteric traits of current times is information - countless loads of them. It has never been a perfect world, yet I often think of years 2013-2014 when I started to notice changes in the way we communicate. Facts became a matter of opinion. The truth has been challenged by noise. And in the middle of the fight - the human being. In times of constant social approval, feedback loops which target our cognition and short attention span there is just not enough time to read, to rationalize, to understand. I do not believe in the path of denying technological advancements which exposed complexities of this world. I rather believe in the possibility of returning the agency to the reader - a critical user and producer of information.

1.2. Objective & Scope

Both contexts hold a common denominator - they have to do with practices of information consumption. For the purpose of this thesis we focus in innovating in the practices of reading-writing with the aim

of improving the experience of reader. The objective we set comes from the need we identify in the fields of education, research and science in which stockpiles of human conduct of exploration and evidence are archived - written in a form that presents a challenge to perceive and comprehend all the complexities of the material in a short time, a challenge of the material's production itself. This we perceive in the activity of learning as well as within the activity of scientific research. Similarly, we identify the need in the field of media and journalism, in which a rising trend of using a video as a storytelling device is substituting written text, demanding from journalists to embrace all kinds of new skillsets in the area of content production [1]. Such changes are driven by the inefficiency of engagement a written text provides. Our goal is located within a common activity and experience shared by all aforementioned contexts - reading. In particular, we would like to explore and possibly design a new more efficient hypermedia interface for activities of reading and writing. We define our criteria of experience and efficiency in particular in terms of comprehension - cost of reading, understanding and acquisition of the knowledge. We also recognize the importance of the tight relation between reading and writing. There are occurrences in which one practice can exist regardless of the other (e.g. AI-generated text or journaling), but in our work we are trying to balance and minimize cost of bothreading and writing so that they can happen in a tight loop. We do not intend to only create content that provides seamless, clear and comprehensive reading experience, but more importantly to give this power of creation of such reading experiences to the writers. Our immediate goal is therefore not just to design an artifact enabling such experience, but to map out a possible way of its spread across the landscape of writing practice(s).

[1] Mary Bock. Showing versus telling: Comparing online video from newspaper and television websites. *Journalism*, 17, 02 2015. DOI: 10.1177/1464884914568076

1.3. Approach

In this thesis we examine the activities of reading and writing within the frames of cognitive and literary sciences. Based on our findings we apply the *research through design* method to create artifacts which address themes - research questions that we identified within our theoetical research process. Within this method we iteratively create and modify artifacts following a particular goal to obtain particular insights. The artifacts we test in the specific nichés and within specific practices with the intention of identifying their critical features. We iteratively improve on our findings and carefully note our decisions. Following the framework of transition design we draw conclusions of possible interventions within real nichés and communities that we intend to engage. We draw a possible multilinear plan - map of interventions that could alter landscape of writing/reading practice within digital

medium and propose our leading integrated artifact.

2. State of the Art Research

2.1. Historical Introduction

2.1.1. As we may think

The first realization and vision for rapid and methodical comprehension and its importance was expressed in an emblematic article of Vannevar Bush from 1945. The vision was driven by the realities of war in which professionals from across different fields had to engage in acts of mutual cooperation. A problem of communicating and comprehending the 'mountain of research' became apparent - or as Bush has called it 'unmanageable scale of the record of human experience' [2]. Bush wanted to solve this problem by standardizing the method of recording and transmitting knowledge to its lowest common denominator - association and for that he envisioned a machine he called *Memex*.

[2] Vannevar Bush. As We May Think. *Atlantic Monthly*, 176(1):641–649, March 1945. ISSN 1072-5520. DOI: 10.1145/227181.227186. URL http://www.theatlantic.com/doc/194507/bush

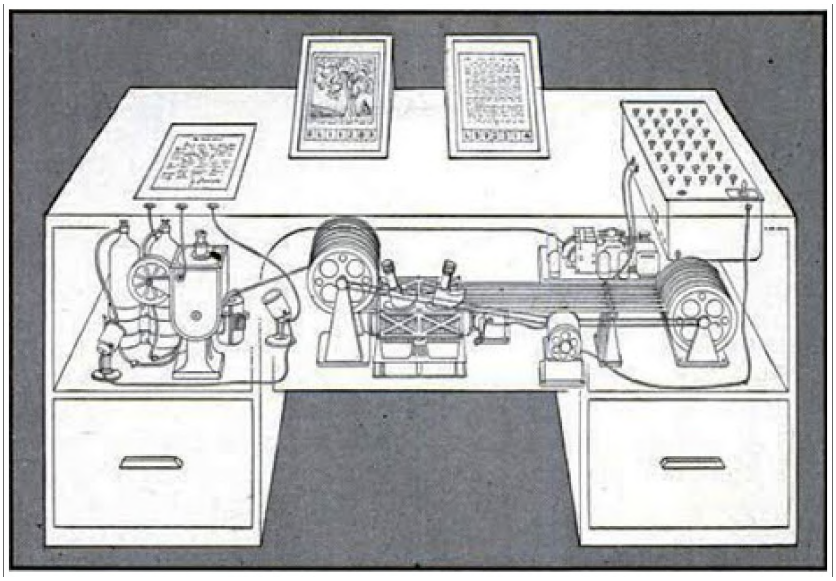


Figure 1: A prototype of Memex as envisioned by V. Bush

He envisioned information to be stored on different media in the internal form of associations and those could be inserted into Memex to

be used. He thought of Memex as an extension of a person's memory and somehow reflected the contemporary understanding of machines being extensions of one's body as noted in Giedion's Mechanization Takes Command [3]. This understanding is also very analogical to the one of Dourish's *embodiment* and Beaudouin-Lafon's *instrumentality* in activity theory in which instruments are understood as extensions of one's body [4].

[3] Sigfried Giedion. *Mechanization Takes Command*. Oxford University Press, first edition, 1948. ISBN 9780816690435

[4] Susanne Bødker and Clemens Klokmose. The human–artifact model: An activity theoretical approach to artifact ecologies. *Human-Computer Interaction*, 26:315–371, 12 2011. DOI: 10.1080/07370024.2011.626709

2.1.2. Ted Nelson & Xanadu

In 1963, based on the ideas of Vannevar Bush, Ted Nelson developed the first model for linked content that he called *hypertext*, *hypermedia* respectively. It's important to understand that it was in the times when the first digital filesystems were being developed [5]. Under the term filesystem we understand the system, the mapping from abstract unit of files into a memory of computer and vice-versa. The proposals of digital filesystems were based on organizational systems of files within the office [6]. Ted Nelson realized the discrepancy between the actual process and practice of writing and researching and between actual format in which the results or record of this process is stored. In his evolutionary file structure, that he also calls *evolutionary list file*, he worked with *entries*, *lists* and *links*. Essentially, he came

[5] R.L. Waring. *Technical investigations of addition of a hardcopy output to the elements of a mechanized library system*. Avco Corporation, first edition, September 1961

[6] Florence E. McGill. *Office Practice and Business Procedure*. Gregg Publishing Company, 1922

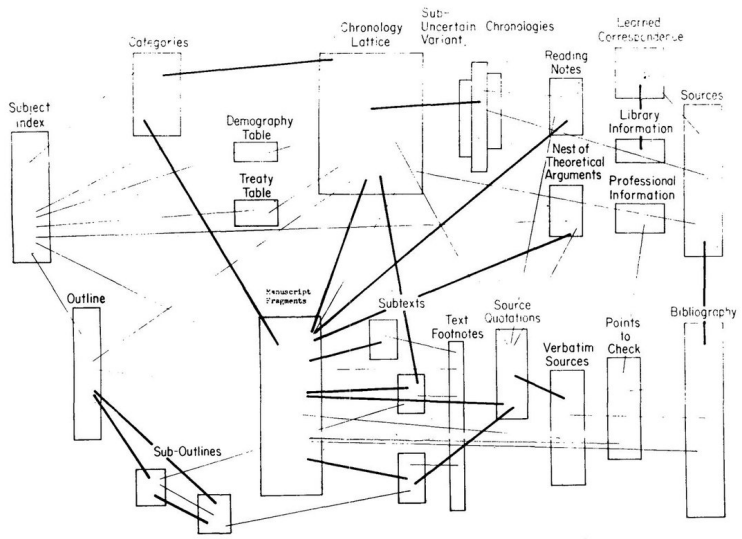


***FIGURE 4*—ELF's capacity for total filing: hypothetical use by historian. Thin lines indicate links; heavy rules indicate some of same entries.**

Figure 2: Hypothetical use of evolutionary list file (ELF) by historian

to the idea of an entry by splitting a file into *segments*. File in this framework is a list of such entries. Such entries can be then interlinked by links as in the visualization above allowing greater perception of

knowledge components and associations by the reader. This was an effort to bring the vision of Vannevar Bush into digital medium using the emerging filesystem organization structure and was intended to materialize within Xanadu project. Xanadu project however never came to fruition and its 40 years long delay of implementation was rather perceived as failure. The idea of hyperlink was put into praxis thanks to the team of Doug Engelbart in 1966.

Both ideations share common trait of understanding potential of machine to sort and organize our thoughts and knowledge. They focus on designing a new, better system for organization. To propose a system is only one part of the problem, we believe, but to be able to intervene in smaller and greater scales of use and to bring it into a regular practice involves much greater complexities. What we intend to pay attention to is to form a general knowledge about the practice of content creation and consumption - writing and reading in particular. This in order to create a continuity between our proposition and existing practice.

2.1.3. Hypercard

The concept of hypertext was later on demonstrated on several projects such as the *Aspen Movie Map* or *ENQUIRE*, but nowhere it did gain a more significant presence than in HyperCard. HyperCard was a hypermedia system in which content was organized into cards which were stacked in stacks. Elements on one card could have been as interactive as well as static. We can think of cards as Ted Nelson's entries and

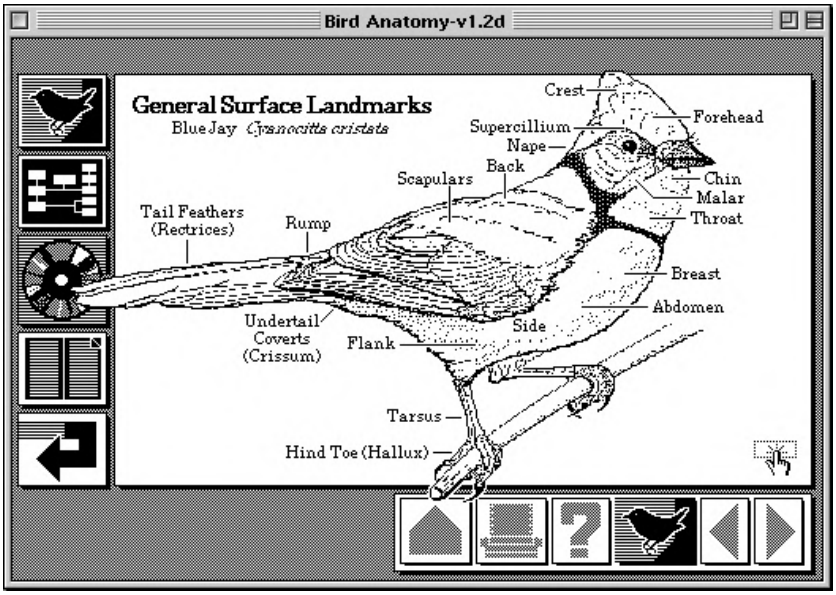


Figure 3: An example of hypercard

stacks as Ted Nelson's lists. The application of HyperCard introduced

media into the domain of interlinked textual content. Apart from web, the interfaces for programming, spatial manipulation and browsing were all included within hypercard. This we believe, is an important concept for future progression within the field. In our own research later on we have been drawn to similar conclusions of searching for potential synthesis between multiple activities into a single interface such merging viewing and editing or in our case - reading and writing. The unfortunate reasons of fade out of the hypercard concept could be identified as emergence of web with affordance of linking and the managerial decisions within the Apple company which sidetracked and later completely abolished the concept. As Bill Atkinson says in his interview for WIRED in 2002: "I have realized over time that I missed the mark with HyperCard. I grew up in a box-centric culture at Apple. If I'd grown up in a network-centric culture, like Sun, HyperCard might have been the first Web browser."[7]. We would like to note here, that even though this quote implies that HyperCard already missed its train without playing a bigger role in the emergence of world wide web, we believe that its potential has not been fulfilled in any viable substitution and something like "Card Web Browser" with the right transitional pivoting could still radically alter the way in which we know and understand world wide web today. We can also perceive rising significance to the notion of storytelling that is associated with hypercard stacks - each stack "telling" a linear story. While Vannevar Bush's trails were treated rather as a secondary consequence of exploration and noting, here we consciously choose which cards to create and include within stacks to create a story or set of associated cards, concepts. That however does not have to be a definite ruling of such concept.

[7] Leander Kahney. Hypercard: What could have been, 2002. URL https://www.wired.com/2002/08/hypercard-what-could-have-been/

2.2. Cognitive Models

As already noted in the introduction, we contextualize the act of **nonlinear storytelling** within the pursuit for rapid, efficient and personalized comprehension. And even though, the general trend in the field of human-computer interaction is to describe problems in post-cognitive frameworks such as *activity theory* and from within standpoints of cultural and ethnographic principles, we would like to address the topic of nonlinear storytelling from within the cognitive field as well. It's important to understand that within the title of this work we are already making assumptions of what solves our problem of rapid knowledge comprehension. Let's put the notions of *nonlinearity* and *storytelling* aside for a moment and focus on the act of comprehension itself.

2.2.1. Internal Representations

Comprehension is described as an "ability to understand the meaning of a concept or an action based on the intelligent power of abstract thought and reasoning" [8]. We define *concept* as a basic cognitive unit that models a connection between a real-world entity and abstract mental object. It's important to understand comprehension as a higher cognitive process of the brain that creates whole internal representation of concepts including their relations and attributes. Wang and Dafurov formalize the notion of internal knowledge representation trough Object-Attribute-Relation model (OAR). Object-Attribute-Relation model is formalized as a triple (O, A, R) in which O is a finite set of objects:

$$O = \{o_1, o_2, o_3, \dots\}$$

A is a finite set of finite sets of attributes characterizing the particular object:

$$A = \{\{A_{11}, A_{12}, \dots\}, \{A_{21}, A_{22}, \dots\}, \dots\}$$

i.e., $A_{11}, A_{i2}, A_{i3}, \dots$ are attributes characterizing object o_i. R is a finite set of finite sets of relations between objects and attributes.

$$R = \{\{R_{11}, R_{12}, \dots\}, \{R_{21}, R_{22}, \dots\}, \dots\}$$

where R_{ik} fulfills

$$\begin{aligned} R_{ix} = \{&(o_i, o_y), (o_i, A_{i1}), (o_i, A_{i2}), \dots \\ &(A_{i1}, o_y), (A_{i2}, o_y), \dots \\ &(A_{i1}, A_{y1}), (A_{i1}, A_{y2}), (A_{i2}, A_{y2}), \dots\} \end{aligned} \tag{1}$$

what can be essential described as a relation of object o_i that includes ordered pair with some other object o_y, pairs of object's o_i own attributes, pairs of o_i own attributes to the other object o_y and pairs between object's individual attributes.

We described this model in order to provide foundation for, for us, more significant model of mental inquiry which we envision as a growing and constantly updating internal representation. For now, we can imagine the process of comprehension in simpler terms - as a 'breathing', growing graph or a network. We used the term 'breathing' because the process of comprehension is understood as constructing of new internal representation based on the previous one [9], [10] ('breathing in') and involves verification of hypothesized representation with the real results and an update of such hypothesized representation ('breathing out'). This is somewhat analogical to what is described as the Polya method of problem solving [11] in following four steps:

[8] Y. Wang and D. Gafurov. The cognitive process of comprehension: A formal description. *Int. J. Cogn. Informatics Nat. Intell.*, 4:44–58, 2010

[9] Ross Quillian. Semantic memory. In *Semantic Information Processing*, pages 216–270. MIT Press, 1968

[10] M.W. Matlin. *Cognition*. Harcourt Brace College Publishers, 1998. ISBN 9780155040816. URL https://books.google.pt/books?id=MoqvQgAACAAJ

[11] G. Polya. *How to Solve It*. Princeton University Press, November 1971. ISBN 0691023565. URL http://www.amazon.com/exec/obidos/redirect?tag=citeulike07-20&path=ASIN/0691023565

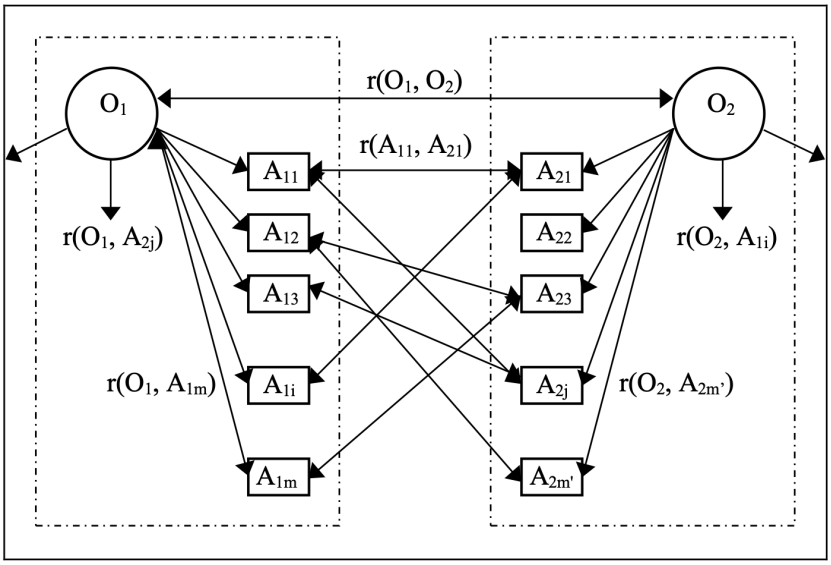


Figure 4: The OAR model [Wang and Gafurov, 2010]

1. Understand the problem
   map external signs to objects of our internal representation
2. Devise a plan
   generate a hypothesis
3. Carry out the plan
   perform an experiment / test the hypothesis
4. Check the result
   interpret and update / correct our hypothesis

in which we continuously generate and test our hypotheses - partial representations.

2.2.2. Lacanian Foundations

To incorporate ourselves into a wider context, we are taking a note of notions of *signifier* and *signified* of Ferdinand de Saussure that is almost completely analogical to what we defined as concept (abstract vs. real). This allows us to extend our understanding to linguistic contexts of mental modelling, including notions such as *metonymy* and *metaphor* that might prove referentially helpful in our later explorations. Similarly, we would like to mention the framework of Lacanian psychoanalysis as highly influential in the author's thought formation. In particular we would like to refer to the lacanian nosography and its three clinical structures (neurotic, perverse, psychotic) [12]. These structures are what Lacan understands as different ways in which

[12] J. Lacan, J.A. Miller, and R. Grigg. *The Psychoses*. Séminaire de Jacques Lacan. W.W. Norton, 1993. ISBN 9780393034677. URL https://books.google.pt/books?id=-z6uhajC6EYC

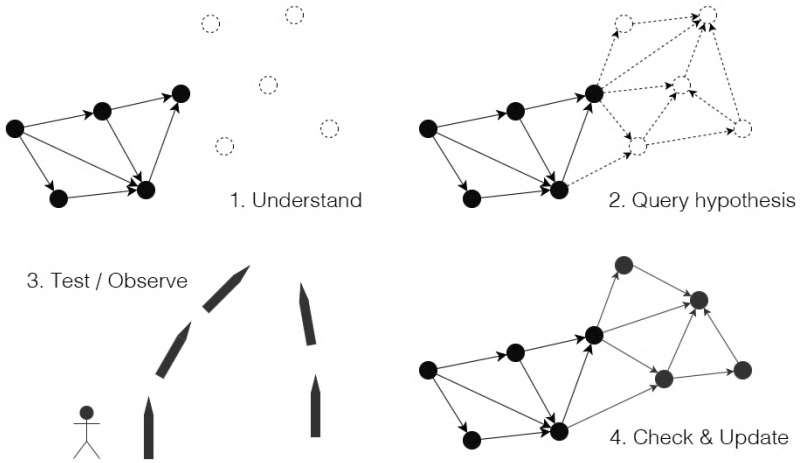


Figure 5: Polya method visualized within the model of internal representations

subjects positions itself within internal representations of signs. This helps us to contextualize the understanding of relationship between the subject and language which we refer to later on when describing the notion of *play*. Even though, Lacan's internal representations referred to the Freud's model of *word-presentations* (verbal language) and *thing-presentations* (visual language), we treat the term with an open mind to generalization, although understanding its contextual peculiarities. And we would also like to briefly mention three registers - imaginary, symbolic and real. We understand three registers as categories for our experience. While imaginary concerns our imagination, a state the hazy dimension of images - conscious or unconscious, the symbolic stands for what can we identify as language, but in much more general sense - a system of signs, what J. Lacan refers to as *a Law* - a set of rules, intersubjective communication. The *Real* is then what is forever to be left without any description. An authentic, unchangeable truth which can be approximated through signs, but never truly comprehended [13]. The formation of subjectivity we can understand then through symbolic register through which, in very simplified terms, we identify ourselves and which is in constant discourse and mediation with the 'outer world' or in Lacanian terms - *Real*. For the purpose of this work we won't go deeper into these topics, but we found it important to mention them as their signature is present within our conceptual modelling [14].

[13] Jacques Lacan. *Freud's papers on technique, 1953-1954*. W.W. Norton, 1991b. ISBN 9780393306972. URL http://www.worldcat.org/isbn/9780393306972

[14] J. Lacan. *The Ego in Freud's Theory and in the Technique of Psychoanalysis, 1954-1955*. Lacan, Jacques, 1901-1981 English. W.W. Norton, 1991a. ISBN 9780393307092. URL https://books.google.pt/books?id=8cAcDb-Ln3sC

2.2.3. Cognitive Metaphors

One way in which we can improve efficiency of comprehension is just through the use of above mentioned metaphors. As George Lakoff

also puts it, metaphor "allows us to comprehend one concept in terms of another" [15]. One could therefore speculate that to comprehend a concept is to look at it through lenses of various metaphors. We say various, because we understand that the use of metaphor, while emphasizing certain attributes of a concept, can neglect others.

Lakoff understands metaphor as a "word container" for an idea - we could say "a window" for the meaning we are communicating. It is through this window through which a specific aspect of the idea - an object is being signified. We could speculate that our internal representations are constructions of such different windows. This pushes us to the role of subjectivism and variation in the process of understanding and knowledge exchange. One could argue that an object's definitive description cannot be accessed (the Lacanian Real) and therefore all that we are left of is only a multitude of subjective metaphoric systems in which different aspects of the object are being modeled and signified. This argument is challenged by the extreme on the other side of the spectrum - what is to be a purely objective and definitive field of mathematics. On the example of conceptual metaphor of number line we can see however the direct involvement of subjective human perception in the role of knowledge construction. Even though, numbers do not require any line for their own existence, it is the existence of *number line* metaphor that allowed us to build foundational principles of mathematics [16]. More over, the clear vivid image of number line gives us an object that we can easily transmit and communicate between each other. It can be speculated whether these "pretty" visualization properties are intrinsic to the objects themselves or are discovered and *designed* - signified by humans themselves. We could argue that one does not exclude the other and that is our aim to discover and identify representations - conceptual metaphors that allow us to easily comprehend and communicate even the most complex topics. Here our vision could be simplified to the idea of "poster upon which you look, you understand the theory of quantum physics in a second". And we can distinguish such efforts in the fields of information visualization and what are so called *explorables* [17]. Even though, they do not necessarily provide a single coherent visual object as a conceptual metaphor, using the device of narration, they are able to interactively guide the reader through the set of convenient metaphors which describe and clarify the topic.

Such visualizations or explorables however suffer from one critical issue - the cost of their production - that includes effort and required know-how for their creation.

[15] George Lakoff and Mark Johnson. *Metaphors we Live by*. University of Chicago Press, Chicago, 1980. ISBN 978-0-226-46800-6

[16] George Lakoff and Mark Johnson. *Metaphors we Live by*. University of Chicago Press, Chicago, 1980. ISBN 978-0-226-46800-6

[17] Peter Brusilovsky. Explanatory visualization in an educational programming environment: Connecting examples with general knowledge. In Brad Blumenthal, Juri Gornostaev, and Claus Unger, editors, *Human-Computer Interaction*, pages 202–212, Berlin, Heidelberg, 1994. Springer Berlin Heidelberg. ISBN 978-3-540-49036-4; and Bret Victor. Explorable explanations, 03 2011. URL http://worrydream.com/ExplorableExplanations/

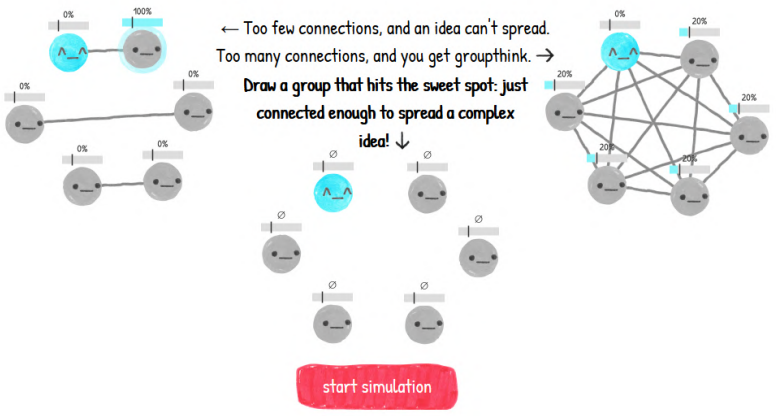


Figure 6: Nicky Case's explorable 'The Wisdom and/or Madness of Crowds' [Case, 2018]

2.2.4. Reading & Writing

As we stated in the last section, interactive visualizations require great costs to make. Let's take for example Nicky Case's explorable "The Wisdom and/or Madness of Crowds". Creation of such interactive experience required great storytelling, good knowledge of the domain - in this case based on Surowiecki's *The Wisdom of Crowds*, designer's skills and programming skills. In many interactive experiences like these, all these skills are to be found within a single author. The process of the creation includes the multitude of activities and they significantly diverge from the mere activities of reading and writing that we focus on in this work. Our aim is to make comprehension more efficient overall, not just within one particular community or a field, but as a part of everyday general practice. We intend to empower an individual through a tool for mass production of such "interactive visualizations".

On the other side of the spectrum we can put minimal text editing interfaces - editors and word processors such as Google Docs which are based on a basic action of typing characters into the structure of lines. However artifacts made by these tools such as traditionally written documents, articles and books require reader's patience and imagination within the process of translation. To understand the process of reading we refer to the model of text comprehension by Kintsch and Dijk. In this model we comprehend the text [18] by infering a set of propositions from it. Propositions are ordered based on the order in which we inferred them from the text. An information we infer is coherent only if propositions are connected. A structure that results from the connections is what Kintsch and Dijk call *coherence graph* [19]. Certainly, this whole process of creating propositions and their graph takes mental effort and energy each time we read. One specific idea

[18] What we refer to by the term of 'text' here is set of linguistic signs, words organized orthogonally, i.e. in lines from top to the bottom or vice-versa or columns left to the right or vice-versa

[19] Walter Kintsch and Teun A. van Dijk. Toward a model of text comprehension and production. *Psychological Review*, 85 (5):363 – 394, 1978

that we are exploring is what could possibly happen if we could see such coherent graph already and possibly make the process of inferring it from the text into our conceptual mental model seamless and much more efficient. How could we alter the activity of writing in a way that it would create such 'readable graphs' which would be easier and more efficient for a reader to read and comprehend?

The process of writing envelops much greater complexity then reading.

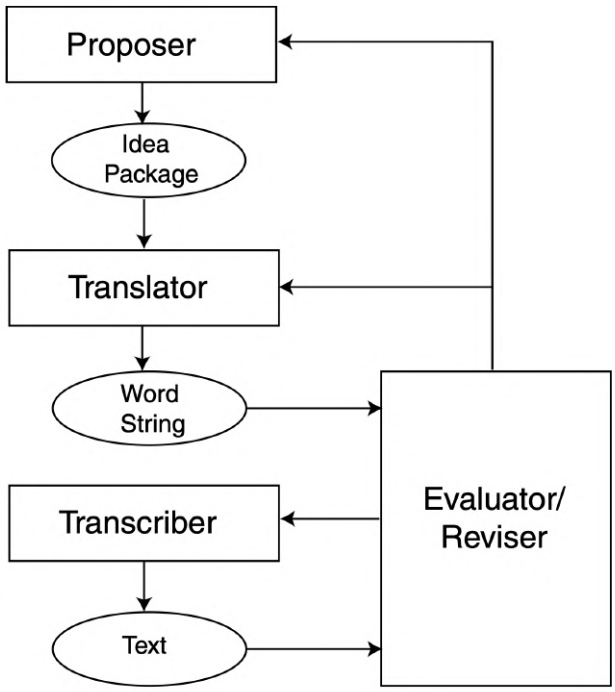


Figure 7: Hayes' Model of text production [Chenoweth and Hayes, 2003]

In the model proposed by Hayes [20] we can see a distinction between 4 processes of proposing, translating, transcribing and revising [21]. In the diagram we see a different roles following these partial processes in the activity of writing. We can almost distinguish a certain mirrorized structural similarity to the activity of reading. While when we read we infer propositions from different text bases, here we start by proposed ideas - propositions that we later on translate into individual strings - sentences which are then transcribed into a text. These sets common structural qualities for the way we access and archive knowledge within our minds.

The model of writing as a knowledge-constituting process frames the activity even further [22]. It describes writing through a dual process-model of *knowledge retrieval* and *knowledge constituting*. In it knowledge retrieval stands for "retrieval of already formed ideas from an explicit

[20] N. Chenoweth and John Hayes. The inner voice in writing. *Written Communication - WRIT COMMUN*, 20:99–118, 01 2003. DOI: 10.1177/0741088303253572

[21] N. Chenoweth and John Hayes. The inner voice in writing. *Written Communication - WRIT COMMUN*, 20:99–118, 01 2003. DOI: 10.1177/0741088303253572

[22] David Galbraith. Cognitive models of writing. *German as a foreign language*, 01 2009

store of knowledge", or "manipulation of ideas prior to translating them into text". Knowledge constituting is the process of synthesizing of content into graphs of connections between subsymbolic units. In other words, besides our own mind, we introduce explicit stores of knowledge from which we infer our propositions. In Galbraith's *Cognitive Models of Writing explicit store* of knowledge stands for the knowledge stored in the long term memory. We would like to extend the understanding of the process by interpreting "explicit stores" as the sources we use during writing which exist out of our minds. The process of accessing such other explicit sources happens in the activity of reading. We read in order to write and we can suddenly see how tightly interconnected the process of reading is to writing. We can leave the process of storing what we read into the long term memory and translate it directly into the knowledge we are constituting by writing. **This way something is written affect the way we write about it in much greater way as the both activities happen within a single time frame.** The activity of reading can also stimulate our imagination in order to generate fleeting thoughts that are immediately captured, written. Similarly, in the process of reading, our own memory limitation can induce us into the process of noting - writing. Being primarily in the activity of reading, we write in order to preserve propositions that we did infer from the text. One activity supports the other. The alternating processes of reading and writing can therefore remind us of a conversation rather than two separate activities. This furthermore resonates with the Polya model that we mapped to internal representations. We can understand querying analogically to reading and infering propositions, setting hypothesis to writing and setting propositions and checking to revising / evaluating.

Understanding the activities of writing and reading as inevitably intertwined as an overarching activity of communication and coherence graphs as a mental model in which we connect propositions inferred from and to text, we wonder: Is there a way to substitute text as a set of lines consisting of words by graph structures? The most notoriously known application for creating such structures is mind mapping.

2.3. Progressive Disclosure

In the previous section we explored the notion of graph as a fundamental structure for internal representations of thoughts and here we are going to explore why don't we utilize this structure as fundamentaly in our daily and written communication. We are also going to set a hypothesis of what could possibly allow us to better utilize its potential and reduce cognitive load of translation and inferring. The apparent neglect of graph structures as forms of expression is foreshadowed

within the neglect of the meaning of graph itself. When we speak of graphs colloquially we often refer to charts or in mathematical context - visual representation of function within cartesian coordinates. However, even in mathematics the term has its different and specific definition as an ordered pair of two sets:

$$(V, E)$$

1. Set of nodes - V
2. Set of edges - E

These two sets define the *graph* or what we generally understand also as *network*. Even though, it's important to note that *network* has a slightly different meaning in mathematical context. We could speculate that the use of the term *network* distracts us from the structural properties of graphs and redirects our attention to the flows in between the network nodes.

2.3.1. Trees & Networks

The most notoriously known application of graph structure within the context of communication is the idea of mind maps. We could trace the conceptual idea of mind mapping and its precursors back to the mythology of tree.

A tree as a fundamental mythical symbol for western and christian tradition served to depict arrangements of family ties, human understanding and evolutionary development between species. This was due to its feature of branching - each structure of branch could consist of and refer to its substructures. In 18th century the structure of tree found its marriage with the desire to gather and sum up all of the human knowledge - the field and movement of encyclopedism. The most notable effort of this union is *Systéme figuré des connaissances humaines* by Diderot and d'Alembert from 1751. Diderot understood the encyclopedia above all as a directory of associations, as a general system for organization and transmission of knowledge.

In fact, Diderot with some of his points foreshadows the notion of hypertext. Diderot stresses out the importance of more loose structure of organization through *renvois* or cross-references, suggesting even that cross-references are the most important part of encyclopedia. The usefulness of cross-references has been already known by many in that time, however what Diderot sees is the potential in which they can create meaning themselves [23]. He doesn't talk about them only in the sense of organizing the content, but suggesting that they themselves and their cohesion can create meaning - closing the gaps between

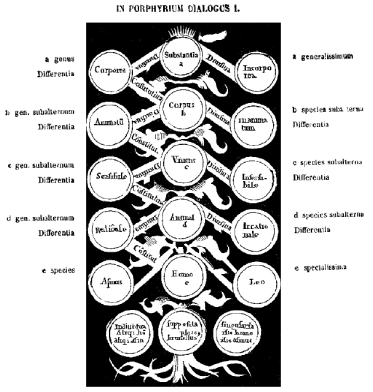


Figure 8: Porphyrian tree - one of the earliest preserved examples of tree classification[Boethus, 6th century]

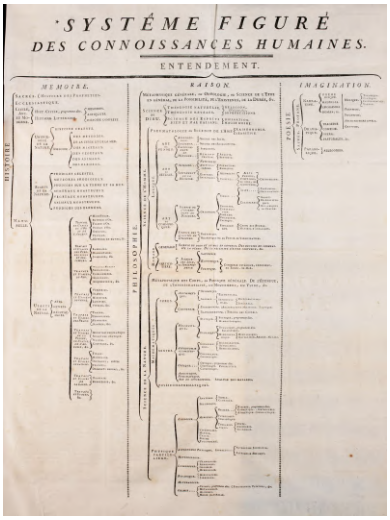


Figure 9: Figurative System of organisation of human knowledge from Diderot's and d'Alembert's Encyclopédie[d'Alembert Jean and Diderot, 1752]

[23] Geoffrey Rockwell. Diderot and hypertext; dreaming the circle of knowledge, 01 1999. URL https://geoffreyrockwell.com/publications/Diderot.Hypertext.pdf

propositions widely separated across different books and pages and providing different paths of understanding.

The idea of a loose structure is something that has been foreshadowed by Diderot and has drawn attention in recent years as an alternative to rigid hierarchies of taxonomy. The term *folksonomy* was coined in 2004 by Thomas Vander Wal to denominate loose social classification or what we know under the term of *social tagging* [24]. While taxonomies suffer from their rigidity and inability to change in time, folksonomies are often criticized to be too loose for any valuable structure of organization. Another one of the crucial points implied by Diderot and referred also by Ted Nelson is separation of intellectual structure from its material organization - something that we are going to return to in the end of the section.

In the awake of structural linguistics and structuralism within the landscape of postmodern thought a critique of tree structures and especially their top-down hierarchy and essentialy centralization has became much more present. Especially within the new rhizomatic model of Deleuze and Guattari, the tree became symbol of totalitarianism, despotism and unidirectional progress. A concept of rhizome was meant to acknowledge multiplicities and multilinearities of a complex world. A shift from trees to networks was sealed.

[24] M. Lima. *Visual Complexity: Mapping Patterns of Information*. Princeton Architectural Press, 2013. ISBN 9781616892197. URL https://books.google.pt/books?id=59xlmQEACAAJ

2.3.2. Mind Mapping

Mind maps as we know them today conceptually experienced their advent within the times of aforementioned developments in 1960. The concept have been experimented with and find its use within multiple fields such as linguistics, semiotics, psychology, computer science and pedagogy. A notable synonymical precursor is the notion of *semantic network* - a knowledge base representing relations between concepts. Semantic networks have been conceived to map human learning and later on implemented within circles of computational linguistics for the use of machine translation between languages in early 1960s, most notably by Allan M. Collins. The more generic term *mind map* came to prominence after being popularized by British psychology author Tony Buzanin 1974 BBC TV series *Use Your Head* [25]. Another significant branch of research on graph diagrams was Joseph Novak's concept maps in 1972 [26]. The main context of Joseph Novak's concept maps has been communicating science knowledge to students. While mind map focuses on one concept that it explains or branches, concept maps represent relations between different concepts. Topic map, a subgenre of concept map, is a more specified diagram, representation of knowledge in which we distinguish between nodes that represent topic - a concept and nodes that refer to the topic's specific occurence

[25] Wikipedia. Mind map — Wikipedia, the free encyclopedia. http://en.wikipedia.org/w/index.php?title=Mind%20map&oldid=991253455, 2021c. [Online; accessed 16-January-2021]

[26] Karoline Afamasaga-Fuata'i. *Concept mapping in mathematics. Research into practice*. New York: Springer, 01 2009. ISBN 978-0-387-89193-4. DOI: 10.1007/978-0-387-89194-1

[27]. We are also familiar with modelling graphs, such as UML diagrams which utilize much more structured model of organization. Besides that there are also other kinds of diagramming such as "idea mapping" or "visual thinking" [28], however we won't describing their specificities as we approach the topic of mind mapping from much more general perspective.

We talk about mind maps as the most common domain for writing graph structures, yet they do not fully reflect the activities of writing and reading, mainly because they serve for the purpose of organization. To provide clear understanding of our goals, we would like to set a distinction from traditional mind mapping software, which, needless to be said, has its own distinctive usefulness and purpose, but provides a good reference for our research.

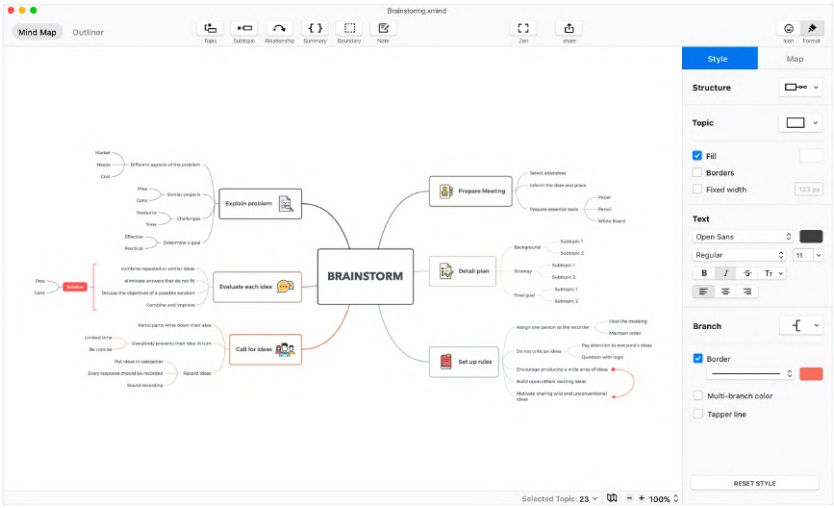


Figure 10: User interface of XMind mind-mapping software

What we find critical is the emphasis on the process of writing. Traditional mind-mapping software as we know it fragments the activity of writing, turning it into a designing. Instead of following and staying within our thought flow, we are interrupted to make decisions on the spatial placement of our written fragments, the types of boxes we can put them into or types of connections and all kinds of other visual attributes. Necessary to be said, it can be often the extent of these visual attributes which can distract the writer in the process of their constant configuration and lead to what we know as *analysis paralysis*. Certainly, if our goal is to create a tool that could embrace graph structures instead of horizontal lines for the organization of word and text, it's difficult not to glide into the activity of 'designing', asking the user each time where to put the textual fragment. The question we are asking and exploring is however: Could we design the interaction in such way that the spatial positioning is seamlessly integrated within the process of

[27] Wikipedia. Concept map — Wikipedia, the free encyclopedia. http://en.wikipedia.org/w/index.php?title=Concept%20map&oldid=999641308, 2021a. [Online; accessed 16-January-2021]

[28] B. Moon, R.R. Hoffman, J. Novak, and A. Canas. *Applied Concept Mapping: Capturing, Analyzing, and Organizing Knowledge*. Taylor & Francis, 2011. ISBN 9781439828618. URL https://books.google.pt/books?id=GhrOBQAAQBAJ

writing itself? This presents a challenge especially when we talk about non-linearity and multiplicity of possible paths which we are going to refer to later as well. One way to resolve this would be to introduce fixed positioning and branching which many mind-mapping tools utilize. This however completely neglects the freedom and expressiveness of spatiality and the potential of its variability - each map having the same spatial organization. Another important issue that we could pay attention to is portability. Portability within itself - copying and pasting parts of graphs internally as well as within external digital environment (web, OS). Mind-mapping software usually features a way to export the map into a common format such as *.pdf or a graphical format such as *.png. This however represents a challenge as the exported map can't be changed. For the original format in which the software saves the map one needs the specific software to access it. What is possible to explore is the possibility of using a format that is already generally accessible and that can also provide features of interactivity when viewing the map.

Seen as notable necessity is also the collaborative dimension which expands the way we design the artifact itself. With the rapid growth of interactive web applications, this is something we could notice being more and more inevitably present in our daily work standards through tools like Metamaps.cc or Miro.com.

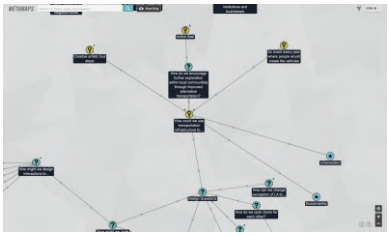


Figure 11: Open-source platform for collaborative visual mapping - Metamaps.cc

What is to be the most important realization however, has been the personal encounter with teachers and professors of applied mathematics on the university of Prague. Upon showing their tool OrgPad applied on the field of linear algebra and one of the earlier version of the map - a perception gave us an insight. Seeing countless nodes, concepts and connections in between of them the so desired goal of rapid comprehension through immediately recognizing a pattern of cognitive metaphors was nowhere to be near what was actually experienced. A sensation of appreciation and admiration, but at the same time confusion, disillusionment and overwhelment is well remembered. Put in layman's terms - if one were able to learn what linear algebra is about, what it entails, one wouldn't know where to start. Underlining the fact that the map itself served rather an organizational purpose of existing fragments a direction has been set - to optimize the experience of reading.

2.3.3. Instant Gratification

As an important contextual aspect of progressive disclosure we would like to briefly introduce the viewpoint of instant and delayed gratification. The instant gratification refers to the strategy or tendency of obtaining a less rewarding, but more immediate benefit over a future

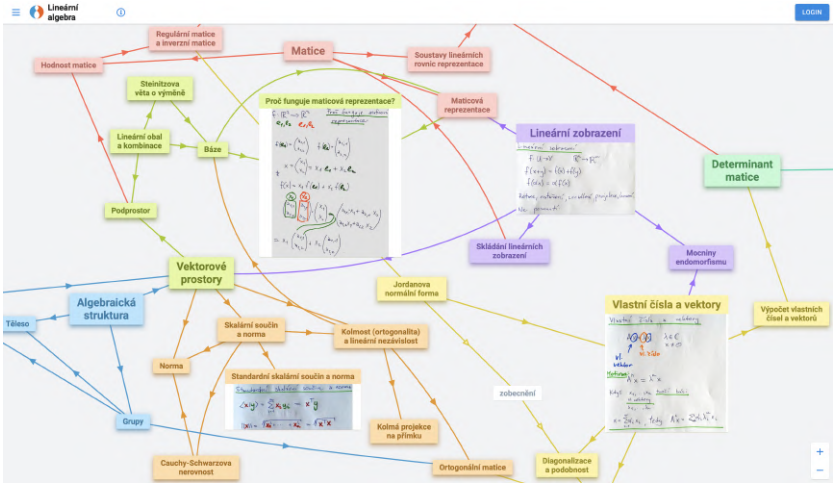


Figure 12: User interface of XMind mind-mapping software

one [29]. Similarly, delayed gratification refers to its opposite. It became much more apparent in 2010s with the wide spread of social media and their efforts to tighten the temporal gap within the user's feedback loop. The instant gratification however existed already before and with the emergence of internet it rapidly affected our behaviour. As the temporal gap between action and reward was diminishing, activities with the same temporal gap - such as reading became, in comparison, much more laborious. In the activity of reading the prospect of cognitive reward is uncertain and only comes after some duration of the activity, while in engagement with interactive content, and let's take for example social media - the reward of social approval can be expected immediately and doesn't require continuous involvement after initial action apart from reading. Many who understand the inevitability of consequences of this mechanic return to the forms of delaying that kind of gratification (by e.g. turning off notifications, uninstalling mobile apps etc.) and in more extreme cases find themselves in opposition to the current trend of technological progress. What is our intention in this paragraph, is to set our look into the opposite way of solving this disproportionality. Accepting the inevitability of the dynamic of emergence of contexts, especially within the activity of reading, which support our tendency to instantly gratify ourselves instead of following path of rather laborious efforts and delayed gratification, we would like to emphasize our aim of narrowing the gap between act of reading and cognitive joy it provides. Instead of rejecting and opposing the existence of contexts for instant gratification, we would like to narrow the gaps in activities that matter for us more.

[29] Courtney E. Ackerman. What is instant gratification? a definition. https://positivepsychology.com/instant-gratification/, 12 2020. [Online; accessed 16-January-2021]; and Wikipedia. Delayed gratification — Wikipedia, the free encyclopedia. http://en.wikipedia.org/w/index.php?title=Delayed%20gratification&oldid=999818207, 2021b. [Online; accessed 16-January-2021]

2.3.4. Progressive Disclosure

One interaction design technique that could solve the aforementioned problems of overwhelment and lack of reading guidance we did find in mind maps is progressive disclosure. As the name suggests, the technique *discloses information progressively*, reducing the overall cognitive workload and helping the user e.g. habitually adapt to a new interface or environment by revealing only what are the necessary features while leaving any advanced functionality hidden. In one of the formal definition it stands for "moving complex and less frequently used options out of the main user interface and into secondary screens". A common application of progressive disclosure is so called *staged disclosure* also known as *responsive* and mostly familiar by as a "wizard", step-by-step interface. Another example is the splitting of long article into multiple pages which extends the time spent on the website and allows the publisher to show more advertisements [30]. An important part of the progressive disclosure technique is an offer of a good teaser such as a sample of what is next. An article splitted into multiple parts serves both of the functions of being a teaser and a content.

[30] Frank Spillers. Progressive disclosure. https://www.interaction-design.org/literature/book/the-glossary-of-human-computer-interaction/progressive-disclosure, 2021. [Online; accessed 16-January-2021]

Returning to our diagrams of mind and concept maps, one would think that exploration of all kinds of possible models in which our propositions could be layered and organized to utilize the technique of progressive disclosure could be a way to more closely fulfill the needs within the particular situated contexts of their use. Yet creating specific models and functionality for various kinds of customizable spatial organization with progressive disclosure could clutter the tool itself with different models of complex rules which were to be followed in a similar way as countless visual attributes that we were speaking of and would not solve the problem we intended to solve. On of our goals within this work is to find a single, subtle yet universal way of progressively disclosing the content along the temporal direction of a reader. A potential way in which the graph structure of concept or mind maps could reflect this would be to let them reveal themselves node by node upon an optional user interaction. In this way the concept map could present, "tell a story" of the subject it concerns, write about. Such a map does not serve the purpose of organization anymore, but represents the content itself in the act of storytelling. It could provide greater empathy for the reader through not overwhelming them with information, but staying in dialogue-like interaction, allowing the reader to stay in control of the amount of information they consume.

Certainly, there are other ways in which progressive disclosure could be applied on graph structures and diagrams such as concept maps. Our intention here was to draw a close connection between what we know as mind and concept maps to a much more empathetic form of

communication such as storytelling. A question that is left unanswered is whether such change could actually alter the genre of concept map from clusters of keywords into a story-resembling artifact. For that a better, literary understanding of what we mean under the term 'story' is necessary.

2.4. Non-linear Storytelling

The word storytelling in the title of this work is together with the notion of nonlinearity purposefully provocative. We could have chosen to talk of *narrative*, but we chosen the word *storytelling* to emphasize a performative, subjective and participatory aspect of human investment within the activity. This has the potential to make the activity more relatable. In our preliminary informal practical observations, we found that users, given a possibility of creating textual graph structure, regularly went for preconceived notions of concept mapping or mind mapping. Our hypothesis is that the activity of storytelling and the genre of story is one of the most generally known and relatable mode of communication. We believe that it could give so much needed semantic framing to the interface that facilitates creation of graph structures and consequentially disrupt the preconceived notions of graph structures as something that exists only within the genres of mind or concept mapping and rather technical fields. In this chapter we explore the literary challenges of nonlinearity as an attribute of narrative device and describe contexts for literary materialization of text within the cyberspace.

Cambridge dictionary defines story as *a description of a series of events*. It states the same definition under the term *narrative* [31]. When we look on the etymology of the word, we can see it comes from the ancient greek *historía* which is much more tightly connotated with knowledge - "narration of what is known, learnt". The word *historía* came from ancient greek verb that means "to know" and refers not only to the act of research inquiry, but also to the knowledge itself that results from it which we can perceive tightly coupled with the notion of recording, archiving that knowledge - "a learning or knowing by inquiry; an account of one's inquiries; knowledge, account, historical account, record, narrative" [32].

When treating the notion of story within its literary context we often find various definitions referring to the particular elements of story which define it, such as *setting*, *character*, *plot*, *conflict* and *theme* or *beginning*, *middle* and an *end* [33]. In this work we approach the concept of story from much broader standpoint. We do stick to the interpretation of story as a description of series of events. We emphasize the aspect of description that involves the subject as an inseparable part of the functional organ of story. The ambiguity that comes with this definition

[31] Cambridge University Press. Story, 2021d. URL https://dictionary.cambridge.org/dictionary/english-portuguese/story

[32] Douglas Harper. History, 2021a. URL https://www.etymonline.com/word/history?ref=etymonline_crossreference

[33] T.R. Sarbin. *Narrative Psychology: The Storied Nature of Human Conduct*. Praeger Special Studies. Praeger Scientific. Praeger, 1986. ISBN 9780275921033. URL https://books.google.pt/books?id=OJFrAAAAIAAJ

allows us much more expanding range of artifacts that can be produced with the tool and change that we want to instill as we will see in the last section. In this way, everything that is sequentially organized on a linear dimension of time as a series of events can be a story. Or as Maggio has put it, "Everything can be a story, if only because everything is an outcome of a process" [34].

A story could be treated as universal object of knowledge transmission. A particularly important research has been conducted by the team of Uri Hasson. An existence of speaker-listener neural, brain-to-brain coupling has been described [35]. This has been observed in particular within the communication through stories [36]. The brain activity of both a speaker telling an unrehearsed real-life story and a listener was recorded. Sequentially, an assessment of listeners' understanding of the story was conducted after the act of listening. The dynamic model of neural coupling between speaker's and listener's brains revealed joint, temporally-coupled, response patterns [37]. What we find important is that this coupling has been observed on the level of words. An interpretation is offering itself and thus whether we couldn't understand the process of storytelling as an alignment of structures of internal representations - coherence graphs of propositions between the speaker, storyteller and listener which we discussed in the section on cognitive modelling.

Findings of Uri Hasson and his team make us believe in the potential of story to be what we call an *epistemic object / boundary object*. An object is what we call a generator and foci of attention, movivation and meaning [38]. With and through object an activity is conducted. Object is therefore something that can be looked at, picked up, used within the level of activity. An *epistemic object* is what we call an underdefined, unfolding object of investigation and inquiry [39]. The aim for a story to be an epistemic, incomplete object renders itself important when we are going to speak about ergodic text. To clarify the use of terms we also denote artifact to be an object designed by humans intended to serve a particular purpose.

Besides the perspective of seeing the graph story as an epistemic object, we also understand its potentiality to be what we call a *boundary object*. Boundary objects mediate transmission of knowledge and interaction between distinct epistemic communities and fields.

We can treat a story as a general boundary object that serve different communities, e.g. scientific research can be retold as a story, mathematical proof can be told as a story, an invention can be retold as a story, an event can be told as as story etc. A story also gives us ability to transmit and communicate both fictional and non-fictional information - which allows to understand and envision knowledge collectively [40].

As already hinted on our preference for the word *storytelling* that

[34] Rodolfo Maggio. The anthropology of storytelling and the storytelling of anthropology. *Journal of Comparative Research in Anthropology and Sociology*, 5:89–106, 2014

[35] Greg J. Stephens, Lauren J. Silbert, and Uri Hasson. Speaker–listener neural coupling underlies successful communication. *Proceedings of the National Academy of Sciences*, 107(32):14425–14430, 2010. DOI: 10.1073/pnas.1008662107

[36] Rodolfo Maggio. The anthropology of storytelling and the storytelling of anthropology. *Journal of Comparative Research in Anthropology and Sociology*, 5:89–106, 2014; and Uri Hasson, Michal Harel, Ifat Levy, and Rafael Malach. Large-scale mirror-symmetry organization of human occipito-temporal object areas. *Neuron*, 37:1027–41, 04 2003. DOI: 10.1016/S0896-6273(03)00144-2

[37] Uri Hasson, Asif Ghazanfar, Bruno Galantucci, Simon Garrod, and Christian Keysers. Brain-to-brain coupling: A mechanism for creating and sharing a social world. *Trends in cognitive sciences*, 16:114–21, 02 2012. DOI: 10.1016/j.tics.2011.12.007

[38] Yrjö Engeström. The future of activity theory: A rough draft. *Learning and Expanding with Activity Theory*, 01 2009. DOI: 10.1017/CBO9780511809989.020

[39] Jiayuan Liu. Trust trigger and knowledge elicitor: The role of epistemic objects in coordinating the fragmentation and heterogeneity of knowledge in digital innovation networks. *Knowledge and Process Management*, 26, 11 2019. DOI: 10.1002/kpm.1613; and Boris Ewenstein and Jennifer Whyte. Knowledge practices in design: The role of visual representations as 'epistemic objects'. *Organization Studies*, 30:7–30, 08 2009. DOI: 10.1177/0170840608083014

[40] Y.N. Harari. *Sapiens: A Brief History of Humankind*. Harvill Secker, 2014. ISBN 9781846558238. URL https://books.google.pt/books?id=B4ARBAAAQBAJ

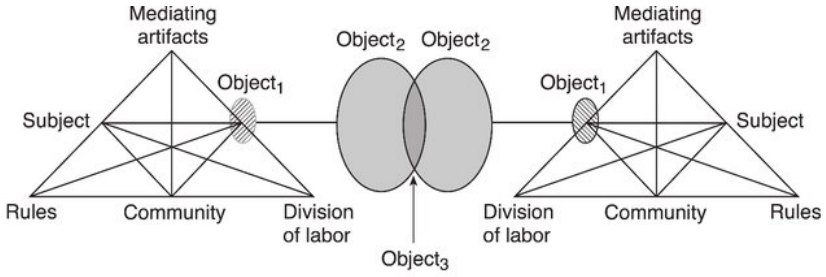


Figure 13: Boundary objects anchoring two different communities as translation and transformation devices [Barnard, 2010]

underlines a human involvement, we clarify the human involvement in analogy to Kaptelinin notion of *functional organs* from within the framework of *activity theory*. In Kaptelinin's definition a functional organ stands for "functionally integrated, goal-oriented configurations of internalized operations and external mediation" [41]. If we understand particular information, information space as a particular *artifact* or set of external artifacts, we could understand a subjective *embodiment* within them as a functional organ of *story*. Similar analogy of understanding technology as a prosthetic extension of one's body we can find in Wigley's *Prosthetic Theory* [42]. A story could be this way looked upon as a technology of communication. We could argue whether propositions which we infer from factual information space that we work with are actually being arranged within a story, but for the rationalization of the role of subject in storytelling it serves as a metaphorical reference. In this way we understand story as "a dialectical concept that encompasses both subject and the artifact" [43] - a story as an object that does not exist without its storyteller. We could also argue whether the actual storyteller in our provisional illustrative model is the author (writer) or the reader. Is the story told and created from factual or evocative propositions in the act of writing or is it created in the process of inferring propositions from the text? Does the whole process of transmission involve a single story or a two separate stories which share a common information space?

The greater involvement of the reader in the activity of reading has been a forming trait of postmodern literature. The emergence of this shift was expressed in Barthez critique Death of the Author [44]. Barthez critized a form of literary criticism in which author's context and biography are incorporated within the interpretation of their text. He argues that the writing and its author can very well be unrelated. Setting the terms "writerly" and "readerly" he distinguishes between the texts which conception is tightly intertwined with their author (writerly) and between texts that "*can be read, but are not written*" (readerly). In readerly texts reader assumes a new role between the author and the text. A reader is invited to interpret events and their

[41] Susanne Bødker and Clemens Klokmose. The human–artifact model: An activity theoretical approach to artifact ecologies. *Human-Computer Interaction*, 26:315–371, 12 2011. DOI: 10.1080/07370024.2011.626709

[42] M. Wigley. Prosthetic theory: The disciplining of architecture. *Assemblage*, page 6, 1991

[43] Susanne Bødker and Clemens Klokmose. The human–artifact model: An activity theoretical approach to artifact ecologies. *Human-Computer Interaction*, 26:315–371, 12 2011. DOI: 10.1080/07370024.2011.626709

[44] Julie Lindas. Engaging with postmodernism: An examination of literature and the canon. Master's thesis, University of Colorado Boulder, 2013

circumstances without giving a definitive answers. Moreover, a reader is often deliberately foiled by the text in their attempt of understanding it. Such active participation in the process of reading is also distinguished as *active reading*.

Expanding such classification to a continuous spectrum, we can trace whole range of texts based on various levels of involvement.

2.4.1. Immersion

To describe the levels of such involvement and participation within the activity of reading we explore the notions of immersion and interactivity. Maria-Laure Ryan takes these notions from the perspective of VR experience and applies them on literary texts textual features describing mapping between literary and technological domain [45].

> The more realized the immersive environment, the more active we want to be within it [46].

We draw our understanding of what *immersion* means from the metaphor "text as world". It comes from the crucial analogy in which the experience of absorption in the virtual reality is compared to the experience of reading.

A story, description, text is immersive enough to suspend its reader in its own **imagination**. This comes without a delibarate effort of the reader. As Italo Calvino describes it, the transition into textual reality is a solemn event of relaxation and absorption, an embarkment onto a voyage [47]. What are therefore the features of text which define its "immersivity"? Marie-Laure Ryan suggests an existence of *expanse* that one has to be immersed within. Such textual expanse has many conceptual analogies being seen as game, network or assemblage. This expanse could be understood as an expansion on existing semantic domain of the text. Semantic domain is a set of related meanings we envision within our imagination as we read the text - a sequence of signs. These domains though similar, could be affected by our subjective, cultural and social experiences.

Marie-Laure Ryan speaks of three types of immersion: 1. spatial, 2. temporal and 3. emotional. For the reasons of complexity they themselves involve, we are going to touch only upon few of their features. Spatial immersion is described as a result of "madeleine effect", also more formally known as involuntary memory. An involuntary retrieval memory is triggered by the chain of signs we as a reader consume, read. For the purpose of our work, we can infer that such kind of immersion is therefore a result of dialectical process involving both reader and writer. This also aligns with the view in which immersion is seen as a coincidental resonance of the text with the reader's memories

[45] M. Ryan. Immersion vs. interactivity: Virtual reality and literary theory. *Postmodern Culture*, 5:–, 1994

[46] Janet Horowitz Murray. *Hamlet on the holodeck: the future of narrative in cyberspace*. Simon and Schuster, 1997. URL http://books.google.com/books?isbn=0684827239

[47] M.L. Ryan, Johns Hopkins University Press, and ProQuest (Firm). *Narrative as Virtual Reality: Immersion and Interactivity in Literature and Electronic Media*. Parallax (Baltimore, Md.). Johns Hopkins University Press, 2001. ISBN 9780801864872. URL https://books.google.pt/books?id=cjAWAQAAIAAJ

than a denomination of properties of the world described. It's the non-relatable and exact definitions which do not trigger any memories or imaginations at all.

For the better illustration of the feature of spatial immersion we include a passage from Alain Robbe-Grillet's Labyrinth that actively tries to inhibit it:

> "I am alone here now, under cover. Outside it is raining, outside you walk through the rain with your head down, shielding your eyes with one hand while you stare ahead nevertheless, a few yards ahead, at a few yards of wet asphalt; outside it is cold; the wind blows between the bare black branches; the wind blows through the leaves, rocking whole boughs, rocking them, rocking, their shadows swaying across the white roughcast walls. Outside the sun is shining, there is no tree, no bush to cast a shadow, and you walk under the sun shielding your eyes with one hand while you stare ahead, only a few yards in front of you, at a few yards of dusty asphalt where the wind makes patterns of parallel lines, forks, and spirals." (Alain Robbe-Grillet - In The Labyrinth).

The text, although it describes very well the atmosphere, it fragments the scenery into repetitive pieces which fragment and interrupt our imagination.

One way to stimulate the immersion is inclusion of famous real places such as Venice, Geneva, California, New York etc. Proust talks of longing and desire they can catalyze which drive and transform into the imagination [48]. It can be noticed that this happens particularly for readers who haven't visited these places, as if a degree of ambiguity could offer them freedom in their fictional depiction. In this particular example we can see how the function of naming is not to denominate the properties of the objects, but to *call them into an existence*.

Temporal immersion is described as a reader's desire for the knowledge within narration. An important relation is the inverse proportion between the range of possibilities in which the narrative can go and the intensity of suspense which drives temporal immersion. The less possibilities for the narrative, the greater the suspense.

We can see how both spatial and temporal immersion are impositions of order, yet only to an extent that allows the existence of fantasy, maintaining the story inconclusive. We see the dynamic of the story therefore as continuous change of how much order is being imposed and how much of it is left incomplete.

2.4.2. Interactivity & Play

Similarly as with the "Text as a world" metaphor, the concept of interactivity presents itself with its own "Text as a game" metaphor. Yet the notion of *game* or *play* as an activity contains much greater complexities [49].

[48] M. Proust, C.K. Scott-Moncrieff, and S. Hudson. *Remembrance of Things Past*. Number vol. 2 in Classics of World Literature. Wordsworth Editions, Limited, 2006. ISBN 9781840221473. URL https://books.google.pt/books?id=PSmIRcmLPSQC

[49] Often, to simplify the discourse within the context of game design a more specific notion of *playfulness* is used.

Playfulness can be understood as a willing positive attitude that faciliates what is called a *playful play* and consequentially creativity itself

Patrick Bateson and Paul Martin. *Play, Playfulness, Creativity and Innovation*. Cambridge University Press, 2013. DOI: 10.1017/CBO9781139057691

Merriam webster dictionary defines game as "activity engaged in for diversion or amusement" [50]. On another place we can find game defined as a structured form of *play*. Speaking of fun or amusement as an objective of play, Huizinga in his Homo Ludens specifically points out "...the fun of playing resists all analysis, all logical interpretation" which underlines the ambiguity of the concept.

In the book he identifies 5 characteristics of play, namely:

1. it is a free activity
2. it exists outside of ordinary life (not real)
3. it exists outside of ordinary life in regard of the location and duration
4. it creates an order (it demands absolute and supreme order)
5. it is an activity of no material interest nor profit

which then leads him to summarize the definition into "a voluntary activity or occupation executed within certain fixed limits of time and place, according to rules freely accepted but absolutely binding, having its aim in itself and accompanied by a feeling of tension, joy and the consciousness that it is 'different' from 'ordinary life'" [51].

A different, yet related take on the activity of play can be found in the Wittgenstein's inquiry of language games in which interpretation, meaning of word, a sign is an object of playing as illustrated in his guessing game [52]. In such game a meaning that is hidden, internal, perceived as ambiguous becomes object of wonder, curiousity and guessing - an object of desire.

Following the inclusion of desire and therefore more closely a subject's role in the definition of play, we can look upon the following Heidegger's definition. In an effort to draw a distinction from Freudian notion of play as an effort to *master one's past traumatic events* and its focus on past, the German phenomenologist describes play as an activity of projecting one's future, seeking thrill and amusement in the act of exploring possibilities.

This is done in the process of sense-making of the world around to escape the anxiety of unknown [53].

We do take note on the word "projection" which suggests an existence of internal tension which manifests through an action. This tension however doesn't have to be a result of an event in the past as Heidegger notes, but rather a discrepancy between an expectation and reality, in this general case - an expectation of familiarity and reality of the unknown.

The way in which enjoyment is 'derived' could also be seen in the context of lacanian clinical structures applied in the activity of playing. In the perverse clinical structure, the enjoyment of playing is derived

[50] Merriam-Webster Online. Merriam-Webster Online Dictionary, 2009. URL https://www.merriam-webster.com/dictionary/game

[51] J. Huizinga. *Homo ludens-a study of the play element in culture*. Beacon press, 1950

[52] Ludwig Wittgenstein. *Philosophical Investigations*. Basil Blackwell, Oxford, 1953. ISBN 0631119000

[53] D.C. Morrison. *Organizing Early Experience: Imagination and Cognition in Childhood*. Taylor & Francis, 2019. ISBN 9781351842419. URL https://books.google.pt/books?id=4FoPEAAAQBAJ

from working through the game's rules and its structure. The enjoyment is derived not from transgression of the Law, game's rules, but by the act of their installation. The play turns into work. In case of neurotic clinical structure, the response to an impossible demand of the game is deferral of the possibility of enjoyment - also named as *interpassivity* - often put into an opposition to interactivity. The player explores the game or even creates their own rules indifferently of the original rules of the game - "avoiding the directed aim of the game". The work turns into play [54].

A more direct emphasis on the role of imagination of what it means is to be found in the journal of play where play is defined as an **externalization of imagination into action**. This resonates with our interpretation of Heidegger's definition. Imagination within the same context follows fulfillment of needs and therefore is moderated by them [55].

This interpretation of play as internalization of rules and externalization of imagination is present in Vygotsky, where Vygotsky defines play as a function of desire yet situated in an imaginary situation and performed within a certain set of rules [56].

Again, a tension between the two worlds - an internal and external can be noted. In fact, we could argue that while immersion is in fact is a willing imposition of an external world into our imagination, interactivity allows an experience in which we are aware of both the external, virtual world and our own internal one within a particular set of rules which the activity of play defines. More so, in the act of play - it allows us to participate, to form a completely new world.

Janet Murray describes the ideal of immersive interactivity reliable on what she defines as the existence of *multiform plot* or *storytelling system*. These are "collections of textual fragments and combinatory rules which generate narrative meaning for every run of the program" [57]. Such runs are influenced and caused by the user's actions. These generate new and new combinations which however in the end always create narratively meaningful picture.

[54] Sarah Thorne. *The Shape of Games to Come: Critical Digital Storytelling in the Era of Communicative Capitalism*. PhD thesis, Carleton University, 2018

[55] Signe Juhl Mo ller. Imagination, playfulness, and creativity in children's play with different toys. *American Journal of Play*, 7:322–346, 2015

[56] L. S. Vygotsky. *Mind and society: The Development of Higher Mental Processes*. Harvard University Press, Cambridge, MA, 1978. URL http://www.learning-theories.com/vygotskys-social-learning-theory.html

[57] Janet Horowitz Murray. *Hamlet on the holodeck: the future of narrative in cyberspace*. Simon and Schuster, 1997. URL http://books.google.com/books?isbn=0684827239

2.4.3. Reading & Writing

Let's summarize our theorizing on immersion, interactivity and play within the context of reading and writing. Following the metaphor "Text as a world" - we interpret reading as an immersion, absorption into a world - a subject enters the room and "reads" its contents. Yet it is in the act that aims to realize subject's fantasy within the imposed order of rules when the subject starts to participate in the shaping of the contents of the room. Didn't subject started to take such participation when they entered the room however? Wasn't the act of entering already an

interactive act of play? Here we can see how the boundaries between reading and writing starts to blurry. Isn't the choice of which worlds do we allow ourselves to immerse into writing? We "write" our choices into the system which then can shape itself accordingly. Similarly, looking from an opposite perspective, we can argue - to receive an incentive to write we have to read - which can already be understood as a form of participation.

Similarly, when we were speaking about cognitive processes we described writing as a process of knowledge retrieval and knowledge constituting. Knowledge retrieval can be understood as an activity of reading - whether we read from an external source while we write, or directly from our memory. Similarly, while we read we utilize memory or we take notes to infer propositions from the content - we engage in the process of writing. This again underlies how related and almost temporarily indistinguishable both activities are.

In the example of Proust we could see how ambiguity of a specific, yet often for the reader unknown places within a literary text allows our imagination to freely participate in the creation of the world we envision in our minds. In the following chapter we will follow with our effort to try to situate and describe the conditions which incentivize readers to participate in the process of writing.

2.5. Territories of Participation

In his 2012 speech, Dan R. Olsen Jr. describes the concept of flexible storylines.

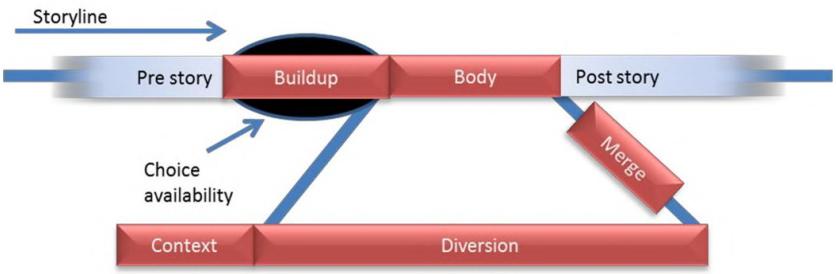


Figure 14: Structure of a flexible storyline [Romashka, 2011]

It does model a situation in which there is a possibility of choice for the viewer (reader) to learn more about something of their interest. This, even though is technically straightforward to implement presented the challenge in terms of content. What is to be created with it?

In a specific example Dan R. Olsen Jr. describes an effort to make the news interactive. He exploits the fact of how a 10 minute interview is being filtered into a 90 seconds slot. Given the possibility of choice,

viewer could be enabled to choose to learn more after seeing only a brief excerpt of the story. A viewer interested in the topic of e.g. budget could therefore skip the cuts they are not interested in and proceed seeing the full interview on budget. More interestingly however Dan R. Olsen Jr. describes prototypes in which they tried to introduce this possibility of choice. In the first prototype they introduced a sign on the screen that directed viewer to a new material, it was mostly ignored. In the second prototype they did, they did pick the same story and they found its CNN and Fox News versions. Then they teased them in the main story. This prototype succeeded in incentivizing viewers to deliberately choose to know more about those particular versions of the story [58]. Now, why did that happen? First of all, they were introduced as parts of the main story - they weren't framed as diversions from the main plot, but more as its extensions. Second, by providing an option to see two different narratives of the same story, they introduced a level of ambiguity. This incentivized viewers into the activity of sense-making [59].

A similar phenomenon is posed in Cybertext from Espen Aarseth when addressing Michael Joyce's hypertext literary work called *afternoon, a story*. The 'afternoon' is one of the earliest examples of hypertext fiction published in 1990 and written by Michael Joyce. While Espen Aarseth calls it a "game of narration" [60], Marie-Laure Ryan describes reader's motivation by the "desire to unscramble and put together the narrative body that comes to the reader in dismembered form" [61]. In *afternoon* the story is split into *scriptions*, fragments of text which however are introduced only as a result of reader's traversal. The reader's choice, participation has a direct impact on the formation of the narrative.

What's the state of the story before reader's interaction? Is it ambiguous? Is it in incomplete? Is it in the state of "superposition" in which all storylines are possible? Is ambiguity or even incompletion a major drive to sense-making and therefore participation on creation of the meaning?

[58] Dan Olsen Jr. Creating the digital future: the role of interactive systems, 05 2012. URL https://www.youtube.com/watch?v=XDLCaBe_UWo

[59] Benjamin Bart Sellers. A general framework for interactive television news. Master's thesis, Brigham Young University, 07 2012. URL https://scholarsarchive.byu.edu/etd/3357/

[60] E. Aarseth. *Cybertext: perspectives on ergodic literature*. University of Bergen, 1995. URL https://books.google.pt/books?id=VRnMPwAACAAJ

[61] M.L. Ryan, Johns Hopkins University Press, and ProQuest (Firm). *Narrative as Virtual Reality: Immersion and Interactivity in Literature and Electronic Media*. Parallax (Baltimore, Md.). Johns Hopkins University Press, 2001. ISBN 9780801864872. URL https://books.google.pt/books?id=cjAWAQAAIAAJ

2.5.1. Ambiguity

Ambiguity is a well-known concept in design. The word ambiguity consists of a greek prefix "ambi" which stands for "both" and the word "agere" that stands for "to drive" [62]. Invoking ambiguity in design can incentivize interpretation and thefore build personal relationship with the product or service [63]. W. Gaver & col. distinguish three types of ambiguity - in particular *ambiguity of information*, *ambiguity of context* and *ambiguity of relationship*. They describe *ambiguity of information* on the example of Mona Lisa's smile. Her smile, as is described, is purposefully blurred to allow indeterminacy and therefore let the portrait

[62] Merriam-Webster Online. Merriam-Webster Online Dictionary, 2021. URL https://www.merriam-webster.com/dictionary/ambiguity

[63] William W. Gaver, Jacob Beaver, and S. Benford. Ambiguity as a resource for design. In *CHI '03*, 09 2003

become a 'terrain of infinite variations' [64]. Apart from ambiguity of information, *ambiguity of context* is not present within the thing itself, but in the way the thing can be understood. One such example could be a Duchamp's Fountain. Duchamp challenged the context in which we are used to see an urinal, by turning it around and calling it a fountain - creating an ambiguity of context in which we can look upon an artefact from different perspectives.

[64] D. Sassoon. *Mona Lisa: The History of the World's Most Famous Painting*. Story of the Best-Known Painti. HarperCollins Publishers, 2002. ISBN 9780007106158. URL https://books.google.pt/books?id=5tynQAAACAAJ

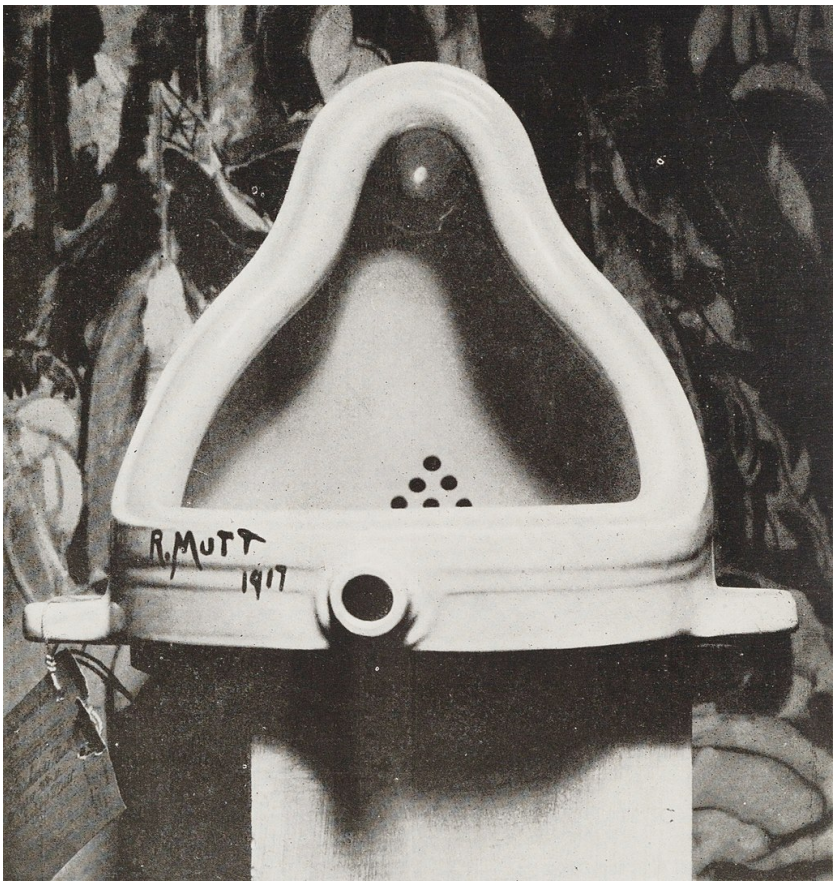


Figure 15: Marcel Duchamp's Fountain [Commons, 1917]

Ambiguity of relationship might seem similar to the ambiguity of context, however it concerns the relationship which we develop with the artefact, not the perspective in which we look at it or the context in which we place it. The example which W. Gaver & col. mention is Van Lieshout's *Bais-ô-Drôme*, a so called 'love caravan'. The agnostic design of the exterior hides an interior that is purposefully decadent, leaving the viewer and visitor questioning how do they relate to it, e.g. whether they would want to inhabit it or not. What has been the most interesting to us however are the named tactics of how to enhance the ambiguity of information. This is done with the objective of making

the information seem mysterious but mostly to "compel people to join in the work of making sense of a system and its context". W. Gaver & col. differentiates following 3 tactics.

Deliberate imprecision is used to increase uncertainty. Our favourite example is of copywriting slogans in which statement like "I used to be restless because of negative thoughts" is decontextualised and indefinite. Not only that such cases of deliberate imprecision incentivize the reader to fill in the blanks, they also create an appeal because they are perceptually undemanding. The example of interactive news which Dan R. Olsen spoke about uses the tactic of *overinterpretation*. By providing two (or more) different narratives of the same story from e.g. CNN and Fox News as in the specific example, we do overinterpret a single story. Inconsistencies between different interpreations create an opportunity for sense-making. More direct *exposition of inconsistencies* is the third tactic W. Gaver & col. mentions. While deliberate imprecision doesn't provide an inconsistency, rather obscures an information. Exposition of inconsistencies does create a space for interpretative engagement.

2.5.2. Territoriality in Writing

We do understand the ambiguity as one of the possible drives for participation. Before we are able to localize it in a specific practice of collaborative writing, we are going to introduce one more concept and that is the notion of *territoriality*.

Within the context of collaborative writing, Larsen-Ledet and Korsgaard use Ralph B. Taylor's understanding of territoriality [65]. Although using multiple definitions, he describes what is called *territorial functioning* as "an interlocked system of attitudes, sentiments and behaviours specific to a particular location which in the context of individuals in a group, or a small group as a whole reflect and reinforce a degree of excludability of use, responsibility for, and control over activities in these specific sites". The concept essentially addresses how do people "manage" the locations they own, occupy, or use for varying periods of time. Within it Taylor also identifies number of behavioural themes such as "active defense, a defense achieved without aggression, laying claim, creating and maintaining boundaries, or the signalling of claims through markers and warnings". The key points to be emphasized are that he identifies territorial functioning as place-specific and he sees it as something that goes beyond behaviour, including also sentiments and perceptions (which do form the behaviours).

While Taylor focuses on spatial aspects of territoriality Bakker and Bakker-Rabdau do extend the understanding beyond physical space. They do understand territory as an area in which one "has special expertise, shows initiative, and takes responsiblity" [66] - an area in which

[65] Ida Larsen-Ledet and Henrik Korsgaard. Territorial functioning in collaborative writing: Fragmented exchanges and common outcomes. *Computer Supported Cooperative Work (CSCW)*, 28, 05 2019. DOI: 10.1007/s10606-019-09359-8; and Ralph B. Taylor. *Human Territorial Functioning: An Empirical, Evolutionary Perspective on Individual and Small Group Territorial Cognitions, Behaviors, and Consequences*. Environment and Behavior. Cambridge University Press, 1988. DOI: 10.1017/CBO9780511571237

[66] C.B. Bakker and M.K. Bakker-Rabdau. *No Trespassing!: Explorations in Human Territoriality*. Chandler & Sharp Publishers, Incorporated, 1973. ISBN 9780883165287. URL https://books.google.pt/books?id=JZnIAAAACAAJ

one has control. This way the idea of territoriality extends to tasks and roles of the participating parties and includes a level of organizational structure. This also extends the scope in which we understand conflicts which arise in collaborative activity.

The notion of territoriality allows us to understand the process of collaborative work in which continuous communication, negotiation and maintenance of a *common information space* is needed to moderate individual "territorial claims" [67]. Collaborative work is therefore not only facilitated by technology itself, but requires an active construction of information space and negotation of what are called *intermediary objects*. This process of negotation is also called as *boundary negotiating intermediaryobjects*. In the previous chapter we did hint on the idea of how a story itself can become a boundary object in a broader societal discourse. Here we see that in the collaborative process of writing a story, there can be intermediary objects preceeding its final materialization.

Larsen-ledet and Korsgaard do also give attention to what is called a *double-level language* which concerns two levels of communication that happen in the coordinative process of collaboration [68]. While *formal* level is governed by objective rules, *cultural* level allows actors for their own subjective interpretations. This has potential to resonate with the activity of play as we described it in the previous chapter which we chose to characterize also through the tension between internalization of rules and externalization of imagination.

In practice we can perceive territoriality in spatial workspaces in terms of claiming an area of the workspace by an individual or a group of people. This can be manifested on touchscreen devices, but also on virtual user interfaces. Territoriality however works also in the one-dimensional space of collaborative writing when an attachment to a textual fragment is formed.

A notable part of the research in the area of collaborative writing has been focused on the distinction between private and social (or personal and shared) writing. We tend to agree with the stance of Delisle and Schwartz who argue that the user should develop the skills of using the interface privately first and only engage in collaborative activity afterwards [69]. An importance of private experience can be found also in the argument that users do not wish to expose their developing drafts publicly [70]. However, there is also an understanding in which seeing writing in its collaborative context brings new perspectives upon the activity of writing in private. The social significance of edits and comments which are trying to mediate the negotiation can help to localize the writing within a particular community or help to reach a consensus [71]. An activity is therefore to be understood mediated not only through the means of technology, but through the interaction with

[67] Liam Bannon and Susanne Bødker. Constructing common information spaces. In *Proceedings of the Fifth European Conference on Computer Supported Cooperative Work*, pages 81–96, Dordrecht, 1997. Springer Netherlands. ISBN 978-94-015-7372-6. DOI: 10.1007/978-94-015-7372-6_6. URL https://doi.org/10.1007/978-94-015-7372-6_6

[68] Mike Robinson. Double-level languages and co-operative working. *AI & Society*, 5(1):34–60, 1991

[69] N. Delisle and M. Schwartz. Neptune: a hypertext system for cad applications. In *SIGMOD '86*, 1986

[70] Christine Neuwirth, David Kaufer, Ravinder Chandhok, and James H. Morris. Computer support for distributed collaborative writing: Defining parameters of interaction. In John B. Smith, F. Donelson Smith, and Thomas W. Malone, editors, *CSCW '94, Proceedings of the Conference on Computer Supported Cooperative Work, Chapel Hill, NC, USA, October 22-26, 1994*, pages 145–152. ACM, 1994. DOI: 10.1145/192844.192893. URL https://doi.org/10.1145/192844.192893

[71] Jeremy P. Birnholtz and Steven Ibara. Tracking changes in collaborative writing: edits, visibility and group maintenance. *Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work*, 2012

others. The social significance is proposed to be extended even further, by moving the focus from attributed tasks in collaborative space to relationships between individual actors [72] [73].

Shifting our attention to the territoriality within the activity of collaborative writing there isn't a better example to study its related behavioral patterns than one of the most counterintuitive examples of freely-accessible yet freely-editable collaborative resource.

[72] Teresa Cerratto Pargman. Collaborating with writing tools: An instrumental perspective on the problem of computer-supported collaborative activities. *Interacting with Computers*, 15:737–757, 01 2003

[73] Ida Larsen-Ledet and Henrik Korsgaard. Territorial functioning in collaborative writing: Fragmented exchanges and common outcomes. *Computer Supported Cooperative Work (CSCW)*, 28, 05 2019. DOI: 10.1007/s10606-019-09359-8

2.5.3. Wikipedia as an Example

Wikipedia is an open-content, collaborative, voluntary, online encyclopedia built within 'wiki' environment. Its main distinctive feature is that it is openly editable and yet it maintains a level of reliability and is in fact being quoted by other media [74]. Moreover, it has been shown that apart from an encyclopedia in which individual entries are owned by individual users (such as *Encyclopedia2*), Wikipedia entries do possess better quality and are comparable with a traditional print source [75]. This is acclaimed for the editing of multiple users and shorter revision cycles. In an effort to grasp the "Wikipedia phenomenon" qualitatively, several studies have been focused in particular on measuring the editing trends.

One of them being the history flow visualization of MIT and IBM researchers which object was to examine editing trends on wikis. History flow visualization discovered and described four patterns of cooperation and conflict [76].

[74] S. L. Bryant, Andrea Forte, and A. Bruckman. Becoming wikipedian: transformation of participation in a collaborative online encyclopedia. In *GROUP '05*, 2005

[75] Will Emigh and S. Herring. Collaborative authoring on the web: A genre analysis of online encyclopedias. *Proceedings of the 38th Annual Hawaii International Conference on System Sciences*, pages 99a–99a, 2005

[76] Fernanda B. Viégas, M. Wattenberg, and Kushal Dave. Studying cooperation and conflict between authors with history flow visualizations. In *CHI '04*, 2004

2.5.3.1. Vandalism

First of them - vandalism is characterized by malicious edits which expose the vulnerability of an open system which Wikipedia is. Such edits include deletion of all contents, addition of offensive content, creation of phony, unrelated copies or links (to an unrelated page for example) or creation of idiosyncratic copy through e.g. addition of one-sided text. Such one-sided text would be for example lengthy description of *cat* linux command under the topic of "Cat". What has been observed that such malicious changes to existing Wikipedia content has been repaired relatively quickly - up to the point in which it was difficult to actually recognize such behaviour over a wider period time. One of the reasons why this is done so quickly is, as we describe later on, thanks to the role of "a watcher" that many seasoned editors of wikipedia do adopt and do watch for changes in articles which affect their integrity.

2.5.3.2. *Negotiation*

The process of negotation which we already hinted on in the context of collaborative writing as a necessity in the moderation of common information space has been observed on Wikipedia mostly through the notion of *edit wars*. These are lengthy exchanges in which one author adds a piece of information and another removes it. Such exchanges can go for several consecutive versions and create a sort of zigzag arrangement in the history timeline. What has also been observed that these edit wars do not necessarily happen in a specific kind of controversial pages, but were observed randomly across various topics. It has to be noted that edit wars are not the only manifestation of negotation. It does happen more indirectly through what are called *talk pages* which we are yet to speak about.

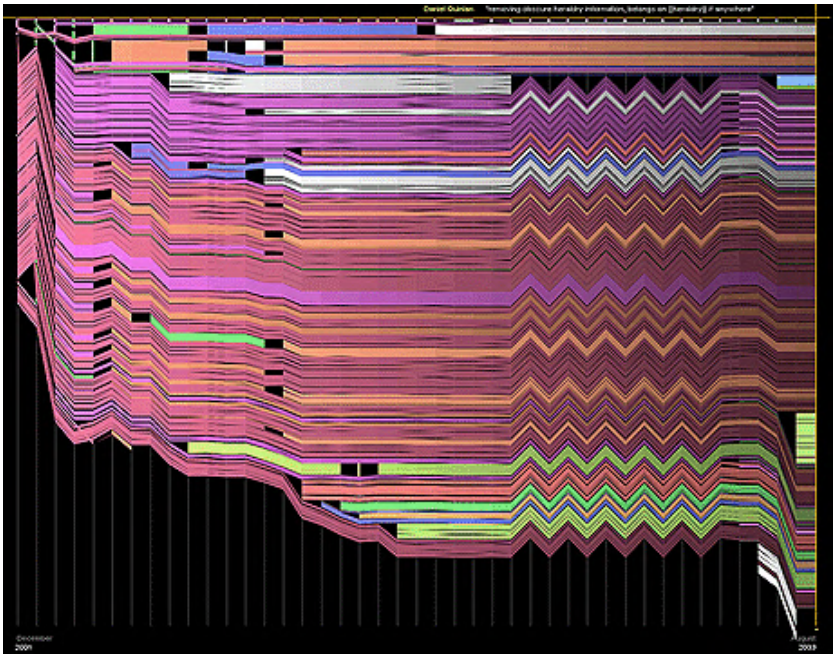


Figure 16: A zigzag pattern observed by F. B. Viégas, M. Wattenberg and K. Dave in history flow on the page "Chocolate" [Viégas et al., 2004]

2.5.3.3. *Authorship & Attachment*

There is a variety of opinions on the role of authorship - a recognizable, visible attachment of a contentual fragment to its authors. There are those who propose that it is part of the content itself and attribute context of the author to what do they write and publish, other say that authorship is irrelevant and we should treat all content as if it was written anonymously. We could see a resonance with a similar debate that we briefly spoke about in previous section and which was ignited by Barthez in his critique of traditional literary criticism which

presupposed the author's context to be a part of the literary work and neglects reader's interpretation. Other perspective is to see authorship as a necessary part of involvement and identity building within the platform. A notable observation in the history flow study was that there is no clear pattern that would assume higher likeliness of either an attachment or anonymity across particular pages.

2.5.3.4. Content Stability

A fascinating attribute of Wikipedia pages which has been observed is *content stability*. One would assume that content in a specific page would stabilize over time - becoming a subject of fewer and fewer changes. In history flow visualization it has been demonstrated that many pages however are actually not stable and therefore in a state of constant unpredictable change. Pages do undergo changes of growth and splits (when a part of a page is splitted into another page). Another two interesting patterns have been observed and those are what is called *first move advantage* and *deletion and insertion*. The text written by the first person tends to preserve itself longer and is less likely to be changed or edited - it sets the tone of the page. The second pattern describes what is higher frequency of occurence of deletions and insertions as individual edits instead of the movements of the text.

2.5.3.5. Conclusion - Two governing principles

The conclusions on the observations of these patterns have been that two governing principles helped to establish Wikipedia as open-content and yet reliable collaborative medium. Firstly its strong emphasis on neutral point of view which helps to negotiate the content and resolve disputes. And secondly its design which does encourage surveillance of others' contributions. Although this only describes the behaviours of the author on the platform.

What is however the what drives participation? What is the relationship that users develop with Wikipedia? And how does a reader becomes a writer?

2.5.4. Legitimate Peripheral Participation

To be able to answer these questions we introduce a notion of legitimate peripheral participation or in abbreviated form - LPP. It stands for "a process by which newcomers become members of communities of practice" [77].

E. Wenger chooses the concept of "community of practice" as a broader conceptual framework within social theory of learning that consists of 4 components: *meaning*, *practice*, *community* and *identity*.

[77] J. Lave, E. Wenger, E.C. Wenger, J.S. Brown, C. Heath, and R. Pea. *Situated Learning: Legitimate Peripheral Participation*. Learning in Doing: Social, Cognitive and Computational Perspectives. Cambridge University Press, 1991. ISBN 9780521423748. URL https://books.google.pt/books?id=CAVIOrW3vYAC

He consequentially describes *community of practice* through three dimensions - *mutual engagement*, *joint enterprise* and *shared repertoire* [78]. In our example it relates with practice of engaging in the process of collaborative content creation. The first characteristic of a coherence for a community of practice is *mutual engagement*. Community of practice is not just an aggregate of people of a common category, but a one in which members are engaged in actions which meanings they do negotiate between each other. A membership does not constitute only a social category, like belonging to on organization nor is defined only by interpersonal relations but it's tight to a particular habit, practice which is agreed upon and which makes mutual engagements possible. These can include activities such as having a dinner together, taking trips on weekends or even a regular exchange of an e-mail. A significant part of mutual engagement is that it creates relationships. These relationships are created through mutual negotiation and the ambiguity of meanings within community allows negotiation and therefore their existence as well as diversity and uniqueness. A second dimension *joint enterprise* emphasises an aim of totality of such mutual engagement and it is defined and negotiated in the process of pursuing it. It's not merely a statement of a goal, but includes mutual accountability. We could understand *shared repertoire* as a set of resources which help us to negotiate meaning. They are collected and build in the process of mutual engagement and they do remain inherently ambigious which allows for open-endedness and generativeness of new meanings and therefore engagements and negotiations. It is differences of perspectives and the ambiguity of a common perspective which allows for negotiation and learning.

This "difference" can help us to understand how newcomers to Wikipedia stop being *indifferent* and start to participate in collaborative content creation through what we call *peripheral tasks* (also *boundary encounters* or *entry points*).

The way in which Bryant, Forte and Bruckman chose to describe the process of legitimate peripheral participation is through the Engestrom's model of activity system or activity within a social-technical system. That is described as a set of 6 interdependent components, namely: *subject*, *object*, *instruments* (or tools), *rules*, *community* and *division of labour* [79].

What interests us are the observed transformations of individual components and their roles which occurred within the activity system of online collaborative writing and in the process of legitimate peripheral participation.

[78] Etienne Wenger. *Communities of practice : learning, meaning, and identity.* Learning in doing. Cambridge University Press, Cambridge, 1999 - 1998. ISBN 0521663636

[79] Y. Engeström. *Learning by Expanding*. Learning by Expanding: An Activity-theoretical Approach to Developmental Research. Cambridge University Press, 2015. ISBN 9781107074422. URL https://books.google.pt/books?id=a6CTBQAAQBAJ

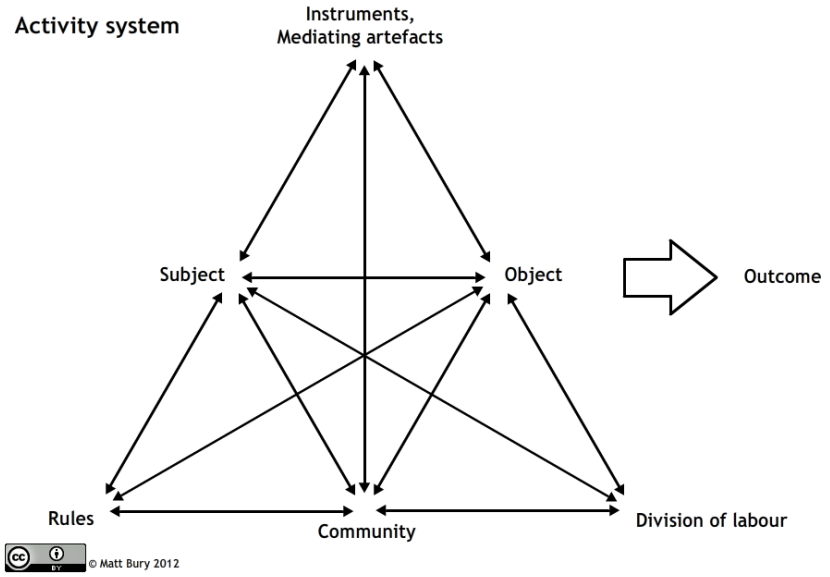


Figure 17: Triangle diagram of activity system [Commons, 2012, Engeström, 2015]

Subject

Bryant, Forte and Bruckman do write that at the beginning of the process, user is a consumer, a reader who reads articles out of interest. Only later on, once they acquire level of familiarity, mostly in the area they feel comfortable in or have expertise in, they start to engage in committing small edits, corrections. A notable phenomenon was their reluctance to commit greater changes to articles which did stem from insuficient knowledge and familiarity of the platform. A crucial part of the process was development of care and attachment to the articles which they edited. As the number of edited articles grew, users experienced need of watching for articles and their changes. As they believed in their changes, they started to believe also in the product that community produces and care about Wikipedia as a whole. There were also other motivations such as participation in something that will last or an experience of a challenge to articulate themselves through the means of writing.

As we hinted before and as we see now, authorship is integral part of the transformation of subject. It allowed for possiblity of reciprocity, reputation and identity building and sustaining [80].

[80] P. Kollock. The economics of online cooperation: Gifts and public goods in cyberspace. In M. Smith and P. Kollock, editors, *Communities in Cyberspace*. Routledge, London, 1998

Instruments

From the perspective of instruments (tools), Bryant, Forte and Bruckman describe *entry point* of early users - search box. This allows users to find a topic of interest. Many Wikipedia pages do almost standardly appear in the first results of Google or other search engines and is

essentially a first encounter with Wikipedia. The second step for many users was the "edit page" button. Even though it doesn't stand out visually in particular it was a logical choice in the transition from reader to writer. Without a need to sign up, there is almost no barrier for participation. Edit page does contain now warning of attribution to an IP address if not logged in and information on how the content must be verifiable and that any work can be submitted, edited and redistributed - which refers to a legal framework of publishing, but also notifies user that any of their edits can be subject of change. With the attribution of IP address there is a heightened sense of responsibility and an edit requires greater commitment. The formatting and complex syntax can be confusing, but Bryant refers to what is called *zone of proximal development*. This concept has become particularly useful in representing the activities which person cannot undertake on their own and for which they require a certain level of support or guidance. This guidance is supposed to exist within the user's interface for writing and its role is to ease the activity of writing. We would argue however that the seeming formatting complexity of editing a Wikipedia article can be a positive feature which creates reluctance in users and assures only truly committed edits to be published. Seasoned users can utilize what are called talk pages which are meta-level discussions on articles. This allows an existence of channel for negotiation of meanings and contents. Absolutely crucial part are so called watchlists which essentially represent a feature of "follow" on an article. This provides a way of watching for potential edits and changes on articles which user cares about and in a way creates a collaborative surveillance of edits.

Community, Rules & Division of Labor

The image of notifications shows us a less known social aspect of Wikipedia. When encountering Wikipedia as a consumer, we hardly see any community. We are aware that "there are some people", but we do not see any interactions, neither we are prompted to immediately sign up. We start to experience first signs of community when accessing the guidelines on edit page. These are not shown immediately and that's also sign of what Lave and Wenger calls *progressive apprenticeship* - being progressively taught the rules and guided into the community (i.e. not being overwhelmed by all the rules at once). The guidelines are a boundary of community as they introduce its rules. Only after we published our changes it is when we are exposed to reactions and messages of other creators which comment and correct our changes. Furthemore these changes do seem less suspicious if we establish a profile and include personal information in it. One could asssume that correction of our edit could be seen as something wrong because we did write something wrong, however what has been a fascinating

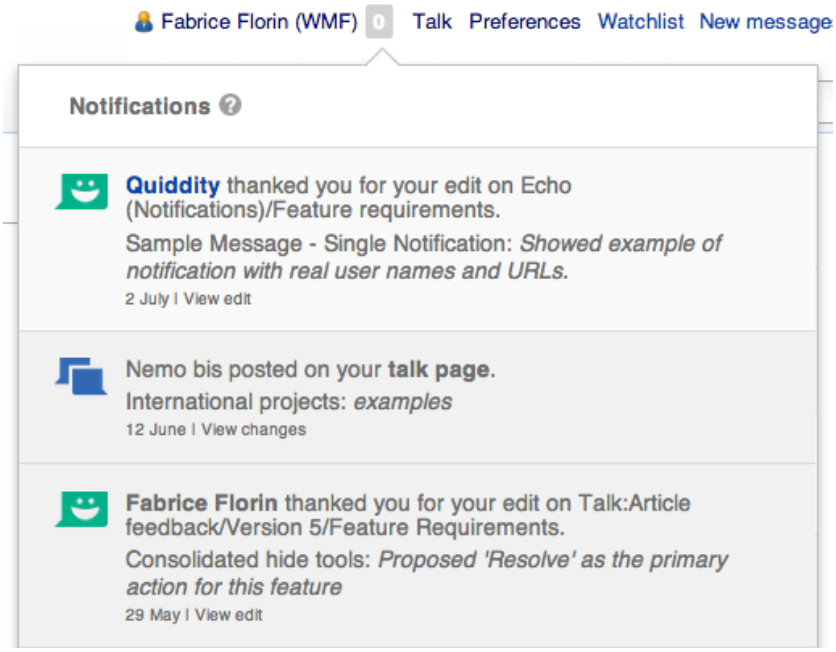


Figure 18: Notifications on Wikipedia [Commons, 2013]

observation is that many users do feel satisfaction from these reactions and even edits of their edited parts. It represents attention. In resonance, the idea of featured articles does put the articles in the eye of the audience and also other writers and allows for more edits to happen.

On the example of Wikipedia we can see how a design of a platform can intervene in the space of collaborative writing and through legitimate peripheral participation create a community of practice. It is important to realize that an example of Wikipedia does serve the purpose of knowledge and information sharing. One of the questions we ask is; should we in our prototype allow existence of multiple subjective stories (user-centric) or should we constrain our design to a one collaborative page per topic (topic-centric)? What are the most efficient ways to intervene in the activity of writing to allow emergence of more comprehensible and "easier to read, interact and explore"-formats? What is our model for LPP? And what is the broader regime of tools in which we want to situate ours?

2.6. Transitional Pivoting

Each time we design something we are not only creating a new product, service, but we are actively intervening in the dynamic system of existing practices and relations. Where are we when it comes to writing and how did we get there? In this section we intend to answer these and

previously formulated questions and situate our effort and problem within a broader landscape of socio-technical regimes and relations. We describe the framework of transition design and the practice of writing, its history and contexts as such with the objective of describing the useful technological relational and chronological mapping.

In the chapter of storytelling we could see how such an extensive and powerful device as nonlinearity could present a challenge in terms of utilization in literary forms. We speculate that this is due to the prevalent historical preference of humans for linear, unambiguous textual content visually organized in blocks of lines as the most standardized, rigorous and descriptive form. One could see such linearity coming from the purpose which text was meant to serve and that is archival and preservation of orally exchanged knowledge. Due to the physical constraints of the way we communicate the linearity from oral communication is attached to the information within its material medium. Nick Sousanis in his work *Unflattening* challenges this attachment and calls for recognition of an image as an equal partner to the text in preservation and communication of knowledge. His point becomes tangible when his work of visually rich comic book pages of interwoven references and meanings, within which every page functions as a whole yet consists of interrelated pieces, is interrupted with a page of raw, dry and blatant block of text. The stimulating and inspirational exploratory experience suddenly becomes uneventful and visually emotionless scanning of words from left to the right and top to the bottom [81].

Similarly we believe that there exists strong social conditioning when it comes to various written formats in which we communicate knowledge and their visual organization. This is somehow underlined by our informal observation which we already mentioned in the section of progressive disclosure. People given a two-dimensional space and ability to write and drag written fragments around often recognize the purpose of interface as mind or concept mapping. These preconceptions are some of the reasons why we treat the problem of inefficient text organization and lack of utilization of hypertext and more immersive visual organization of content as a wicked problem.

In 1973 article, "Dilemmas in a General Theory of Planning", Rittel and Weber introduce a special category of planning problems within the context of resolving social policies. They call them *Wicked problems* and they distinguish them by emphasizing their lack of scientific and logical basis and their complexity. Wicked problems lack clear description and objective, definite solutions and they cannot be accurately modeled through an engineering approach. When defining a problem of inefficient organization of (mostly written) content as we were trying to do so far, one could be tempted to reach for dissonance between

[81] Nick Sousanis addresses and challenges this practice of reading within the context of western culture and it is important to say that other cultures do experience the 'directionality' of reading differently. Such examples would include reading from right to left in arabic script, from the top to bottom in traditional east asian scripts or even from the bottom to top in e.g. *Hanunóo* script

P. Daniels and W. Bright. *The World's Writing Systems*. Oxford University Press, Incorporated, 2010. ISBN 9780195386929. URL https://books.google.pt/books?id=DTvNkQEACAAJ

our cognitive models of thoughts and the written forms in which we express them. Yet we already touched upon multiple contexts in which this problem presents itself in various shades. These shades become apparent not only across the binary relation between activities of writing and reading and their different particularities, but also across the range of tools and their various contexts of practice within which they are situated. The study of these specific contexts lead us to practice theory and for the purpose of containment of this work, we won't go much deeper into their distinctions. It's also important to understand that we are already setting a specific practice for the use of nonlinear narratives within the title and framing of this work. In our work we focus mostly on the activity of storytelling in which we situate our problem, exploration and later on - artefact.

Here we are utilizing a broader way in which we perceive the activities of reading and writing, but even more so - the problem of inefficiency we aim to solve. Seeing it in the context of sociotechnical transitions and mapping it through what Geels calls a "Multi-level perspective" [82] we can better understand major shifts and influences in the practices in which the problem and the related problems are being resolved.

[82] Frank Geels. *Multi-Level Perspective on System Innovation: Relevance for Industrial Transformation*. 02 2006. ISBN 1-4020-3755-4. DOI: 10.1007/1-4020-4418-6_9

2.6.1. Sociotechnical Transition

To understand sociotechnical transition, we first have to take a look of what *sociotechnical system* means. As Geels describes it, sociotechnical system consists of variety of layers such as technology, regulation, user practices and markets, cultural significations, infrastructure, maintenance and supply networks [83]. Their objective is the fulfillment of societal functions. They are constantly being redefinedby various actors, social groups, interest groups, users in other word *stakeholders*. We understand the term *stakeholder* as someone who "has a stake or interest in a specific issue or is affected by a particular problem" [84]. An explanation that precedes the framework of transition design we find stakeholders defined as "any individual, group, organization or institution that can affect or be affected by an individual's, group's, organization's or institution's policy or policies" [85]. The sociotechnical transition is consequentially defined as a multi-dimensional shift from one sociotechnical system to another. The multi-dimensionality does reflect the variety of layers a sociotechnical system embeds. Another way to look onto sociotechnical transition is through what is called *multi-level perspective*. *Multi-level perspective* or *multi-level concept* separates functional scale levels in which transition takes place [86]. The most notable example of the description of a sociotechnical transition through multi-level perspective is the historical case study; the transition from

[83] Frank Geels. The dynamics of transitions in socio-technical systems: A multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860–1930). *Technology Analysis & Strategic Management*, 17:445–476, 12 2005. DOI: 10.1080/09537320500357319

[84] Terry Irwin. The emerging transition design approach. *Cuadernos del Centro de Estudios en Diseño y Comunicación. Ensayos*, pages 19–46, 2018. DOI: 10.18682/cdc.vi87.3762

[85] I.I. Mitroff and H.A. Linstone. *The Unbounded Mind: Breaking the Chains of Traditional Business Thinking*. Oxford University Press, 1993. ISBN 9780199879540. URL https://books.google.pt/books?id=NyV-BwAAQBAJ

[86] Rutger Brugge, Jan Rotmans, and Derk Loorbach. The transition in dutch water management. *Regional Environmental Change*, 5:164–176, 01 2005. DOI: 10.1007/s10113-004-0086-7

horse-drawn carriages to automobiles in the use [87]. The multi-level perspective distinguishes three conceptual levels: a so called micro-level of *niche*, a meso-level of *socio-technical regime* and a macro-level of *socio-technical landscape* and it is what constitutes a nested hierarchy of these three conceptual levels and transitions between them.

[87] Frank Geels. The dynamics of transitions in socio-technical systems: A multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860–1930). *Technology Analysis & Strategic Management*, 17:445–476, 12 2005. DOI: 10.1080/09537320500357319

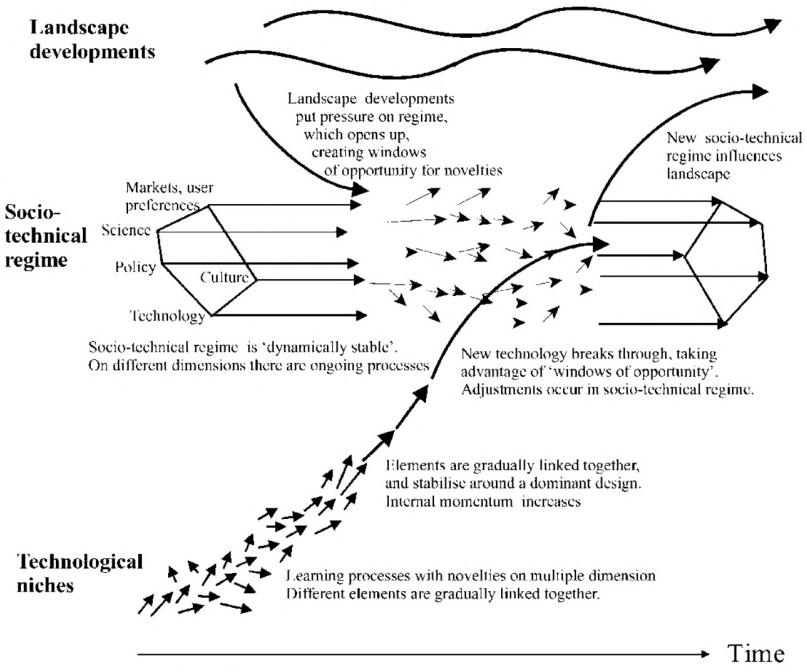


Figure 19: A sociotechnical transition from a multi-level perspective [Geels, 2004]

2.6.1.1. *Niche*

In 1933 a German-born American geneticist Richard Goldschmidt published a paper called "Some aspects of evolution" where he used the term "hopeful monsters" to call rare but consequential mutations which are able to start a whole new evolutionary line [88]. He extended upon the idea emphasizing how such "mutans producing monstrosities" may have played considerable role in macroevolution. Such radically new creatures could allow for an emergence of a completely new environmental niche within one evolutionary step [89]. 57 years later, a professor of economics and history Joel Mokyr describes technological advancement in parallel to biological evolution. Long periods of stasis are disrupted by discontinuous change caused by what Mokyr calls *macroinventions* - "inventions without clear-cut parentage, representing a clear break from previous technique". Drawing a parallel to Goldschmidt's hopeful monsters, their numbers are not important, but they are the ones to be found in roots of new evolutionary lines

[88] Richard Goldschmidt. Some aspects of evolution. *Science*, 78(2033):539–547, 1933. ISSN 00368075, 10959203. URL http://www.jstor.org/stable/1660832

[89] Sewall Wright. The material basis of evolution. *The Scientific Monthly*, 53(2): 165–170, 1941. ISSN 00963771. URL http://www.jstor.org/stable/17521

of species, or in the terms of technological transition - societal and technological practices [90]. Borrowing from Goldschmidt's term, Geels writes a further contextualization explaining that these macroinventions are 'hopeful', because they can fulfill a certain function, but they are monstrous because their performance characteristics are still low. He illustrates this on examples of a phone in which early prototypes one has to yell loudly into to be heard or early computers which weighted several tons. Geels distinguish two types of niches: 1.) technology niches and 2.) market niches. In technology niche there are almost no market relationships. The value of innovation in technology niche lies in expectation of how much potential the new technology can have in the future. A network of actors are ready to invest into an invention within such technology niche to create a new market. In market niche, market and consequentially market relationships are already established. An innovation solves a particular problem with clear requirements and specification and understanding of the problem. Geels illustrates this on the example of a jet engine. Jet engine, even though already developed in the early 1930s was put into an actual chain of use only in the late 1930s when military budgets increased and the threat of war was imminent - market did already exist, but it was the conditions of market that had to change. Geels also emphasizes that it is in the military context where the need of performance outweighs the costs [91].

[90] D. Coleman, Joel Mokyr, David Mowery, and Nathan Rosenberg. The lever of riches: Technological creativity and economic progress. *The Economic Journal*, 101: 996, 07 1991. DOI: 10.2307/2233883

[91] F.W. Geels and R.P.M. Kemp. *Transities vanuit sociotechnisch perspectief*. Ministerie van VROM, Netherlands, 2000. Achtergrondrapport voor het Vierde Nationaal Milieubeleids Plan NMP-4

2.6.1.2. *Sociotechnical Regime*

There are three reasons why the word "regime" has been chosen, the most significant for our understanding however is that the word suggests more fluid, dynamic structure that can be a subject of a transition. On the other hand, the word "system" stands for more rigid, fixed, unchaged structure [92]. Technological advancement can be in evolutionary economics described as a process of variation and selection. A variation that is not "blind" per se, but is guided and directed by engineers, managers of research and development and other actors who decide which technology to invest financial, human, social capital into. This can be done in coordination with the right heuristic. Selection process itself then happens when the technology is exposed to the environment which consists of governmental regulations, relationships between employers and employees, political structure, public opinion or supply and demand. It is these two processes which constitute a *technological trajectory*.

[92] F.W. Geels and R.P.M. Kemp. *Transities vanuit sociotechnisch perspectief*. Ministerie van VROM, Netherlands, 2000. Achtergrondrapport voor het Vierde Nationaal Milieubeleids Plan NMP-4

As Geels further describes, there have been efforts to try to describe and understand technological trajectors within the right context of so called *technological regime*. However this definition has been mostly

focused on the cognitive aspects of the stable processes which were shared within the community of engineers. A broader definition has been pondered by Rip and Kemp [93] which included also economic, organizational, cultural and social aspects - e.g. social norms, duties of engineers etc. Similarly, the scope of engineers' minds and their shared cognitive repertaire was extended into practices and machines. This way the rules of a regime included much broader range of requirements of users, rules of the market, regulations etc. What we call a *sociotechnical regime* is therefore is a semi-coherent network of social groups acting within an environment of mutually harmonized rules and elements. It is the technology and the habitual accomodation to it which in such regime provides stability and inertia.

[93] Arie Rip and René Kemp. *Technological change*, pages 327–399. Battelle Press, 1998. ISBN 1574770462

2.6.1.3. Sociotechnical Landscape

While we addressed the sociotechnical regime by deriving it from a technological trajectory, by *sociotechnical landscape* we can understand a space through which these trajectories move. Their pathways are influenced by slow-moving trends and developments - external factors to the regime and niches.

> There is a distinction between the material and intangible aspects of a sociotechnical landspace. The material aspects could include material infrastructure and policies such as highways, electrical grid, raw material deposit or urban planning, while intangible aspects of a sociotechnical landspace could be culture, lifestyle, social organization, social values or even prices, demographics and economic trends (e.g. recession). A trend which could be characterized as a part of sociotechnical landscape was for example industrialization which positively affected the transition from steam engines to electric motors. However, sociotechnical landscape does not have to defined only by a slow-moving trends, but also by sudden unexpected events such as major accidents. An example, given by the authors, of such an event would be Fukushima disaster which did affect a transition from nuclear energy to other sources (especially in Germany)

[94].

[94] F.W. Geels and R.P.M. Kemp. *Transities vanuit sociotechnisch perspectief*. Ministerie van VROM, Netherlands, 2000. Achtergrondrapport voor het Vierde Nationaal Milieubeleids Plan NMP-4

2.6.2. Multi-level Perspective of Digital Writing

Writing is an activity that appears in multitude of contexts and affects almost everyone in the world. To narrow down and specify the context of writing we have to return to our crucial intention and that is to resolve and that is making communication of knowledge faster, more efficient and comprehensible. **Transforming this formulation we can define the problem as tedious, inefficient and incomprehensible reading of knowledge.** We can infer that this problem is vivid the most when we approach a complex topic or a topic that includes analytical reasoning. Our proposition also includes the format of a story in which such topic

is being told, described or explained. This narrows down our problem space.

2.6.2.1. Stakeholders

When trying to define stakeholders of what we just defined as our wicked problem, we look onto people who needs to produce, write or consume, read complex topics that includes analytical reasoning. Most notably we identify two key areas which we call *academia* and *media*. In the academic area we can identify people involved in the activity of education - teaching - professors, teachers, but also the ones who need to communicate their research - researchers, scientists. These two groups, even though they often do overlap, do present themselves with a slightly different motivations. As consumers, readers we identify students, teachers, professors, researchers and scientists themselves and general public. Furthemore we can infer that this group of stakeholders are likely to be situated in an educational or scientific institution (spatially situated) or a conference (temporarily situated). Specifically we could mention *Tools for Thought* community [95] or anyone participating and working within the field of *science communication*. In the second area of *media* we can identify stakeholders as individuals, groups and institutions who are involved in the activity of sharing information and knowledge for the general public. Those can constitute of journalists, bloggers (within a certain niche area), (visual) storytellers, news portals and platforms, but to a certain degree also marketers and businesses. There is another perspective from which we can look upon the activity of writing and that is whether we write for our personal use, whether we write for a particular person or a group of people or whether we intend to publish what we write to a wider audience. Personal use could include for example journaling for therapeutic purpose or for the purpose of building "second brain" - taking notes and sorting out thoughts, ideas and references in the process.

[95] Brian Goodrich. Tools for thought, 2021. URL https://twitter.com/i/lists/1275110172348821504

2.6.2.2. Activity Categorization

When describing niches for our specified activity of writing we identify major challenges. First, the activity of writing occurs in the great variety of contexts. From writing business reports to scientific articles, from blogging to note-taking, from literary writing to instant messaging. Another problem is the broad understanding of what do we mean by writing. Are we still writing when we use emojis? What about memes? Is using images in our written expression still writing? What about interactive content, videos? Of course, in our work we do work with and try to address this broad understanding of what does it mean to write. We start by defining related contextual activities of writing

and those, after a lengthy analysis of the activity / problem space we identify as:

1. Recording / Publishing
2. Sensemaking
3. Performing

In this analysis we did collect applications, keywords, concepts, machines, activities and tried to group them into bigger related contextual groups. Within these contextual groups we then identify these more specific contexts and tools - their applications and their particular features. It has to be said there are many ways in which the practice of writing (and reading) can be sorted into various contextual categories. For example, in Anthropology of Writing, D. Barton and U. Papen focus on organization as one of the central activities for the incentive of writing and communication as another one. Organization then involved documenting and maintaining records to make sense of social and local participatory activities [96]. This practice goes as back in time as the history of writing itself and we include it under the practice of documenting. There have been a further discussion on this categorization that for example included a debate on the activity of "creating". One could imagine the activity of "creating" on its own - a programmer writing code is creating a software through the process of writing or similarly, when writing a diagram of architecture, one is involved in the process of creation within the act of writing, writing of a literary work could also be considered an act of creation. However, inspired by the Inuit's attitude to the act of creation, we see these these particular instances of writing as transitory acts, in which thought is being translated into a material world through one of the already mentioned activites. We classify writing of any literary works as a special kind of recording, a recording of a myth that even though emerges within an individual is situated within a certain collective. Programming and drawing diagrams of architecture could be attributed to sense-making. We also did differentiate the activities from the one which occur to transcribe the past (recording, note-taking) and the ones which orientate themselves towards the future - i.e., *writing from the past*, *writing to the future*

[96] D. Barton and U. Papen. *The Anthropology of Writing: Understanding Textually Mediated Worlds*. Bloomsbury Academic, 2010. ISBN 9781441108852. URL https://books.google.pt/books?id=blSJc1qM3TgC

2.6.2.3. *Recording / Publishing*

The meaning of the verb **record** can be traced to the Latin *recordari* - "to remember, call to mind, think over". From *re-* (to restore) and *cor* (heart) - literally - "to restore from the heart", later on from Old French *recorder* - "tell, relete, repeat, make known" [97]. The contemporary definition as

[97] Douglas Harper. Record, 2021d. URL https://www.etymonline.com/word/record

we find it in Cambridge dictionary describes **record** in the context of storing information as an act of "keeping information for the future, by writing it down or storing it on a computer" [98].

We chose the word *to record* because it directly connects to the first motivations of humans to write. [99]

Even before the use of complete writing, humankind made of use of various graphic symbols and mnemonics in order to store the information. The objective of these mnemonics was to encode, preserve and optionally also communicate an information [100].

A notable example of such a recording device was *quipu*. As one of the most common mnemonics - *knot record* it consists of several strings, each representing a number. A number is then encoded on a string using decimal representation - each group of knots representing a cipher within a number. These strings then represented various information depending on the context of the quipu's use (for example, white strings can represent number of sheeps, while numbers of cattle could be represented by green strings, etc.).

Figure 20: Quipu in the Museo Machu Picchu [Connective, 2018]

To illustrate the antiquity of writing, we could go even further into history and speak about mere slashes or notches in the barks of trees representing one of the earliest documented attempts of an 'idea transmission'.

We could also reflect on the extended understanding of writing and speak about drawings of *Leang Bulu' Sipong 4* Cave in Sulawesi being with an age of at least 43,900 years as "the oldest pictorial record of storytelling and the earliest figurative artwork in the world" [101]. All these examples could be understood as examples of documentation / recording. In the case of the cave painting - documentation of an event, beliefs or values.

[98] Cambridge University Press. Record, 2021c. URL https://dictionary.cambridge.org/dictionary/english/record

[99] We originally started with the tuple *documenting* and *publishing*, to emphasize the object of a document which is created in the activity of writing. Yet the contempotary definition of **to document** already refers to the act of recording, in particular "to record the details of an event, a process" . We also find that in the historical context, writing was done most commonly in order to preserve, to *record* an information, hence we changed it to recording.

Cambridge University Press. Document, 2021a. URL https://dictionary.cambridge.org/dictionary/english/document

[100] Not to get lost in the various definitions of *communication* we use narrow definition of an information exchange with a clear intent to transmit an information to an existing receiver. This receiver is a different person than the sender. One could argue that recording or documenting is also communication as the information is assumed to be "received" in the future. In such case the communicative intent is however uncertain as the purpose of such recording is primarly preservation

S.W. Littlejohn and K.A. Foss. *Encyclopedia of Communication Theory*. Number vol. 1 in Encyclopedia of Communication Theory. SAGE Publications, 2009. ISBN 9781412959377. URL https://books.google.pt/books?id=2veMwywplPUC

[101] M. Aubert, R. Lebe, A.A. Oktaviana, M. Tang, B. Burhan, Hamrullah, A. Jusdi, Abdullah, B. Hakim, J. Zhao, I.M. Geria, P.H. Sulistyarto, R. Sardi, and A. Brumm. Earliest hunting scene in prehistoric art. *Nature*, 576:1–4, 12 2019. DOI: 10.1038/s41586-019-1806-y

Returning back to the knot records and some of the earliest kinds of proto-writing (such as markings in Vinča culture or Indus valley) we want to emphasize that they were used as tools mainly for organization of social participation, often marking possession or association (with creator of an item). These tokens and markings did start to develop into a language in the process of *phonetization* - a process in which symbols, instead of refering to an object, started to refer to the sound. This extended the possibilities of a language and communication as a such, but also required a certain level of literacy. A role of scribes have been introduced. These were people who were meant to write and read and communicate within the given symbolic system [102].

We did already hint how the act of scribing recorded not only numbers and counts driven by the bureaucracy of an ancient empire, but also events, sacred texts, social rules and laws, stories.

Until the invention of printing press, precursors of books in its papyrus or later codex forms have been unique objects of their own individual artistic and material value themselves. In ancient Greece and later Rome, books were a medium for the performance of public speaking or reading. This way a public person could gain enough influence to have his manuscripts copied and distributed to libraries and private collectors [103].

And even though there aren't enough artefacts to exactly trace the beginning of publishing due to the fragile nature of the papyrus scrolls, we can assume the act of publishing being as old as the first occurence of a need of the ruler, prophet or other 'influencer', to communicate with their audience.

Examining the word **publishing** more closely we find the latin origin of *publicare* - make public, later on *publier* from Old French, meaning "make public, spread abroad, communicate" and *publishen* from 14th century - make publicly known, reveal, divulge, announce [104]. A contemporary definition in Cambridge dictionary defines publishing as an action of making information available to public, to people, mentioning mediums of a book, magazine, or newspaper [105].

It's important to understand that the demand for printing has been established with the gradual emergence of educational institutions. Monastic schools started to turn into universities in the 10th and 11th centuries through the process of restoration (*reformatio*). The regulations and legislature which formally established universities as institutions differ individually. Nevertheless, the educational practice preceeded the formal recognition of the status of the university. The universities have been in early stages organized communities of individual responsible for higher education [106]. The invention of printing press was situated in the context of a well-known problem and that was high price of the books, insufficient numbers of copyists and consequentially low quality

[102] S.R. Fischer. *History of Writing*. Globalities Series. Reaktion Books, 2003. ISBN 9781861891679. URL https://books.google.pt/books?id=Ywo0M9OpbXoC

[103] Roger Pearse. Publishing in the ancient world, 2016. URL https://www.roger-pearse.com/weblog/2016/11/24/publishing-in-the-ancient-world/comment-page-1/

[104] Douglas Harper. Publish, 2021c. URL https://www.etymonline.com/word/publish

[105] Cambridge University Press. Publish, 2021b. URL https://dictionary.cambridge.org/dictionary/english/publish

[106] H. de Ridder-Symoens and W. Rüegg. *A History of the University in Europe: Volume 1, Universities in the Middle Ages*. A History of the University in Europe. Cambridge University Press, 2003. ISBN 9780521541138. URL https://books.google.pt/books?id=5Z1VBEbF0HAC

of copies.

Despite of that, the invention of printing press and its implementation and spread as a technique has caused a multifaceted spectrum of changes rather than an improvement in single variable of a book production chain. This has however been difficult to precisely track due to the graduality and variety of these changes. The handwork and presswork did appear similar if not the same after all. Yet the heightened scale of distribution allowed writers and sellers to offer additional perks such as more readable texts or better indeces. It also allowed for a more impersonal link between the reader and the book, moving from a retail trade in which producer sold their products directly to the users to a whole industry [107].

The exponential change that invention of printing press brought also caused opening of a social inquiry to the society rather than staying focused on an individual. A sharing of knowlege detached itself through aforementioned impersonal link from the individual relationships and became part of the commons which allowed for development of professional societies and later on provided opportunity for the practice of peer-reviewing [108]. Peer-review was one of the many effects of scientific revolution [109] firstly introduced in the publication of the Royal Society of Edinburgh in 1731, which included a collection of peer-reviewed medical articles. The focus of the writing shifted from Aristotelian "why" to much more descriptive style of "how" with the emphasis on observation, experiment and its methodology. With the purpose of examining and discussing each other's observations a whole branch of new societies emerged which were meant to cultivate scientific findings as an addition to the existing educational institutions. These communities provided the base of the practice of scientific publishing [110].

Another revolution that we would like to briefly mention is the industrial revolution. It spawned the transformation of hand production to machine production. The drive of mechanization and the possibility to develop stable linear methods of manufacturing for individual interchangeable parts affected the way of thinking in which processes which were subjects to multiple indeterministic nodes within a network, most often bounded to a particular craftsman, could be all embedded within one manufacturing line or even a single machine [111]. Besides other effects, in this process, publishers started to take more responsibility and control of whole book-making including editing, printing and binding [112]. Within the context of these changes multiple inventions could have been made, one of them being the invention of typewriter by Christopher Latham Sholes in 1868. This wasn't the first typewriting machine however and the efforts to invent go as back as to 1829 with the first attempt of William Austin Burt's and his "typographer". Burt's

[107] E.L. Eisenstein, E. Elizabeth Lewisohn, P.E.H.E.L. Eisenstein, and Cambridge University Press. *The Printing Revolution in Early Modern Europe*. Canto Classics. Cambridge University Press, 2005. ISBN 9780521845434. URL https://books.google.pt/books?id=5xIP4UVqHZ8C

[108] C. Hess and E. Ostrom. *Understanding Knowledge as a Commons: From Theory to Practice*. Mit Press. MIT Press, 2011. ISBN 9780262516037. URL https://books.google.pt/books?id=5UCCkgAACAAJ

[109] Dale Benos, Edlira Bashari, Jose Chaves, Amit Gaggar, Niren Kapoor, Martin LaFrance, Robert Mans, David Mayhew, Sara McGowan, Abigail Polter, Yawar Qadri, Shanta Sarfare, Kevin Schultz, Ryan Splittgerber, Jason Stephenson, Cristy Tower, Grace Walton, and Alex Zotov. The ups and downs of peer review. *Advances in physiology education*, 31:145–52, 07 2007. DOI: 10.1152/advan.00104.2006

[110] Britannica Contributors. Scientific Revolution | Definition, History, Scientists, Inventions, & Facts. URL https://www.britannica.com/science/Scientific-Revolution

[111] I.I. Mitroff and H.A. Linstone. *The Unbounded Mind: Breaking the Chains of Traditional Business Thinking*. OUP E-Books. Oxford University Press, 1995. ISBN 9780195102888. URL https://books.google.com.na/books?id=VE_nCwAAQBAJ

[112] Sheila McVey. Nineteenth century america: Publishing in a developing country. *The Annals of the American Academy of Political and Social Science*, 421:67–80, 1975. ISSN 00027162. URL http://www.jstor.org/stable/1040870

typographer was best characterized by an arm which one had to turn until desired character was found, then by pressing it, it would imprint the chosen character on the paper [113]. After each letter a shifting of the whole platform for the arm was required. Another prototype was called pterotype and was made by 1831 by an inventor John Pratt. Pterotype allowed for faster retrieval of the letter, but still required the writer to bring the typebar to the typing point before imprinting it [114].

Only the Sholes' prototype from 1868 turned out to be practical enough to truly become less complex and therefore more efficient than handrwriting which was the aim of inventors. Sholes' prototype benefited from an easily comprehensible metaphor of a "literary piano". He decreased the number of action a writer would need to do in order to write a letter to 1 - typing that exact letter (instead of moving, aligning, turning and hammering as with previous proto-typewriters).

In his improved version he fulfilled his vision of allowing the writer to look on the text being written without the need to focus on the buttons. This is also the time of conception for the QWERTY keyboard. Sholes noticed that using neighbouring letters caused hammers to get jammed. That's why he transitioned from A..Z layout to the one in which letters commonly used in writing aren't close together on the typewriter [115]. This example is a great illustration of how an invention was situated in the specific context of needs and how important role the design played in finding the right and useful specific configuration for technology. A notable effect of the transition to typewriters and mechanical typing is the depersonalization of the written text. Letters and words did not hold personality of one's manual labor of writing, but appear the same with a literal machine-like precision. Many writers did use handwriting as much as typewriting observing different kinds of style of their writing when changing the practice. We already hinted on how many production chains and processes merged within single manufactories as a result of industrial revolution. One of the implications of this change is centralization and gathering of data. For the accounting of high number of employees, factories and careful monitoring and measuring of production processes a so called tabulating equipment or *tabulators* were used. First time invented by Herman Hollerith who himself was a clear at U.S. Bureau of the Census and directly in touch with the problem of rapid calculation. In fact he was incentivized and sponsored to build a faster recording system after the census in 1880 took 8 years to complete [116]. Inspired by railways tickets in which traveler's details were punched in, in the form of holes, he chose this as a machine-readable medium for the recording of data. Data are organized in the matrix on a punch card. When put into the reader, between the plates, pins that would traverse through the holes would come into the contact with mercury, closing

[113] UKEssays. The impact of the typewriter history essay, 2018. URL https://www.ukessays.com/essays/history/the-impact-of-the-typewriter-history-essay.php?vref=1; Herkimer County Historical Society and J.W. Vrooman. *The Story of the Typewriter, 1873-1923: Published in Commemoration of the Fiftieth Anniversary of the Invention of the Writing Machine*. Press of A. H. Kellogg Company, 1923. ISBN 9780598711168. URL https://books.google.pt/books?id=rN9EAAAAMAAJ; and Encyclopedia Brittanica. Basic typewriter history, typing methods & posture 1940s movie 49344, 1943. URL https://www.youtube.com/watch?v=ztyzGit1dTI

[114] MARTYN LYONS. *The Typewriter Century: A Cultural History of Writing Practices*. University of Toronto Press, 2021. ISBN 9781487525736. URL http://www.jstor.org/stable/10.3138/j.ctv1g248q7

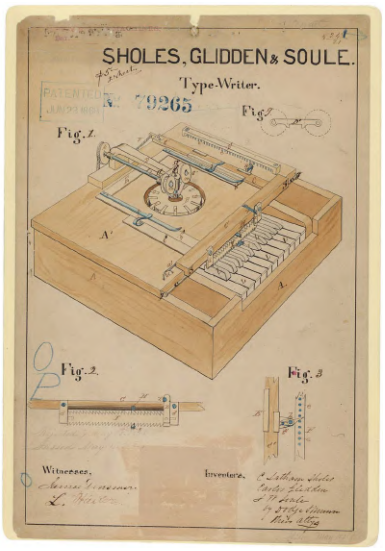


Figure 21: First prototype of Sholes' typewriter from 1868 [Commons, 1868a]

Figure 22: Improved version of typewriter from 1870s with QWERTY keyboard layout [Commons, 1868b]

the electronic circuit and made counting hands advance within the corresponding magnetic dial - cell [117]. Even though Hollerith made his device for the purpose of American census, he quickly realized the potential in the commercial sphere too, where users also worked with massive amount of data. In the beginning tabulating equipment was just a small part of office, nevertheless by the 1930s the demand for processing large datasetsincreased as big organizations realized their efficiency for their large calculating needs. This narrative has also been reinforced by increasing demands on record keeping, bureaucracy and control measures on corporations and many new companies such as CTR (Computing-Tabulating-Recording Company) - later IBM [118]. Another area which with the need ever growing need of recording witnessed the period of diversified inventions was copying. For various kinds of copying a different tool was used. When needed a single copy for outgoing correspondence a carbon copy was sufficient. With larger quantities of copies needed for several parties or for a letter campaign, a stencil duplicating machine such as mimeograph was used. This was the machine that used stencil paper to preserve the shape of written imprint and to serve as a stamp afterwards. There were other techniques and machines such as cyclostyle, lithographic duplicators, cylinder duplicators, hektographs, etc. In many cases for heavy duty copying and printing the companies just preferred to buy whole printing press or go to a commercial printer. The mentioned machines and techniques were also unable to create copies of already existing documents. With the development of photosensitive paper in 1840s an emergence of several photocopying techniques have been witnesses. Techniques such as *blue process* or camera-based photocopying witnesses however have been either time or space consuming, impractice for the daily office use. A reflex copying machine on the other hand required special paper and the quality of the copies have been questionable. They also possessed a rather particular unfavorable smell [119].

The invention of electrophotography in 1938 by Chester Carlson allowed for first dry photocopying process - one that did not involve any liquids. It also proved not to share any negative aspects of its predecessors and could be utilized within a relatively small-sized tool.In the process of electrophotographic copying, the parts of the drum (rotating cylinder) are lit by the projected image of the copied original. The ones that are enlightened lose their electrostatic charge and the toner (charged thermoplastic particles) is attracted to the rest of the electrostatically charged parts of the drum. Consequentially the toner is transferred from the drum to the paper which is heated up to make the toner stick to it (also called fixing) [120]. A different way to copy is to store the sequence of typed characters. This was made to be possible with the introduction of automatic typewriter by Shultz Co. in the 1930s

[115] J.M. Utterback. *Mastering the Dynamics of Innovation*. Harvard Business School Press, 1996. ISBN 9780875847405. URL https://books.google.pt/books?id=oT-3oLvR1_EC

[116] M.J. Anderson. *The American Census: A Social History*. EBL-Schweitzer. Yale University Press, 2015. ISBN 9780300195422. URL https://books.google.pt/books?id=NzNOCgAAQBAJ

[117] Frank da Cruz. Herman hollerith, 2021. URL http://www.columbia.edu/cu/computinghistory/hollerith.html; and TilTuli. 1889 herman hollerith census machine by tmc which became ibm, 2007. URL https://www.youtube.com/watch?v=9HXjLW7v-II

[118] J.W. Cortada. *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865-1956*. Princeton Legacy Library. Princeton University Press, 2015. ISBN 9781400872763. URL https://books.google.pt/books?id=dbl9BgAAQBAJ

[119] Early Office Museum. Antique copying machines, 2016. URL https://www.officemuseum.com/copy_machines.htm

[120] H.J. Arpe, E. Biekert, H.T. Davis, W. Gerhartz, H. Gerrens, W. Keim, J.L. McGuire, A. Mitsutani, H. Pilat, C. Reece, et al. *Ullmann's Encyclopedia of Industrial Chemistry, Complete Set: Part A, Part B, and Index (37 Volumes)*. Ullmann's Encyclopedia of Industrial Chemistry. Wiley, 1993. ISBN 9783527201006. URL https://books.google.com.ag/books?id=IgxuAAAAIAAJ

- also called repetitive typewriter. Similarly as with tabulators, Shultz's automatic typewriter stored the typed tex through punch-coding it onto paper rolls. These could later be reused and activate the typewriter as the typing itself. The rather big paper rolls have been substituted by smaller tapes in so called "Flexowriter". It also included non-print character that would allow overriding and "deletion" of wrongly typed characters. It was also common to cut the tape and paste it back together in order to remove longer passages of text [121]. In 1930s we can already notice the merging of calculating machine technology and tabulating equipment technology which sets the pathway towards computers. This has been even further accelerated in the events and needs of World War II. Many industries had to change their business focuses and utilized resources in new ways. Within this environment where practices were soft and susceptible to change, digital computing could easily be utilized. Such great changes caused interventions in dynamic systems of large scale which created even greater demand for mapping, recording, calculating and computing. Returning to the article of Vannevar Bush which we mentioned in the very beginning of our work, within this era of emergent knowledge society, the need for more efficient technological organization of scientific knowledge and information was evident. The title of the first high-speed printer is generally attributed to Remington-Rand in 1953. It was designed as a peripheral for the first general purpose computer UNIVAC [122]. The same UNIVAC brand of computers was the first to use the magnetic tape for recording computer data in 1951. This time marks the beginning of digital revolution, a rapid transition from analog form of data preservation (such as punching holes) to digital where the data is preserved in binary form. The potential and consequences were slowly becoming apparent, as digital data has practically a zero-cost for their duplication, dissemination and within the right technological environments they provide instant and free communication [123]. This transformation started to be present in the industry of typerwriters where tapes with punched holes were substituted by magnetic tapes such as in the case of 1964's Selectric Typewriter from IBM. This has also been the first time when the term *word processing* has been used. Coming as a literal translation of German *textverabeitung*, it aimed to communicate the broader vision of typewriting machines in which they serve all range of purposes of composing, revising, printing and filling documents. The idea of MagCards from 1969 introduced the detachable mediums of magnetic storage which could be put aside for a later recall and reprinting of stored text. The potential of storing much larger quantities of information on magnetic and other mediums of storage did kickstart the process of digitization. This was supported by the need of academic publishers for having large quantities of documents transferred and reviewed quickly. In the

[121] Brian Kunde. A brief history of word processing, 1986. URL https://web.stanford.edu/~bkunde/fb-press/articles/wdprhist.html

[122] Mary Bellis. History of computer printers, 2019. URL https://www.thoughtco.com/history-of-computer-printers-4071175; ASL News. The history of printing in the computer age, 2017. URL https://asl-group.co.uk/history-of-printing-computer-age/; and A. Norberg. Computers and commerce: A study of technology and management at eckert-mauchly computer company, engineering research associates, and remington rand, 1946-1957 (history of computing). 2005

[123] Heather Brooke. Inside the digital revolution. *Journal of International Affairs*, 70(1):29–53, 2016. ISSN 0022197X. URL https://www.jstor.org/stable/90012596

same, in 1969 the ARPANET successfully transmitted its first message. With this promise and a new digital storage, documents were no longer practical to be printed. It was much more reasonable to read them on a screen and have access to their large quantities instantly. Hence what is known as the practice of electronic publishing started gain popularity in 1970s. While digitization intends to transform physical content into digital form, electronic publishing defines a whole range of production practices (e.g. editing, layout) which transitioned from physicality of books and printed media into digital realm. Notable examples of digitization projects include project Gutenberg from 1971 with the objective of making literature more accessible or the dictionary of French National Centre for Scientific Research (*Centre national de la recherche scientifique*) - *Trésor de la langue française*. The dynamics of digitization however reached their exponential pace with the introduction world wide web in 1991. Returning back to electronic publishing, its true advent began with the introduction of floppy disks in the early 1970s. What was before once encoded and hard-coded into a digital medium, could now be accessible for an everyday user and more so, it could be rewritten. Documents and even software itself could be shared via floppy disks. The capacity of storage raised with floppy disks from 1-2 pages to around 80-100 pages of text. The invention of floppy disks consequentially caused also a boom in the creation of software - most commonly - word processing software. In this environment what is considered a first desktop publishing software was created at XEROX Parc (Palo Alto Research Center). It was supposed to offer not only typing and editing functionalities, but also to allow the writer to set their own layout of the document, i.e. pulling the practice of publishing from an industry to an individual [124]. Its name was Bravo and it was part of Xerox Alto - the first operating system based on the graphical user interface. The main invention it brought was the wYSIWYG principle ("What you see is what you get") which changed writing software from a purely typewriting tool with special characters for formatting to a personal publishing tool. Other different notable mentions of the desktop publishing software are Type Processor One (1983), Ventura Publisher (1986) even Microsoft Word being released on 25th of October in 1983. It wasn't however until it was included by default as part of Macintosh OS in a form of Apple Laserwriter (1985) when the practice of desktop-publishing started to rise in its popularity and use. What was needed was not just the tool, but a heavy campaign which communicated that desktop-publishing is not typewriting, that *The Mac is Not a Typewriter* [125]. We can see on this example how necessary is to understand the state of the technology and the human practices of use with it to successfully communicate an innovation that can provide a radically channging shift. It's not the "What is being done and how",

[124] S. Jones. *Encyclopedia of New Media: An Essential Reference to Communication and Technology*. SAGE Publications, 2002. ISBN 9781452265285. URL https://books.google.pt/books?id=YgVzAwAAQBAJ

[125] R. Williams. *The Mac is Not a Typewriter: A Style Manual for Creating Professional-level Type on Your Macintosh*. Peachpit Press, 1990. ISBN 9780938151319. URL https://books.google.pt/books?id=8I0IkhZnd9sC

but "How it is being framed and seen" - not merely the act of using, but the act of becoming which ultimately won the attention of the masses. The turning point of the revolution was the transition from analog to digitally recorded music with the emergence of optical discs in 1980s. Allowing several hundred times greater storage capacity then floppy disks, they provided a way to store only simple textual files, but also audiovisual content. Publications were suddenly given a new degree of freedom in the formats of content they were allowed to include. It was in the 1990s where we could see a rise of great variety of multimedia CDs such as digital atlases or encyclopedias. With the web 2.0 a new architecture has been conceived - an architecture of participation - in which a community could not only publish the content once, but engage in the process of continuous publishing and improvement of the content. This is what we also know as participatory web and we already spoke about some aspects of it in the section about Wikipedia. This participatory and collaborative nature of the new web is what pushes tools for writing forward, allowing not only to access and edit shared text immediately, but to actually see someone else's activity in realtime. What has been a space long dominated by the tools of Microsoft Office and other enterprise suites for business which once started as desktop-publishing tools, is now shifting towards constant online presence in the form of e.g. online word processors such as Google Docs (2006) or Office Online (2010). Following the WYSIWYG principle they all seem to assume that their contents are once going to be printed on a paper sheet of A4. Yet majority of these documents are never imprinted into the material world. Is the constaint of space that copies the dimensions of an A4 paper sheet still actual?

Encyclopedias

There are two contexts of writing which we decided to put slightly on side due to the specificity of their development. First of them being the writing and publication of encyclopedias. The first use of the word encyclopedia was preserved from 15th century as a misreading of greek *enkyklios paideia* from the texts of Pliny and Quintilian, yet certainly many earlier works such as ancient chinese and babylonian glosseries could be considered encyclopedias. The works or encyclopedias from before the 18th century could be considered either specific cases describing a particular set of knowledge, or glossaries or almost a quasi-political publications in which rulers inscribed their idealogical belief of what was important for a general public to know. What we date as the first general purpose encyclopedia were indeed the works of E. Chambers - *Cyclopædia: or, An Universal Dictionary of Arts and Sciences* from 1728 and Encyclopédie of Diderot and d'Alembert from 1751. This was the first time when encyclopedia appeared as a distinctive genre of

comprehensive, deeply described yet systematically organized topics. We can already detect a general intention and practice in the act of writing encyclopedias and that is to collect and organize the knowledge. This is a particular case of recording activity in which we try to construct a general form a methodology of recording in advance and the purpose of recording the content and topics is organization. Yes, one could argue that we are trying to communicate various complex topics in accessible format, but primarily, the intention is to organize them into a single place so there is a clear signification of location where to search for a kind of knowledge we don't really know anything about or we can't situate it in our experience and resources. The genre of encyclopedias developed into a special kind of publications which were made through contributions of hundreds of contributors and managed by an organization. These organizations could be funded by government or also, later on, could exist completely independently by their own profits. These model hasn't really changed, though it has increased in range and size. It wasn't until the emergence of compact discs in 1980s which gave a reason for digital transformation also for encyclopedias. Encyclopedias with their enormous contents could hardly be stored on floppy disks and smaller storage mediums. CDs allowed also for an inclusion of audio, image and video content. The potential of a multimedia encyclopedia was firstly demonstrated by the project Microsoft Encarta in 1993. The encyclopedia contained texts, images and allowed reader to access them in dedicated browser with a set of basic functionalities.

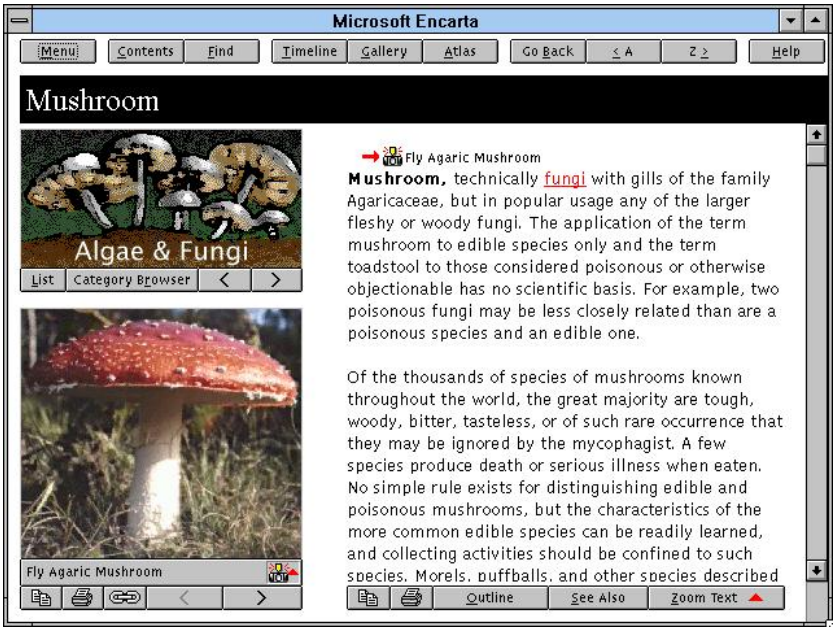


Figure 23: Microsoft Encarta 94 [Inc, 2021]

Personally favourite has been the DK Multimedia Eyewitness Encyclopedia of Space and Universe from 1996. It contained aesthetically crafted and thematic environment with distinctive visual links and menus. Each page contained an image or video and one could play a spoken audio of the text. During the whole experience an ambient music, reminiscing the endless space of universe and exploration was playing and smoothly fading in and out when transitioning to another context (video or audio). And the environment even contained a virtual observatory with exact positions of starts calculated up to the year 9999 and a set of puzzles where one could, for example, assemble their own Saturn V rocket.

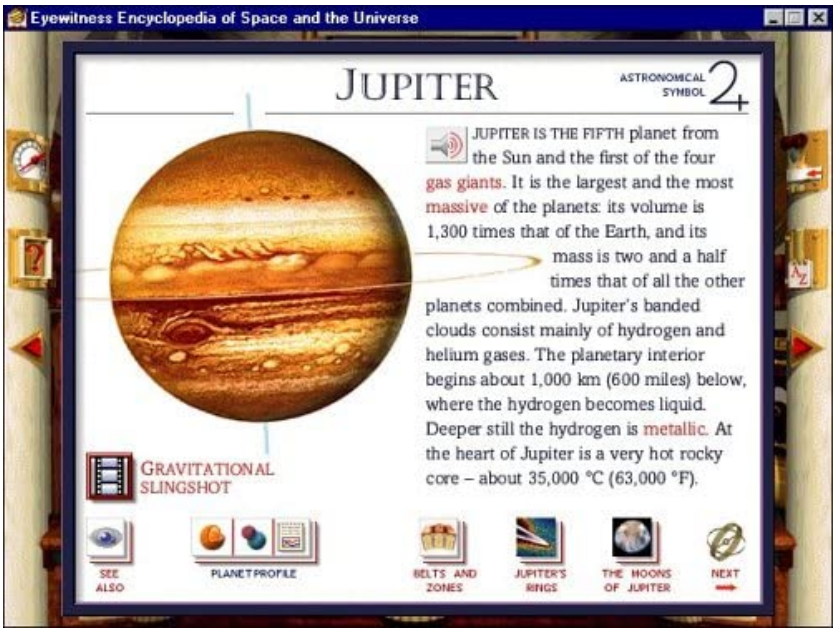


Figure 24: DK Multimedia Eyewitness Encyclopedia of Space and Universe [Software, 2021]

The creation of multimedia encyclopedias was costly, the space on compact discs was still limited for such amounts of multimedia content and their creation required much greater efforts than already exerted practices of encyclopedia production. Moreover, it was just the time of the world wide web and the focus of companies shifted towards online content. One of the first online encyclopedias which was trying to take advantage of the perks of participatory web was Nupedia and it operated since October of 1999 until Septemebr 2003. It was conservative in its seven-step approval process for the content and likely that was one of the reason why it failed inactive in 2003. The founder of Nupedia Jimmy Wales was in that time already decided to commit to the new Wikipedia project.

Self-publishing

As a second context of recording/publishing we would like to briefly take a note on what is known as self-publishing. It stands for the activity in which the writer, creator of a literary artifact also takes responsibility for production and distribution of it. In the history there have been cases of writers which did take this responsibility for the whole publishing process and even owned their own printing press. These were John Locke, Jane Austen or Emily Dickinson [126]. While most of publishing houses were carefully choosing with which authors they'll choose to share the risk of gaining profits and it was difficult to get a contract with a publishing house, a new term came to existence in 1940s - so called *vanity press* or *vanity publishing*. With the improvements in technology of printing, expenses were lowered and it was no longer necessary to print high quantities of copies for one publication. This opened door for those who were willing to pay enough to cover the costs of printing a smaller quantity. The publishers who allowed this service were called vanity publishers, mostly because of the stigma held against authors who wanted to publish their books this way. While major publishing houses had their name, their readers, their identity, vanity publisher would publish anything if it was offered enough money. This caused vanity publishers to be associated with the lack of quality and the notion of self-publishing has been stigmatized similarly. It wasn't until the use of print-on-demand and ebooks when this perception started to shift. Digital revolution allowed printing of smaller quantities of copies and while traditional offset printers couldn't stay economical for such small amounts, digital printers could print with a fixed price per item [127]. This and also broader emergence of e-books in the advent of digital storage devices provided authors with more sustainable model of distribution for their works. With the shift of accessibility to an individual through the online market, traditional publishing chain could have been completely bypassed.

Today, thanks to the world wide web, self-publishing became very closely associated with web publishing, i.e. publishing of websites and content on the world wide web. Various communities are driving factors for the distinction in the language and formats in which knowledge is distributed and published. From a mere blogging, we can now recognize unfolding of all kind of interbreeding forms of web publishing such as blogging, micro-blogging, computational notebooks, visualizations, explorables etc. We would like to briefly mention maybe two areas that has caught our attention more significantly. By interactive or computational notebooks we characterize platforms or open-source tools which allows inclusion of the code into the document. In fact, they allow this code to be rendered and provide interactive apple related to the content. An example of an open-source tool would be Jupyter

[126] Christina Patterson. How the great writers published themselves, 2012. URL https://www.independent.co.uk/arts-entertainment/books/features/how-great-writers-published-themselves-8053570.html

[127] M.L. Kleper. *The Handbook of Digital Publishing*. Number v. 1 in The Handbook of Digital Publishing. Prentice Hall PTR, 2001. ISBN 9780130175458. URL https://books.google.pt/books?id=qE0OAQAAMAAJ

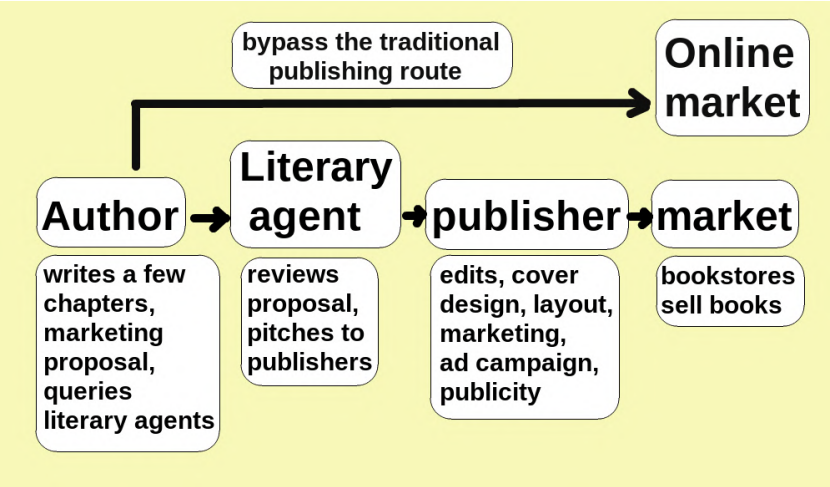


Figure 25: Bypassing of publishers through the means of self-publishing [Commons, 2018b]

Notebooks made in Python and mostly utilized by data scientists. A platform that offers inclusion of the code and visualization of data within the published artifacts is ObservableHQ and it also calls itself "computational medium". What we perceive as a distinction of these platforms and our effort is the fact that they are specifically focus on providing computational capabilities and visualizations which narrows down the target to those who are able to write code. We would like to create medium which would be simple enough to be used by anyone and which wouldn't have an identity of medium "by programmers - for programmers". A specific kind of attention is receiving the comics theory or the studies of visual narration [128]. They are exploring efficient ways of communicating a narrative visually and its possible pitfalls. Within this framing we would like to mention a very specific example of a "spatial essay" or as W. Hsu calls it, a comic log - a narrative that consists of randomly placed images and text fragments across a web page. The ambiguity of the placement can incentivize the reader to engage with the content, yet it's the production of such a comic log which can still take a little bit of skilled passionate designer / artist and programmer and some amount of time.

[128] Neil Cohn. Visual narrative comprehension: Universal or not? *Psychonomic Bulletin & Review*, 27, 12 2019. DOI: 10.3758/s13423-019-01670-1

2.6.2.4. Sensemaking

Note-taking

To note as a verb have been used first as a word *noten* and that stands for "observe, take a mental note of". The likely origin is from the latin word *notare* - "to mark note, to make a note" which was verbalized latin noun *nota* - meaning "letter, character, note". A related word "notice" could be described as "adding something to attention" [129]. Note-taking

[129] Douglas Harper. note, 2021b. URL https://www.etymonline.com/word/note

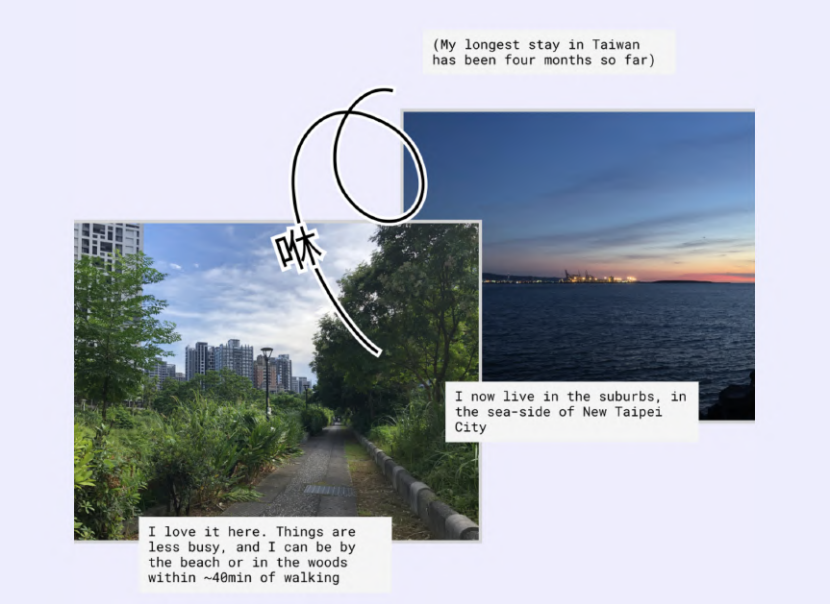


Figure 26: An extract of a comic log by Weiwei Hsu [Hsu, 2020]

as an activity could be seen as a special case of recording in which we try to preserve a mental imagination. And even though, historically it has been more associated with the act of recording, we would like to provoke this notion, by focusing more on the fact that it serves personal use, placing an individual into a conversation with itself which made us more likely to include note-taking into the category of sensemaking activities. As many other activities related to writing, the activity of note-taking is as long as humanity itself. We can trace what we call as *hypomnema* to the to world of Ancient Greece meaning "reminder", "a public note". A slightly different connotation has note-taking in the early age of universities where it was associated with the activity of students taking notes during classes. These notes were often turned into reference works for other students. Particularly curious genre of note-taking have been commonplace books. They weren't diaries, neither journals. They haven't been chronological. They were mere scrapbooks of thought, encyclopedias of personal knowledge encrypted in statements, quotes and aphorisms [130]. John Lock's method of making commonplace books was meant for better organization and indexing of thoughts - related to love, religion or politics, each having different page or section of pages in the book [131]. In a way, this has been a precursor of non-linear note-taking because it did allow one to go back to particular section and insert more information. Several precise methods and systems of linear and non-linear note-taking have been developed such as outlining, Zettelkasten or Cornell Notes and they are practiced within their particular contexts of note-taking on the medium

[130] N.A. Basbanes. *Every Book Its Reader: The Power of the Printed Word to Stir the World*. HarperCollins, 2006. ISBN 9780060593247. URL https://books.google.pt/books?id=o4K_KMO1DWUC

[131] J. Locke, J.L. Clerc, and J. Wallis. *A New Method of Making Common-place-books*. J. Greenwood, bookseller, at the end of Cornhil, next Stocks-Market, 1706. ISBN 9780598657084. URL https://books.google.pt/books?id=D3_AtgAACAAJ

of a finite paper, yet there can be better methods invented once we move into the digital space. The practice of note-taking in the digital space has been initially associated with productivity and planning. One of first recognized note-taking ecosystem or note management tool that was meant to be accessible on multiple devices, such as desktop pc, tablet and handheld was Evernote founded in 2000. This has been an era of pocket PDAs or also handhelds and therefore the major focus of the application was handwriting recognition. A more significant competitor entered the market in 2003 - Microsoft Onenote. As handheld devices were absorbed by smartphones, the practice of note-taking shifted into mobile devices. Today we can distinguish note-taking tools for particular areas. For studying one can find Goodnotes, Notability or Notes which support creative handwriting, drawing and are designed for tablets. Tools like Bear or Notion organize the notes primarily as text. While Bear is communicated as tool for private notes, Notion is meant to serve both personal and collaborative use. Evernote stays truthful to its branding and communicates itself as an app for productivity. More complex and collaborative solution not only for taking notes could be Miro or Microsoft Whiteboard - both allowing handrwriting and insertion of various items such as text blocks, images, stickers, diagrams etc. What started being marketed as a practice for productivity is turning into whole variety of use cases across different contexts. Yet, it has to be said that none of these examples serve primarily the purpose of telling a story. They can be used that way, but in no way they communicate such purpose, neither they incentivize it in their interfaces. A very recent branch of note-taking tools is what some calls "networking note-taking" or "note-taking for networked thoughts". This area consists of tools such as Roam Research, Athena Research and then other open-source alternatives such as Foam, org-roam or docuwiki. With their main representive being Roam Research, they do utilize the concept of links and linking. Their main idea is that while we write we do not thinking in compact blocks of though related to one particular topic, but we rather jump from one topic, one context to another. And through this jumping is how connections are being reinforced within our thought.

Similarly, Roam Research allows user to move to another page using a special double bracket notation by introducing a link to an existing document. This way, the flow of writing is preserved while the network of interconnected pages is being created. Such network can be later on enjoyed, studied, browsed and explored. As the founder Conor-White Sullivan explains "Roam Research's goal is to break the 'authoritative' structure of internet which breaks our explorative and independent model of using it." [132]. One would argue a very similar vision, yet what we perceive as the main problem of Roam Research is the fact that in

[132] Conor White-Sullivan. Roam sketch, 06 2018. URL https://www.youtube.com/watch?v=Kef3LvQnggg

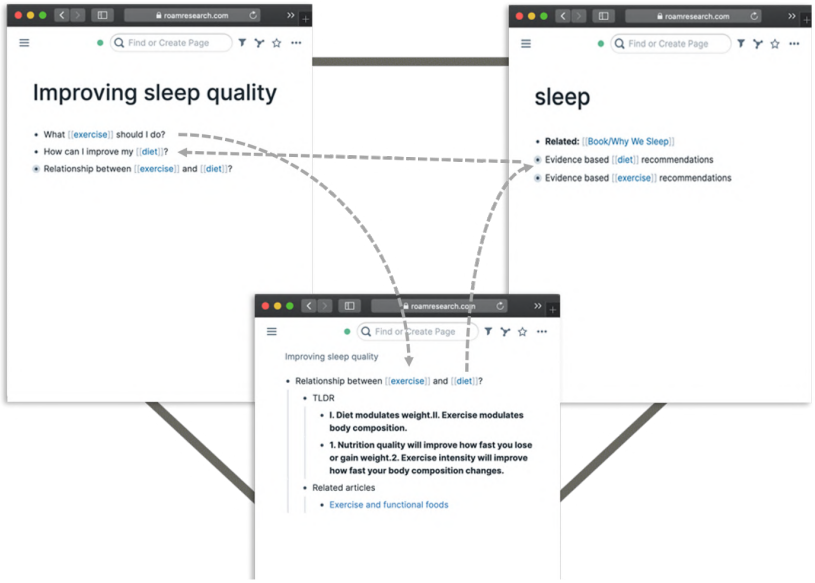


Figure 27: Roam Research Tool Illustrated [Chan, 2021]

the end of the day one still has only pages with bullet points. Certainly, there is a level of internal interconnectedness which can be managed and which is pleasing both aesthetically and in terms of reading and exploration, but it doesn't affect the orthogonality in which the text, the content is organized on the page. One could argue that their design enforces it. Moreover, the value on which the Roam Reseach is centered upon is the use of various syntactic shortcuts during writing. They are not difficult to learn, but it creates an impression of coding, of programming which many people are consciously or subconsciously scared of. Seeing multiple words in text randomly wrapped in double brackets can not only distract the reader but with the whole schematic structure can induce an impression of something very technical and complex.

2.6.2.5. Performing

We would like to finish our excursion to the current practices of writing by a short mention of the activity category of performing. The word *perform* comes from 13th century *performen* - "carry into effect, fulfill". The theatrical meaning the word connotated in 16th century, standing for "act or represent as on a stage". The word is inherently tied to the notion of acting, carrying out an act. How does this goes in hand with writing? We could say that one is performing when writing, but even publishing is a process that happens separately from the specific occurrence of writing. The performing for us stands for the context of reading which is, apart from recording / publishing, synchronous. The

content, knowledge, information are being read, consumed in the very act of performance. It is that act in which the audience is in the touch with the information for the first time and it involves the author or the interpreter of the written text. We could jump into deep studies on what exactly constitutes the act of performance, yet for our definiton, the major distinction between synchronous and asynchronous conveying of information is going to be sufficient.

As we already wrote about in the section on publishing, public speeches has been a way how to spread one's thoughts before they have even been written or distributed. This way one could collect enough influence to be able to pay for copying and distributing of their thoughts. During those public speeches one could help themselves with notes, but also use a chalk and draw on the road. Even though, there are a occurrences of its use as early as from 11th century (such as writing slate in Indian schools [133]), the artefact of a chalkboard began to be officially used on universities in 19th century [134]. In a way, the chalkboard was a tool for the preservation of the boundary object of meaning which was conveyed to the students during classes. This way, much more than just spoken word in that given moment could have been "cached" and recorded to be read and communicated upon. The act of drawing and writing content in front of the audience can be tedious in particular cases when a public meeting or event is being conducted. This was the idea of flip chart first time used in 1912 by John Henry Patterson [135]. Instead of having to draw and write the content, it was already prepared on the big posters which could be easily flipped. A more minimal version of the flip chart was poster card which was basically just one poster and served as a tool of discourse more commonly in smaller groups. What we consider a projector can go as back to history as to 1659 and Christiaan Huygens' Magic Lantern which was a simply a light source shining through a painted glass and projecting a shadow in the form of the drawing on that glass. It was the first opaque projector and only in the late 19th century they began to be used by lecturers, photographers and general public. By the end of the World War I, public school in Chicago had 8,000 opaque projectors. Opaque projectors were later substituted by overhead projectors which thanks to the ability to iluminate also through transparent materials needed less luminous source of light. These devices still required however someone to prepare the paper, slide which would be projected. Their use started to rise in 1950s and 1960s [136]. The digital revolution affected also the technology of projectors which in 1980s transformed into what we know as the modern data projector. These instead of a material slide transmit digital version of the slide through either an LCD crystal or a cathode ray tube in the case of CRT projectors. With the possibility of projecting digitally stored content the first commercial

[133] M.A. Bīrūnī and E. Sachau. *Alberuni's India: An Account of the Religion, Philosophy, Literature, Geography, Chronology, Astronomy, Customs, Laws and Astrology of India about A.D. 1030*. Number v. 2 in Alberuni's India: An Account of the Religion, Philosophy, Literature, Geography, Chronology, Astronomy, Customs, Laws and Astrology of India about A.D. 1030. K. Paul, Trench, Trübner & Company, Limited, 1910. URL https://books.google.pt/books?id=A5EtAAAAMAAJ

[134] S.E. Ambrose. *Duty, Honor, Country: A History of West Point*. Johns Hopkins University Press, 1999. ISBN 9780801862939. URL https://books.google.pt/books?id=SC5wr5A_hbkC

[135] J. Gitomer. *The Patterson Principles of Selling*. Wiley, 2004. ISBN 9780471662624. URL https://books.google.pt/books?id=KV_MwAEACAAJ

[136] Scott Schwertly. A brief history of the projector, 2014. URL https://ethos3.com/2014/03/a-brief-history-of-the-projector/

computer software for creating presentations in WYSIWYG mode was Cromemco's Slidemaster released in 1981. The PowerPoint was released as a standalone software for Mac in 1987 [137]. The presenting software followed the model that was established with previous projectors and their method and that was to split the content into separate slides. The first widely recognized tool that intended and partially managed to break this convention was Prezi. Founded in 2009 it provided an interface in which it was possible to design presentation with one big plane and where slides were represented by different areas of this plane, preserving the context of the presentation as a whole. We said partially, because even though Prezi managed bring a novel perspective on what does it mean to be a slide, it essentially still followed the structure of slides in the way it created presentations. Every crafted area of the whole plane still worked as a slide and was transitioned into accordingly.

[137] David Brock. The improbable origins of powerpoint, 2017. URL https://spectrum.ieee.org/tech-history/cyberspace/the-improbable-origins-of-powerpoint

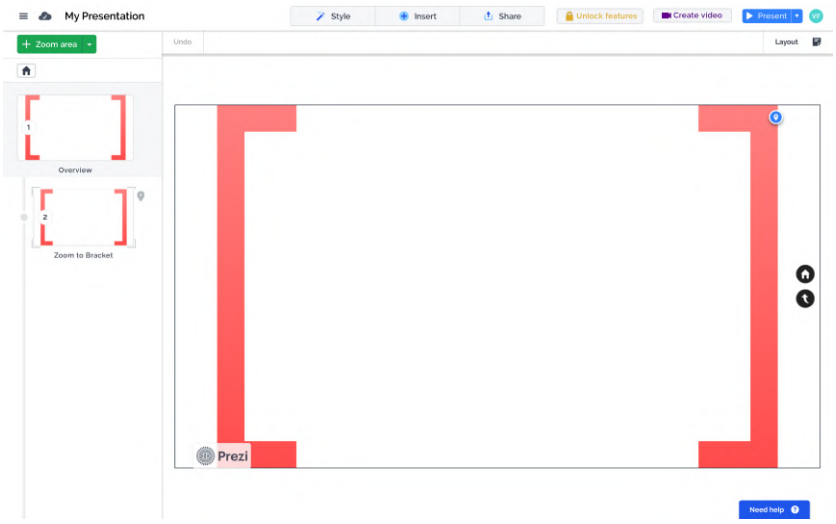


Figure 28: Prezi Interface [Inc., 2021]

Another fact from which we would like to distinguish ourselves is that with Prezi it is easy to fall into the mode of being a designer. To stop writing and rather spend another 15 minutes setting a style, or formatting of a block or slide. In fact, the interface puts us into such a place where we focus on the visual style and spatial organization much more than on the actual written content. It's true that presentations are meant to convey a meaning and they are not meant to be read as a structured text, but with the separation of semiotic blocks into different slides we are losing the sense of continuity for the story when we are writing it, while we preserve its visual continuation. The number of options to choose from can also be overwhelming, directing our focus on the format and distract us from the actual message which we want

to convey.

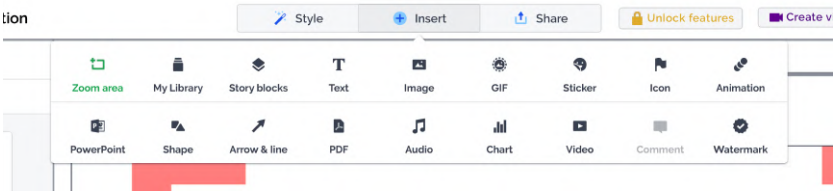


Figure 29: Prezi Interface's Toolbar

With the activity category of performing, we would like to emphasize that performing in the context of writing/reading is not only presenting, but rather entails variety of contextually different activities such lecturing, computing (on the board), explaining, showing, persuading - each of them having slightly different needs and mode.

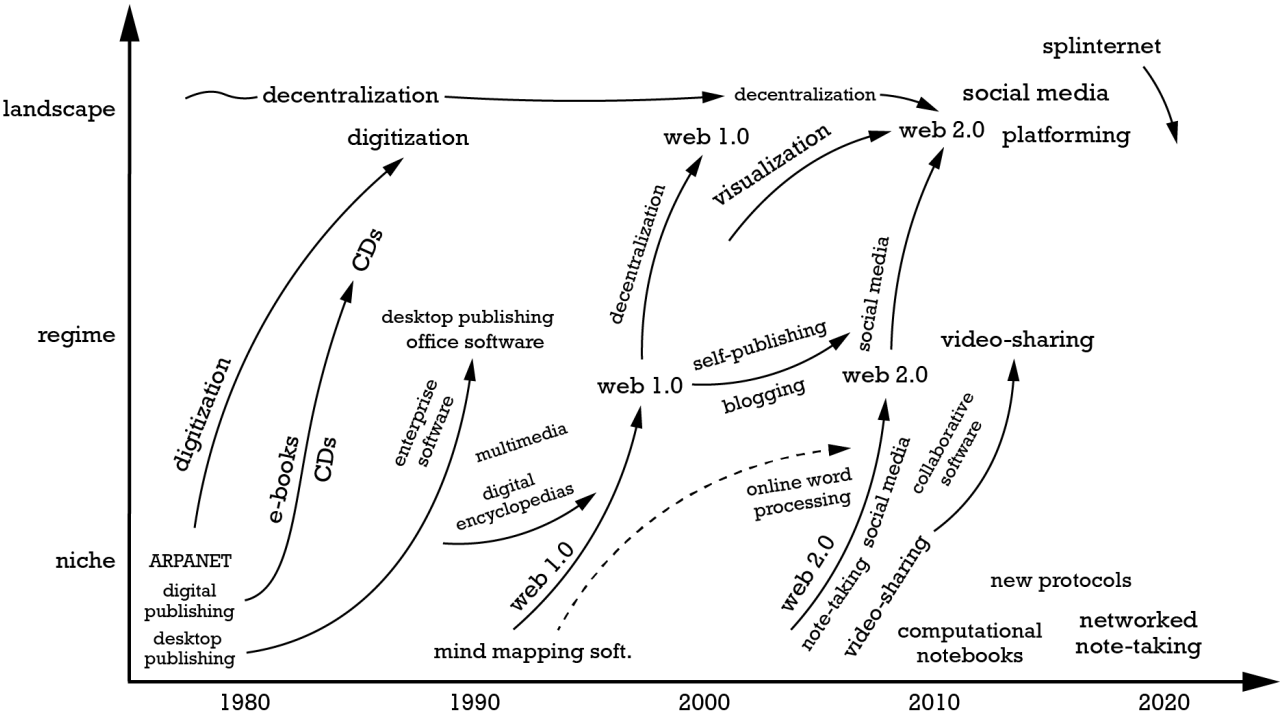


Figure 30: digital tools for writing - mlm perspective

Finally, with the aforedescribed analysis of the transitional space in which we want to situate our artifact we create the multi-level perspective diagram. The most significant parts of it reflect the processes of digitization which we described earlier with the radical change of the emergance of CDs and the rapid rise of web 1.0 and web 2.0. There are certain parts of the diagram which we would like to clarify. One of them being the trend of decentralization which is described as present within the landscape since the very beginning of the graph.

We understand the process of decentralization in much broader terms, starting with the beginning of the use of the copying machine. With copies being made easier, there was no need for centralized storage and archives of documents. This process was in play already in 1930s and of course has been further accelerated with digitization and new digital methods of storing and effectively copying documents and then it was accelerated with the spread of the internet in 1990s. It is questionable how this process will continue in the years to come as we had seen a certain pullback with causes like net neutrality, centralization of environments and computing resources by big corporations such as Google or Amazon and even political developments which appear to be in favor of protectionist and isolationist policies which is expressed in the notion of the *splinternet* or "balkanization of the internet". Because of the external nature of this effect and phenomenon it is pictured on our diagram as affecting the landscape (and regimes) from the top. From the perspective of technological development we can see the systematicity and rationality yet also arbitrariness in the way which reading and writing practices situated and adapted themselves. One can recognize one of the most crucial transformations as adapting to typewriting from handwriting - affecting the practice of writing on the level of its technical realization. Another radical transformation has been related to the storage, the form of a medium for writings which we produce, allowing the practice to be almost costless on large scale. We can't forget about the aspect of distribution which with the rise of internet became accessible to everyone indivually. We would like to point out on certain still existing, one could say - dogmatic, concepts which persist. The medium of a paper and its dimensions still dominates the format of space in which we write digitally. The change of it is however happening in the very moment, when traditional printed media are moving to online digital space and the practice of printing material issues is slowly diminishing as the demand for it decreases. This allows for new formats in which news can be presented on the screen. Another concept which we would like to challenge is the orthogonal organization of the text. Following strict linear lineage, it discourages any form of diversion or free exploration. It dictates the way in which the text has to be read. This has been enriched with the notion of hyperlinks in interactive documents, yet in that sense we are still in the beginning of this process of transformation. Even interactive documents, yet interlinked, they still pose as separate pages, separate blocks between which ones has to switch as completely separate entities and keep their synthesis apart. With new digital medium there is a potential to make the text behave. To not only make it an objectified and rigid depiction of one particular state of someone's mind, but to make it a reflection of the process - a process of discovery, a process

of exploration, a process of understanding which can be observed and traversed through as an active, speaking and reactive artifact of the knowledge in the time in which it was conceived.

3. Methodology

3.1. Research through design

In the development of our artifact and research contribution we follow methodology of *research through design* which allows us to do continuous iterations of reframing of the problem and reflection through the artifact improvement. It also functions for our approach of seeing the problem of rapid knowledge comprehension and its direct relation to activities of writing and reading as a wicked problem and understanding in a wider context of habitual practice.

Zimmerman and col. set definition for *research through design* as a model of interaction design research with the focus on benefit for the HCI research and practice community [138].

[138] John Zimmerman, J. Forlizzi, and S. Evenson. Research through design as a method for interaction design research in hci. In *CHI*, 2007

The methodology is based on Frayling's practice-led research *researchinart* with an aim on designing artifacts that can transform the world through the lenses of addressing the problems they solve as wicked problems which we described in the previous chapter. It also sets criteria through which we can evaluate resulting interaction design research contributions.

Research through design is a material inquiry focused on producing a contribution of knowledge.

Increasing complexity of systems that designers were being asked to create lead to segmentation of research processes from designing of artifacts to development of knowledge. This allowed inclusion of reflective practice and possible improvements within the methodology itself. What was started once as *usability engineering* turned into *creative design* when designers developed their methodology of work from meeting software specifications to reframing the problem itself. Daniel Fallman also describes that as *design-oriented research* - a methodology in which design prototypes have been used to demonstrate research contribution. This also allows for identification of patterns across multiple artifacts and development of pattern languages - sets of design patterns within a certain examined context. Even though he also uses the term *research-oriented design* to describe the actual development process used in HCI. The critical distinction is that while research-

oriented design, we are designing, creating new products through the means of research, in design-oriented research the main objective is the research conducted through the means of design [139]. In design-oriented research or research through design, the main objective is the research - contributions of knowledge within the activity of design which is unbounded from the imperative of serving a purpose any other than the research itself. This can be best illustrated on the field of critical design where even nonsensical and useless artifacts do aim to pose a provocative, yet carefully crafted research question.

[139] Daniel Fallman. Why research-oriented design isn't design-oriented research: On the tensions between design and research in an implicit design discipline. *Knowledge, Technology & Policy*, 20: 193–200, 10 2007. DOI: 10.1007/s12130-007-9022-8

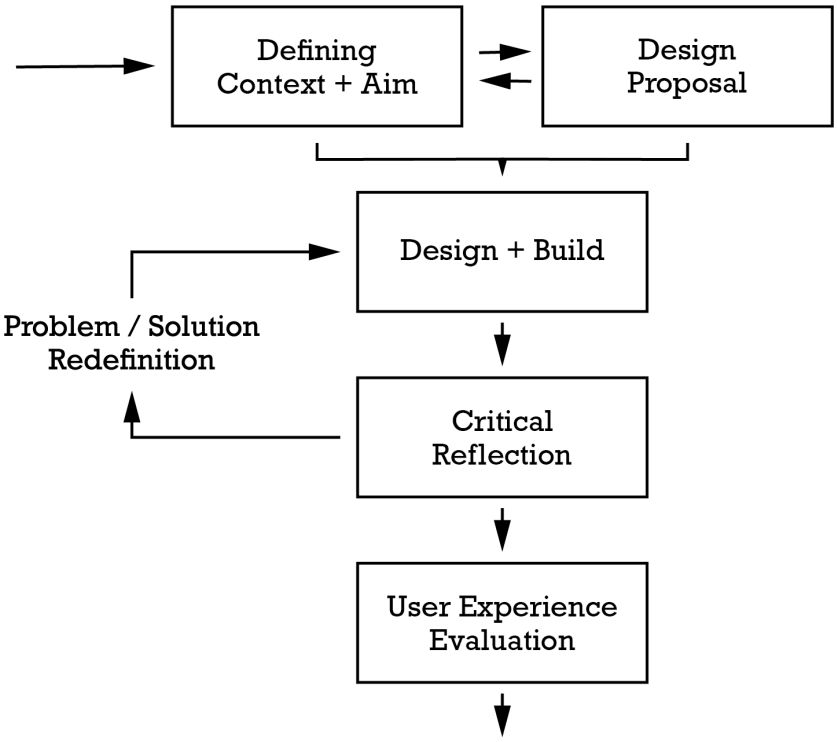


Figure 31: Scheme illustrating our methodology

The model we follow in our process of research through design is illustrated on the scheme 31. We described and defined the context in the last section of our state of the art research and defined our aim in the introduction. In the next chapter of design proposal we discuss the assumptions with which we enter our research process. The research process is defined as iterations of designing, sketching and building our artefact with the step of critical reflection that allows us to make progression in a way we understand and see the problem and its possible solution. Once having the prototype we start to challenge and refine the critical assumptions we build in the research through design process within the frame of actual user experience evaluation.

What therefore completely defines the methodology of research

through design is the understanding of framing. Rather than solving the problem, the aim of design is to allow problem to be solved - to identify conditions and critical leverage pointswithin the chaotic process of exploration. This is done through a such kind of reflective framing that can easily lead to intentional actions and alter reality into a desired state [140]. An artifact that results from the process of research through design reflects such kind of framing. Apart from design practice artifact, research artifacts ignore commercial aspects such as economics or manufacturability, we would like to note however that we reflect on the inevitability of commercial aspects playing a crucial role in the process of design intervention and world transformation.

[140] Harold Nelson and Erik Stolterman. *The Design Way: Intentional Change in an Unpredictable World*. MIT Press, 01 2012. ISBN 0262018179. DOI: 10.7551/mitpress/9188.001.0001

3.1.1. Criteria

Zimmerman and col. define 4 criteria based on which they evaluate the concrete application of the research through design method.

1. Process
   rigor of the used methods and the reasoning behind the choosing
2. Invention
   extensive literature review, advancement of the contribution in the current state of the art
3. Relevance
   based on the motivation and impact which the design aims to achieve
4. Extensibility
   ability to build on the resulting outcomes of the research

Within the practical part of our work we would like to evaluate our steps and decision based on these criteria, in particular on the criteria of the extensibility.

4. Design Proposal

The design proposal we would like to outline is a summarized set of contextualized, yet subjectively driven assumptions with which we enter the iterative process of design-building. We intend to describe these assumptions within the proposal, yet we would also like to provide a visual reference of our vision which could possibly reflect the assumptions and subjective beliefs which are yet to be identified and described.

Following the methodology of research through design we aim to frame the problem we intend to resolve. That we have already done to an extent in our state of the art research where we approached the problem from variety of viewpoints and research contexts.

Our basic aim is to catalyse rapid comprehension of knowledge through the intervention in the practices of reading/writing, in particular by proposing a new medium for non-linear storytelling. We did describe how both activities are tightly intertwined and that efficiency in reading comprehension of existing content is dependendent on the process which entails its production.

4.1. Structural Aspects

We imply the existence of two dimensions within which the problem is framed - structural and semantic. In the structural dimension we perceive the structural differences and deficiencies between forms in which recall knowledge in our mind and archive and transmit it into a medium. A possible structural loss of information within the object of text as it is transformed from coherence graphs in our minds to lines of words could be speculated. This is the reason why we choose the object of graph for knowledge representation. With the introduction of graphs as forms of text organization an ambiguity within its hiearchy is introduced.

One could proceed to read the graph in e.g. western convential manner, from left to right, yet this doesn't provide complete definiteness, as some of the words are purposefully omitted. Similarly, it requires reader to construct their own direction of reading or be skeptical to-

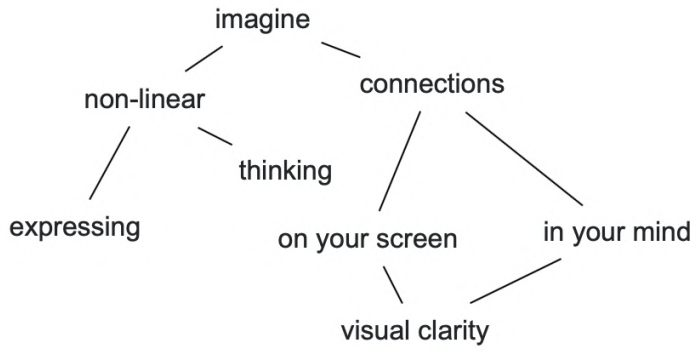


Figure 32: An example of a graph illustrating ambiguity within hierarchy

wards traditional reading directionality within this new form. We can imply that by destroying the linearity in which text is read, we can perceive a new problem - lack of visual hierarchy. All the content appears at once without a clear, definite beginning and end. What creates visual hiearchy? We believe that spatial organization itself isn't sufficient in creating visual hierarchy for the reader. Are features such as visual connections relevant for the experience of spatial orientation?

The semantic features could also support spatial orientation to an extent. As we see in some of the other examples, apart from cognitive modelling and the model of coherence graphs where each node is a proposition, a node can serve as a connector and support the process of translation. Yet, it is a question whether such appropriation of nodes does outline a natural pathway of progress or is more of a relict of the grammar from the past.

Another structural aspect that we pose to explore it the size of the node. Should the node only consist of 1-2-3 words? Should it be more descriptive, 'literary' and contain 1-2 sentences? Or regardless of size, should there be a unit of meaning to which nodes should be compared and measured? It's difficult to measure or even propose the ideal scenario as for the abstract nature of reading efficiency which we aim for, nevertheless what we would like to question and understand is: How does the size constraint of textual node affect created stories, graph, objects our of artifact? Should there be any constraints at all?

The apparency of the problem of the lack of guidance for the reader leads us to one of the assumed concepts and that is the progressive disclosure. Breaking the linearity of sequential ordering of the textual content from its spatial organization requires us to move it into its temporal dimension. One could pose questions whether this is the

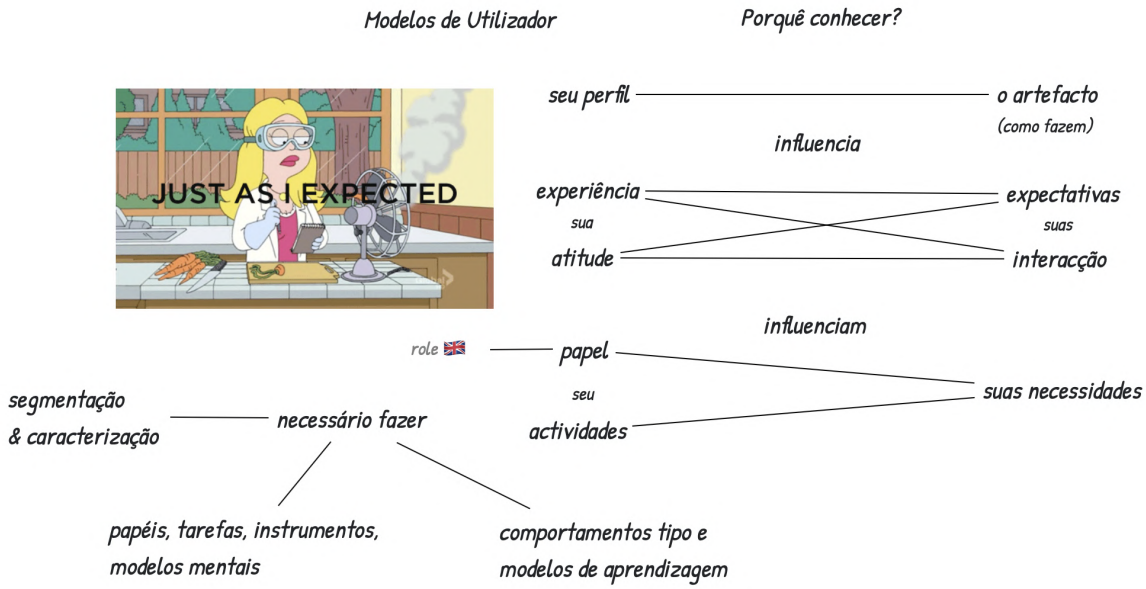


Figure 33: An example of a graph illustrating various sizes of textual fragments

most efficient way of creating guidance and direction for the reader, whether it is truly required and whether we are actually making any improvement. It is the role of this work to prove it.

4.2. Semantic Aspects

The second dimension we split our assumptions into apart from structural is the semantic one and it concerns the material organization of objects being created using our artifact. By material organization we mean the organization of meaning that is being delivered to the reader. We could have chosen to talk of *narrative*, but we chosen the word *storytelling* to **emphasize a performative, subjective and participatory aspect of human investment within the activity**. We chose this term also to stay in line with the consideration of story as a fitting epistemic object for the knowledge exchange and transmission. The main question we ask in this dimension is: How can we intervene to encourage people to write stories within the spatial interface for writing? To affect the technical process of writing we intervene in the tangible tool which mediates the act of writing, yet the aim of affecting what we write is much more challenging. How can we support the writer to present their information in the form of a story? To rely on the mere presentational quality of the progressive disclosure would be exaggeration of its role. Yet, there is no clear way to limit the generative property of text only

Figure 34: An example of an explanatory graph story being gradually revealed

to support the storytelling genre. The story template has to be either induced via guidance during the process of writing or inspired by the existing stories written using the tool.

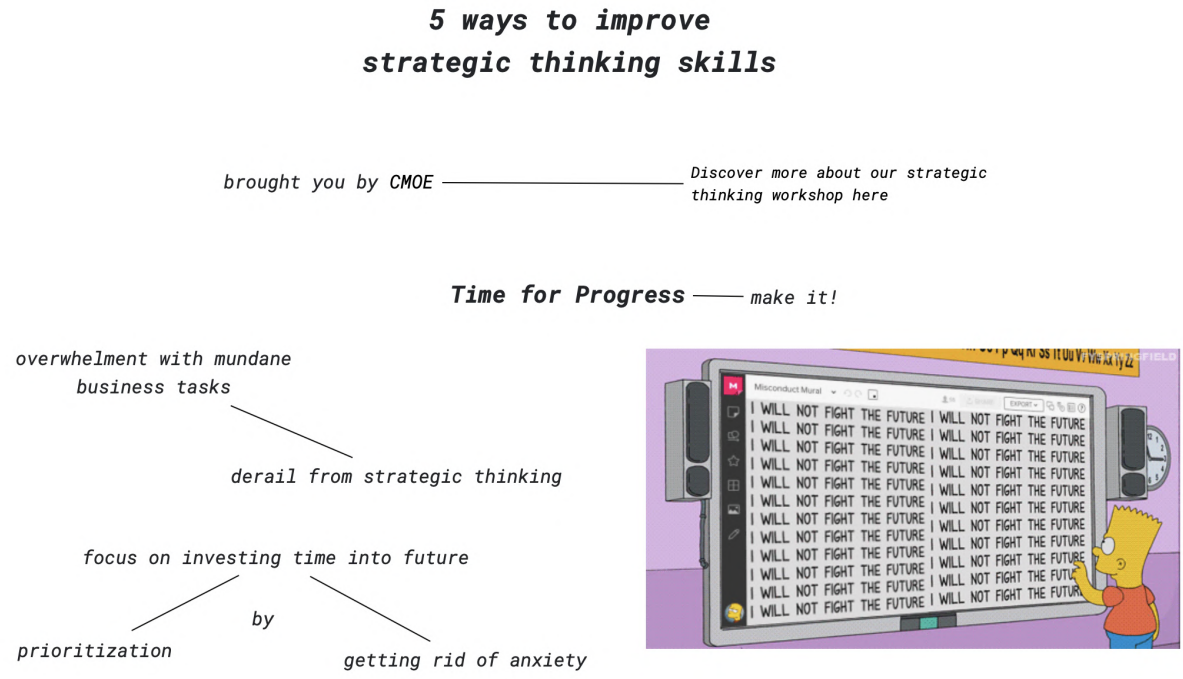


Figure 35: An example of a graph illustrating the case of a story

4.3. Querying

In the part of our design-oriented research we would also like to explore the tight relation between writing and reading. We already described how interrelated the processes of reading and writing are. While we write we access the information by 'reading' them from our either internal (brain) or external (resources) memory. Similarly, while we read, we translate (write) partial information again either into our internal or external memory (by e.g. taking notes). The unifying action within both processes is the action of querying. We query (retrieve) information from memory and we query when we translate information into the memory. This way we can query while we are reading to infer propositions from the text, but we can query for the new content during writing as we are accessing different resources. This sets a single very particular context in which we understand the separation of the user activity between viewing / editing interfaces. A following questions offer themselves: Can we merge activities of writing and reading into

a one creating a completely new experience? Could we, by merging the activities of writing and reading, create favorable conditions for (peripheral) collaborative participation?

4.4. Organization

Another issue that we would like to address is the organization of content. We are familiar with the organization of written content within a constrained information spaces such as documents or canvases. Similarly, a world wide web has been constructed following this type of organization - linking existing documents in between of each other. In this particular case document precedes link. A link is only created after a document that it refers to exists. What we would like to ask is: How can we allow for much more "liquid" creation of information units - stories / graphs? Are we able to design an experience in which document is creating by browsing? What we refer to is the possibility to explore the path before inserting a document, a story. By exploring such path we are creating it and we can leave information relicts on our explorative journey.

As we did explore in the chapters of nonlinear storytelling and territoriality; an ambiguity plays a key role in the activity of exploration. In the exploration a new world is being constantly (re)created. In this particular aspect of the project we would like to explore generative capabilities as a source of ambiguity and these new worlds. Either within the direct dialogue with the writer - providing suggestions based on what is written or more indirectly by continuously generating a spatial organization in the activity of writing or by suggesting a reader possible continuations of the story that they are reading.

4.5. Niches

Last, but not least, we would like to situate our tool within the right niche communities to further advance our research in alignent of the actual need and use. The nature of communities we would like to target has been partially addressed in the section of transitional pivoting, within the state of the art chapter. Out intention is to eventually evaluate the use of our tool in contexts of communities such as Tools for Thought community, #scicomm community, various university communities and the communities of independent journalists, storytellers and bloggers. We also bear in mind a possibility of testing our artifacts in the community of our own university - in particular in the context of note-taking, learning and collaborative sensemaking.

4.6. Research Questions

We summarize our assumptions upon which we reflected on in the following research questions which intend to frame our research activity into distinctive aspects:

- Is there a way to substitute text as a set of lines consisting of words by a graph structure?
- What is the preferred use of connections in the graph structures created within the activity of writing?
- How can we design the spatial positioning of nodes so it does not negatively affect the thought flow of writer?
- Can we encourage people to write stories within the form of graph structures and spatial interface for writing?
- How can we design actions of prune and graft to facitilite copying and pasting parts of graphs?
- How can we design aspect of collaborativity so we can encourage interaction on someone else's subgraph?

4.7. Activity Plan

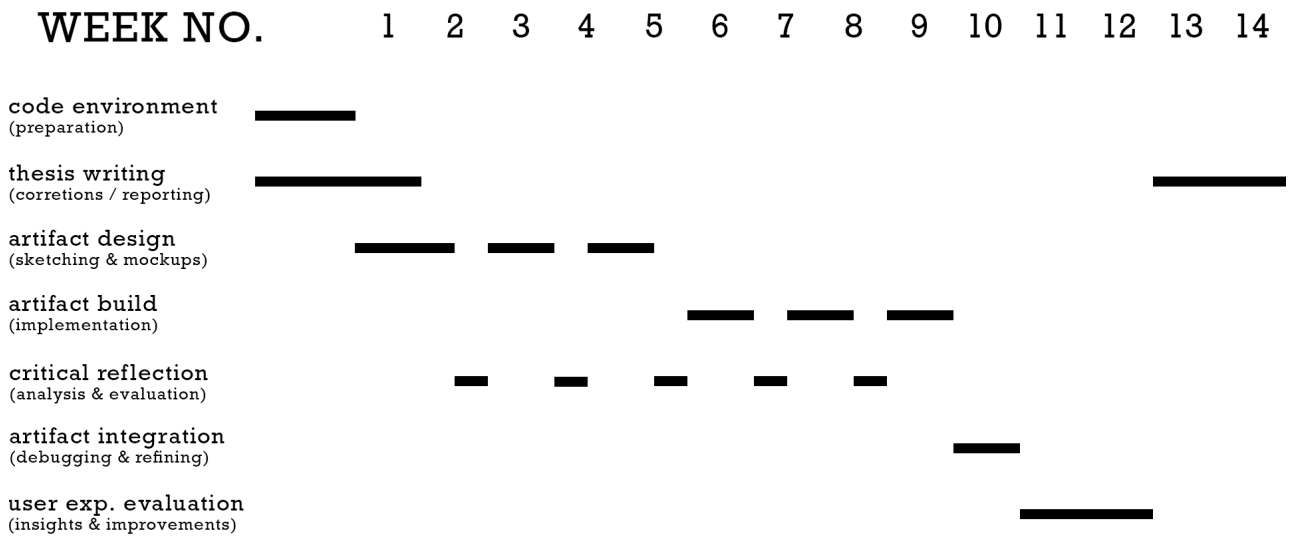


Figure 36: Possible approximate schedule of the activity for our practical part

The activity plan for the practical part of our thesis intends to follow the methodology of research through design. In it we iteratively,

through the activities of designing, building and consequentially reflecting, try to define the better the conceptual space of the problem within which we work. This plan illustrates a 'naive' default path that we would take if there were no surprising changes or challenges within the process. Even though we are sketching out a fairly linear process, this plan is meant to serve orientational purposes for providing a schedule we can compare our progress to, assuming that the process of design and building could diverge from exact times and pathway we are outlining. Similarly, a time unit of week is seen as more flexible, given that for particular features or artifacts more time will be needed, while for example, for the critical reflection less. Nevertheless, we still included it within the gantt chart as it plays a significant role in the process. What we identify as the critical part of the plan is an approach to a clear design description of the solution we intend to propose. Our activity plan did undergo some changes and adaptations due to the circumstances of the design process. We include the initial version within the annex of the this work. What we define as the main output in our process of research through design is a journal with created artifacts, decisions and steps being taken and their reasoning. This follows the methodology of research through design describe in the previous chapter. We follow the framing for our design proposal as we did define it here and our intention is to address aforementioned questions and contexts of our research while orienting ourselves towards the aim of improving efficiency of knowledge comprehension.

No.	Date	Month	Category	Activity
1	2021-02-15	February	Artifact Design	Completing last parts of the state of the art research. Contextual design, discussion and of the minimal writing interface. Scenarios and scenario analysis.
2	2021-02-26	February	Critical Reflection	Reflecting on the ideas of minimal writing interface and scenarios.
3	2021-03-01	March	Artifact Design	Sketching the first prototypes, marking the crucial issues, features. Creating an early working sketch / model of the interface.
4	2021-03-08	March	Critical Reflection	Debating the sketches, identification of the possible challenges between the design propositions and our theoretical model.
4	2021-03-12	March	Artifact Design	Creation of the first mockups with an intention of depicting the user journey. Proposal for the brand identity of the tool.
5	2021-03-19	March	Critical Reflection	Reflection on changes between the sketches and mockups, identification of possible issues in implementation.
6	2021-03-22	March	Artifact Build	Proposition of the object model. Creation of basic user environment for story objects with authentication and authorization with a minimal interface for writing.
7	2021-03-29	March	Critical Reflection	Finalizations of any work that might have been pending.
7	2021-04-02	April	Artifact Build	Implementation of infinite panning, dragging, editing and adding of images.
8	2021-04-09	April	Critical Reflection	Reflection on the implementation progress. Reassessment of the implementation plan.
9	2021-04-12	April	Artifact Build	Implementation of the connections, node dependencies and image resizing. Attempt to implement one of the more exotic features that has been discussed.
10	2021-04-19	April	Artifact Integration	Debugging, refactorization and refinement of the artifact. Preparation of the possible use cases for the user experience evaluation.
11	2021-04-26	April	User Experience Evaluation	Definition of key concepts to be evaluated and test protocol. Interview sessions with participants. Pattern and theme identification, analysis and insights.
13	2021-05-10	May	Thesis Writing	Finalizing writing of the thesis. Creation of structure, interface design model, reflection on methodology.

5. Conceptualization

In the chapter on transitional pivoting we did narrow down our problem space to tedious-to-read, inefficient and incomprehensible content, mostly on complex topics which include a level of analytical reasoning. We reiterate on our aim to make comprehension of such topics more efficient through the means of a medium that can extend our mental process so it can be observed, shared and collaborated upon. Notably, we orient ourselves to encourage the form of a story within the activity of writing. In this chapter we conceptualize the problem by the means of personas, user scenarios, sketching and mockups.

5.1. Scenarios

5.1.1. Scenario Analysis

Instead of task analysis, the activities we have been investigating and for which we are designing our solution are rather unstructured. The activities of writing and similarly - reading varies across different contexts, methods, personalities. They do not consist of structured tasks which we could clearly identify in advance and therefore we have to imply usage of a different analysis. For this sake we are drawing our sketches, mockups and propositions directly from the carefully selected and identified scenarios with the goal of identifying and applying commonalities to our general design which could satisfy a significant range of problems arising within them. During the making of our scenarios we used the service generated.photos for the photo generation.

5.1.2. Scenario Criteria

Scenarios are meant to provide context of why and how a user uses our tool, our application and what kind of goal are they trying to achieve [141]. In writing of scenarios we help ourselves with *personas* through which we specify who our potential users could be, their background, knowledge and skillset in order to develop empathy. In scenarios

[141] Interaction Design Foundation. User scenarios. https://www.interaction-design.org/literature/topics/user-scenarios, 2002. [Online; accessed 02-July-2021]; and Usability.gov. Scenarios. https://www.usability.gov/how-to-and-tools/methods/scenarios.html, 2006. [Online; accessed 02-July-2021]

we focus on setting the goal of what the user wants to achieve, their motivation and the tasks they follow when achieving their goal. We also intend to describe the context of encounter between the user and our tool - in which situations do users use our tool. We can speculate on what kind of obstacles users can face in the path of achieving their goals.

5.1.3. Scenarios

5.1.3.1. Peetu Rautio

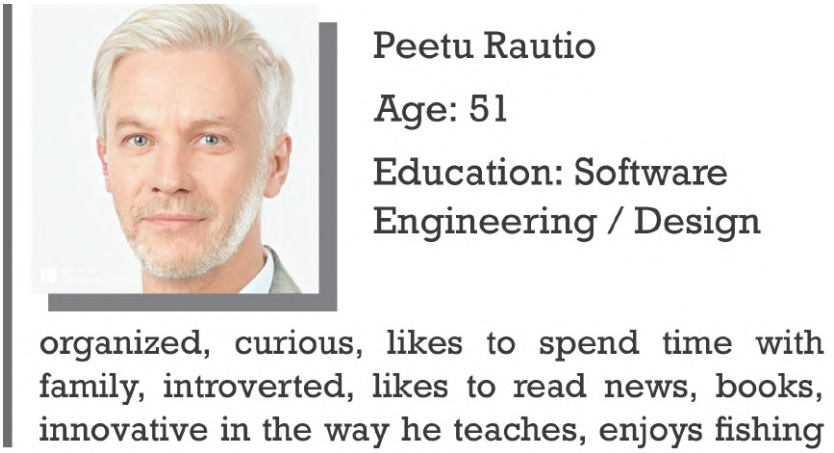


Figure 37: Peetu Rautio - professor on Grand Ridge design school

Peetu Rautio is a professor at Grand Ridge design school and he wants to bring closer the concepts of service design to his students. He understands that the key components of learning are within the experiences students go through during the course. An engaging experience can trigger a revelation, stay in the memory and make learning more fun. Professor Rautio builds over the years an interactive environment on his academic website in which students can enter his field of view on service design and then explore different particularities, each within a frame of his website. Yet, it took Mr. Rautio too much time and he would like to introduce more interactive applets to the environment, without putting so much effort into programming whole pages. Even if having a profound programming expertise, he simply can't alone deliver the experience for his students which he would like. In Semioskop he finds a tool that allows him to create such environment including multiple of interactive applets. He can even embed it on his webpage.

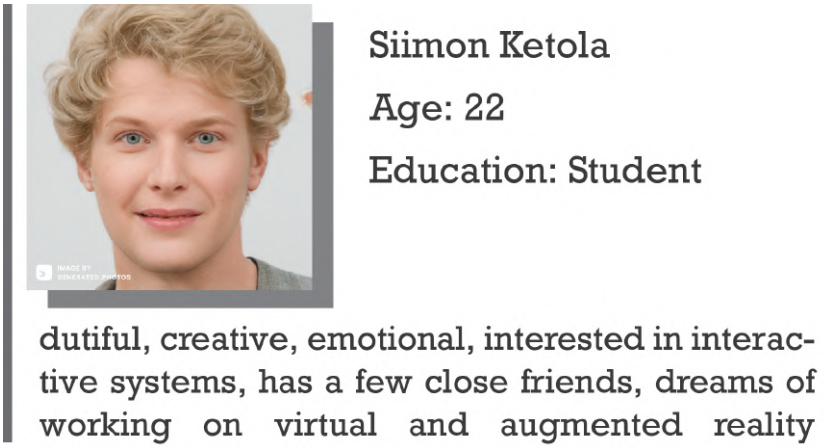


Figure 38: Siimon Ketola - student on Grand Ridge design school

5.1.3.2. Siimon Ketola

Siimon Ketola is a student of Grand Ridge school and based on a recommendation of his professor Peetu Rautio he is starting to prepare for the exam of service design by using the tool Semioskop. He finds his profile and a story batch for his course. He starts with the first story about service design. He finds it engaging. He reads it all. He especially likes that he can see the progress of his reading which encourages him to read more. At the end of the first story he is prompted to write what service design is in his own words. After writing and completing the tasks. He is shown and recommended new unlocked stories he can follow from here.

5.1.3.3. Kianna Pham

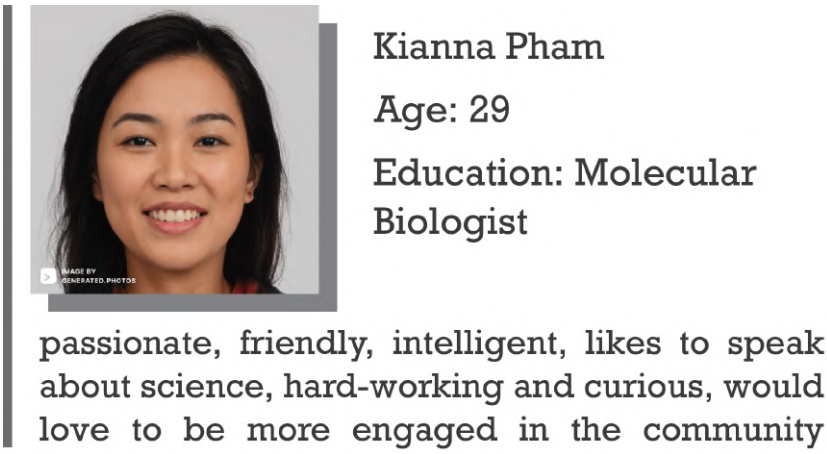


Figure 39: Kianna Pham - Longevity Researcher at Palo Alto

Kianna Pham is a longevity researcher based in Palo Alto, CA. She has been seeking ways to make her research more efficient while also sharing it with more people. She takes particular interests in AR/VR technologies as a potential medium to share and experience her biological research. Still in its infancy though, she hesitates to use it as it offers only limited models and there are no familiar ways to share it (yet). In Semioskop she finds a medium in which she can brainstorm, organize, but also present her research and explore and find related one. She especially likes the ability of a graph to reveal itself which gives her a way to provide information gradually.

5.1.3.4. Randy Tejeiro

Figure 40: Randy Tejeiro - Hobbyist & Electrical Engineer

Randy Tejeiro is a hobbyist who is greatly passionate about and interested in astronomy. Since the recent innovations in space industry, mostly fueled by Elon Musk's ambition, he grew very interested in the field. Randy started to publish weekly videos about the most important events in the world of astronomy. It takes a lot of research to script and prepare a one. Randy also likes to ocassionally write a blog about events that are of unique character to him, but moreover he likes to explain concepts. Recently, thanks to his friend, he stumbled upon the website of Semioskop. He was informed how great it is to explain and research even multiple topics at one and to preserve that process. Suspiciously he tried it out. He grew quite ecstatic about it as the tool can provide a better way he writes about and explains those more specialized topics and unique events he likes to speak about in more detail. It also provides him with a way to organize research for his new video.

5.1.3.5. Taiquana Wheeler

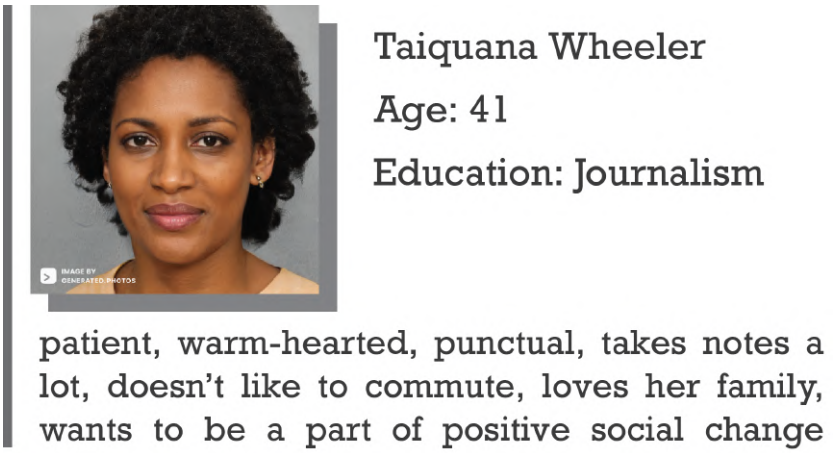


Figure 41: Taiquana Wheeler - Investigative Journalist

Taiquana Wheeler is an investigative journalist who uses open sources to investigate various suspicious activities within government. Thanks to her analytical skills she is able to create complex networks of relationship between suspicious companies, politicians, their lackeys and donors. However, the complexity of information she collects makes it difficult for her to contain it within a story. It's difficult for her colleagues to keep up with her. Finding about the new tool called Semioskop as a tool for explanatory storytelling she starts to map her networks within the tool. Thanks to the feature of progressive revelation she can more vividly be aware of the time dimension of the graph she creates and the story it tells. It still is very complex for general public, yet with a few descriptions it becomes much more accessible and could serve as an interactive addon to the story. Her publishing newspaper embraces this and adds such an exploratory applet to the article.

5.1.3.6. Israel Botín

Isreal Botín is a freelance graphic designer who after his time working for an online media outlet as a designer of infographics wanted to have more independent say in his designs. He signed a contract to work for a more disrupting company where he can be more independent in what he publishes. He is especially interested in increasing his viewership, his online personality which benefits both him and the company he works for. He is exploring new, innovative ways to make telling his stories more efficiently, seeing how much time doing a research on the topic, but especially designing it can make. In his twitter feed he notices a story retweeted in by his friend written in this very avantgard,

Figure 42: Israel Botín - Visual Storyteller

yet interactive form. He tries it out and he realizes the potential - in this tool he can write his research notes and design the final story at once. This is something he was always looking for - to make the process of taking notes, designing and telling a story much more fluid. Even though Semioskop doesn't have all the tools of a designing software, the tool suits him, because he has been transitioning to the role of journalist more anyway. He slowly figures out how to make his stories in Semioskop and his viewership steadily increases.

5.1.4. Scenarios Reflection

When assessing our scenarios we can start by characterizing the personas we managed to create. They are relatively young, but most of all independent and curious people with high level of self-awareness. They use the tool mostly for the goal of communication whether it is for observed topic (in case of publishing) or professional topic (e.g. in the context of learning) - a topic related closely to their profession. We can also assume that these people are well-educated, they like to take initiative - they are disruptive. They see Semioskop as a tool that enhance their communicational ability - mostly to other people, but also to themselves. They encountered the tool through the act of active searching or their engagement with a particular community of other writers, bloggers, teachers.

5.2. Sketching Strong Concepts

The first and the most immediate step to materialize the visions of our imagination is sketching. We utilize the concept of *strong concepts* by Höök, i.e., using sketching to capture "a particular form of generative

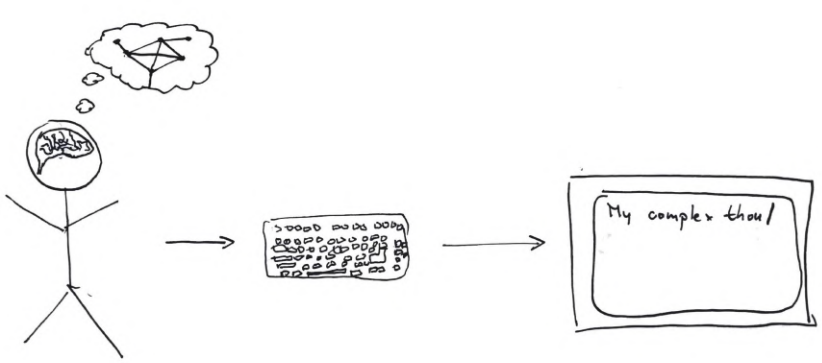
intermediate-level knowledge" [142]. Sketches provide us a signifier for our descriptions but also, within the methodology of research through design, they are an important leverage for reflection [143]. Within this attitude, we include and describe our sketching and dicussing process of this work.

[142] Kristina Höök and Jonas Löwgren. Strong concepts: Intermediate-level knowledge in interaction design research. *ACM Trans. Comput.-Hum. Interact.*, 19 (3), October 2012. ISSN 1073-0516. DOI: 10.1145/2362364.2362371. URL https://doi.org/10.1145/2362364.2362371

[143] B. Buxton. *Sketching User Experiences: Getting the Design Right and the Right Design*. Interactive Technologies. Elsevier Science, 2010. ISBN 9780080552903. URL https://books.google.pt/books?id=2vfPxocmLh0C

5.2.1. "My complex thought"

Our primary goal that is also implied from our scenarios could be described as the ability of an interface, a medium to encourage an expression of the complexity of interconnected structure of knowledge we hold in our minds in a way that is easily accessible and comprehensible. The following sketch does illustrate the state of the art of the understanding of our problem.



5.2.2. Knowledge-centric vs. Author-centric Interface

During the process of sketching we visually revisited or in fact verbalized the ideas some of which we already identified in our work. Notably we can speak about the different kind of targetting in personal communication / messaging and publishing which is intended to a wider audience. These activities happen in an interconnected structure between individual actors which due to the dynamic processes of group theory create clusters of various contextual topics and themes. Within this framework of thought we challenged our understanding of a node of such a structure, substituting it for the actual object of knowledge to what we call an information-centric or knowledge-centric system. Such thinking could allow us to decouple the relationship of ownership to the story or document, essentially seeing out platform as a database of interlinked stories similarly to what Wikipedia is. In fact, it is this model that allow us to let go of the distraction of profiles and

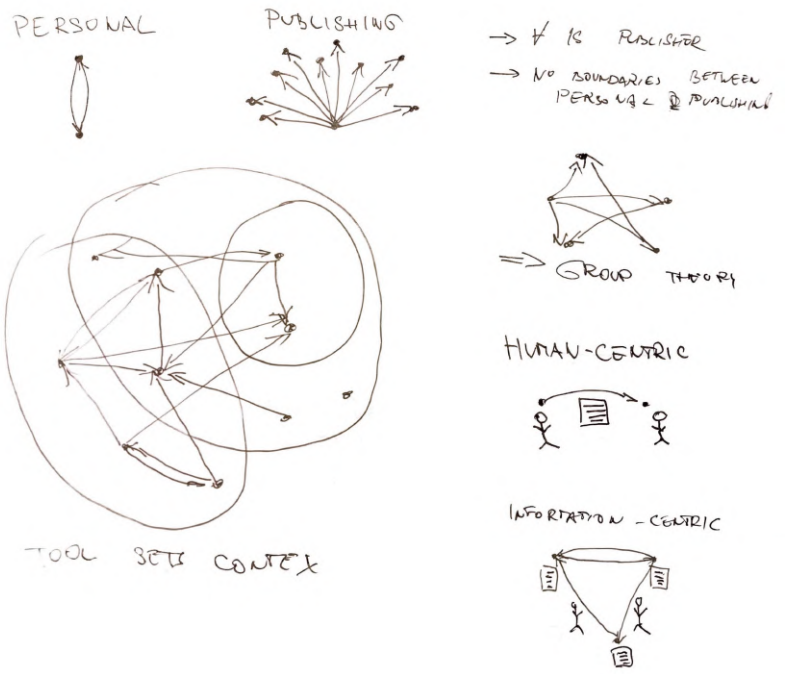


Figure 43: Basic features of our framework of thought

personalizations and rather focus on the quality of the content itself that is being not only created but sustained.

5.2.3. Semantic Snowflakes

The question follows; How to create content that could support comprehension and two of the described aspects of narrative as written by Marie-Laure Ryan - immersion and interactivity. A speculation was conceived to propose not only a single textual fragment as a node, but in fact the whole semantic domain consisting of multiple fragments. The same way a literary author describes a scene, guiding our attention to different parts and details of the room. Such semantic domain could describe a scenery in which reader could more easily immerse. However to assume that only detailed description is what drives immersion is bold and very likely false statement. As even the very detailed description could not allow a reader to immerse itself into the scene (as we referred to Marie-Laure Ryan example in the section about storytelling). Nevertheless the idea provided us with a speculative base for the space - or spatial aspect of writing for the genre of a story where each node takes us into a different scene. In this regard we also discussed the potential of utilizing temporal aspect. While in our application nodes reveal themselves based on the interaction of the user, the way in which they emerge and remain in the screen could be a subject of discussion.

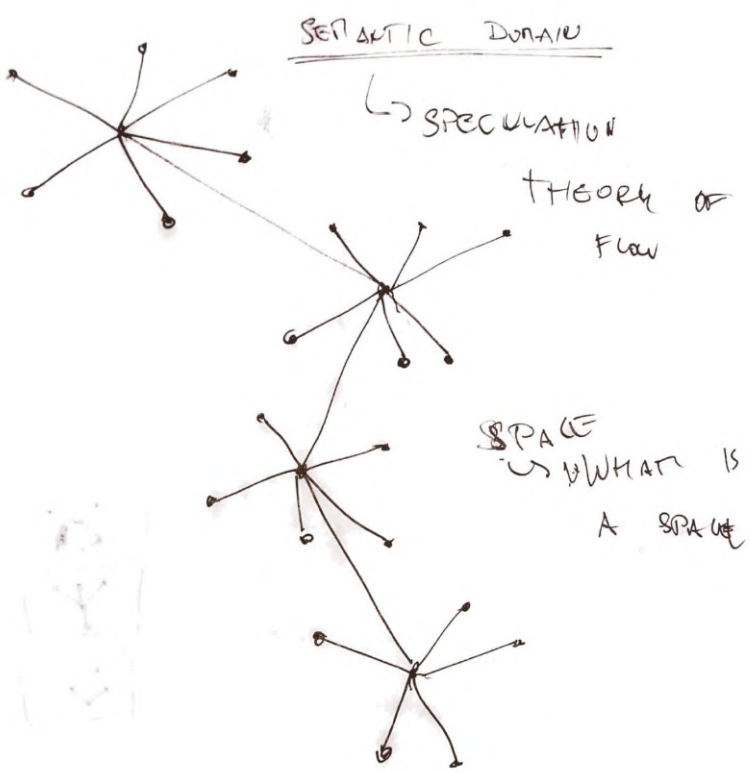


Figure 44: Model of graph organization of textual fragment where each major node ("snowflake") consists of smaller nodes, descriptors

One such idea would be to always have only a single "snowflake" - scene revealed. Furthermore, we could take the control from the reader completely or partially and let scenes reveal themselves conditionally based on time, interaction or mouse movement.

Another important part of our design is the way in which the acts of viewing a story and editing a story is defined. In an effort to break the boundary between the interface for writing and reading we played with following concepts:

5.2.4. Variety of Perceptions

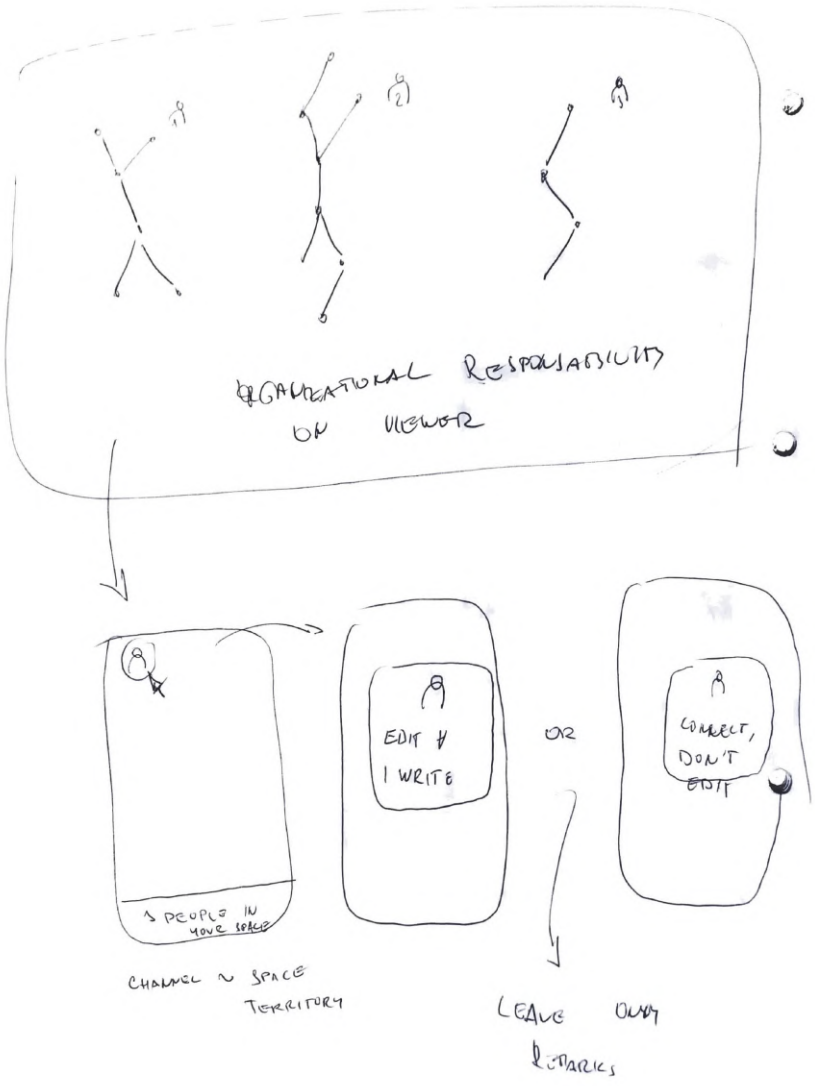


Figure 45: Organizational responsibility on reader

One of the ideas that has emerged was to preserve the set of nodes

and their attachment to the story, but to provide every reader with the possibility to reorganize or organize the story by themselves - creating their own spatial organization of the story which is being created in the act of reading. The ambiguity in which the nodes are organized could incentivize the interaction. There is a whole spectrum of how much ambiguous the spatial organization of the story's nodes can be. On one side of the spectrum it can be completely rigid, defined by the author, on the other side, it can be generated completely randomly with each new read. We speculate that neither of these extremes would prove themselves helpful, rigidity not engaging our imagination (creativity), while too much of a randomized generation would harm our ability to remember. One way to resolve this would be to allow certain extent of variation within a certain system of rules, limits (e.g. proximity) which could be even dependent on the reader's mouse movements and interaction. A very related idea is a question - should we allow the reader to change the spatial organization of nodes manually? Our speculation is that yes, with an option to return to original perception. In a way, manipulating spatial organization of one such space creates a completely new space, even though, very tightly related to the original one. Further editing however could lead to complete contentual detachment of the original - this could however be calculated by some sort of originality factor based on, e.g. overall likeliness of original nodes with each other.

5.2.5. Play as a form of querying

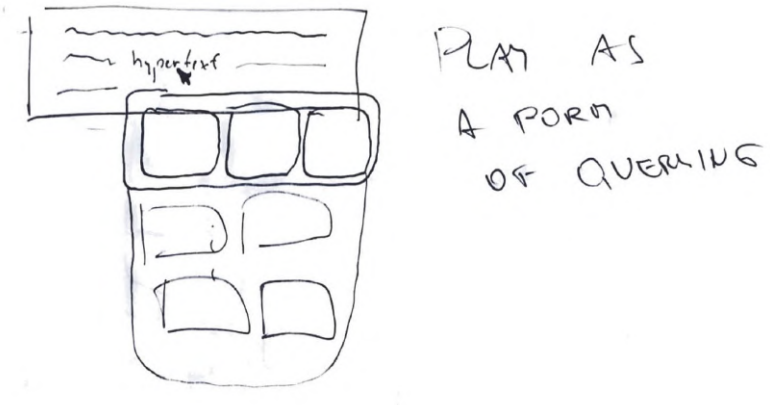


Figure 46: Play as a form of querying #1

What we call "play as a form of querying" has been another idea that intends to break the traditional organization of HTML documents and traditional experience of browsing through extending hyperlink to multiple pages with the intention of blurrying the lines between

writing and editing. Being recommended countless related (or even unrelated) videos on Youtube, we get curious, we follow, we click on a single recommendation. Similarly, when reading an article, a link it leads only to a single page. What if the hypertext could link to multiple pages - multiple stories as in our case? Hyperlink would serve as a cluster of related stories, documents which we could choose from.

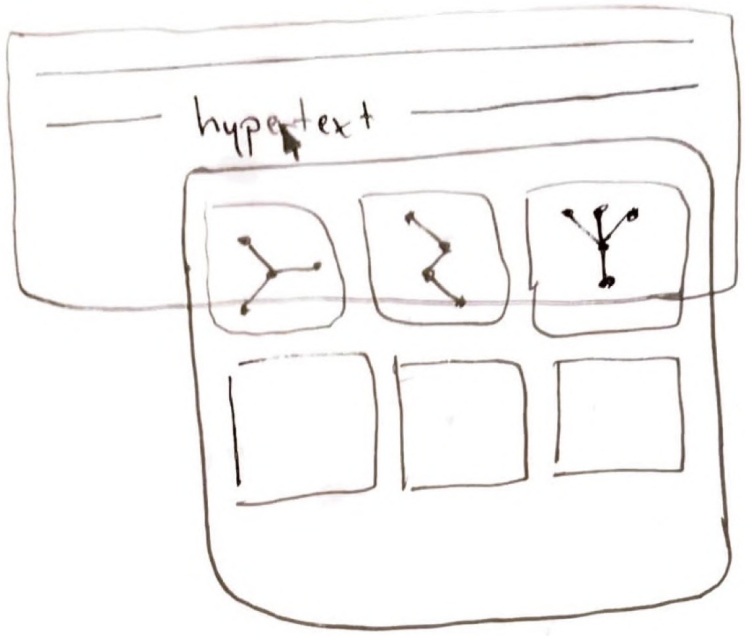


Figure 47: Play as a form of querying #2

This way the hyperlink itself would turn itself into a query - a similar kind of query that we use when we google something. However, this way, we would be suggested which queries to use while reading a story. This could lead us to different stories, but also to other related, maybe secret or more detailed parts of the story we are reading. The question is, should such hyperlink be generated automatically if it does find enough related stories to itself? Or should it be determined by the writer whether they want this particular word or phrase to be a link? Another idea that has been speculated was the automatic creation of a page upon clicking on a hyperlink if it doesn't yet exist. Using a Google analogy, this would be if instead of multiple results, Google, upon querying, would just direct us into a single page. This page could however be editable - being a story, a collaborative space on its own. This however presents itself with a few challenges such as a completely fluid authorship, but also it would require the links to be automatically generated. Usually system which work on similar premises of link generation are utilized in SEO as various rogue sites which intend to

be viewed regardless of what you are searching for. In this case, the attachment of link and its content could be completely non-existent and both could be unrelated. More sensitive idea is to make a transitional page with the search results of the link / query, but in this case we just reinvented the search engine.

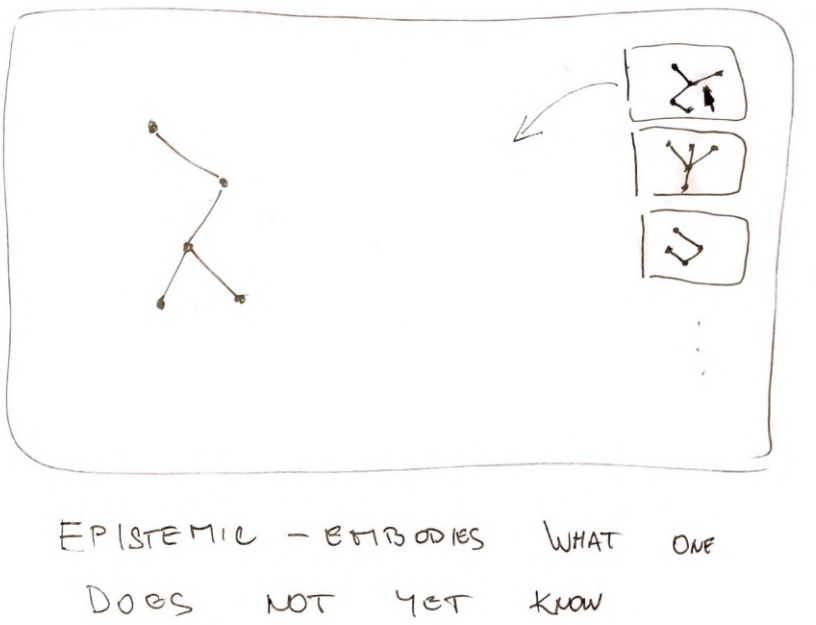


Figure 48: Writing feedback recommendations

We tried to utilize these ideas of playing as a form of querying in the process of writing as well. Mostly, in the process of including parts of other graphs / stories into our creative space. These parts of whole individual stories at first, most likely, would be recommended and updated during the process of writing, suggesting stories which already explained given topic and on more meta level, giving us information about the current discourse on the given topic, showcasing us existing stories. This could act as a distraction however and it is also questionable whether we could be actually able to see the whole stories or go through them without having to maximize them within our space, essentially bringing them to our space for a preview as a pre-step of actually copying them or parts of them.

5.2.6. Node Dependency

One of the most heated up topics we explored has been the introduction of non-linearity or in other words the idea of node dependence. This essentially is the requirement of a story to be non-linear - to allow multiple options for the reader to branch into. There are a few ways

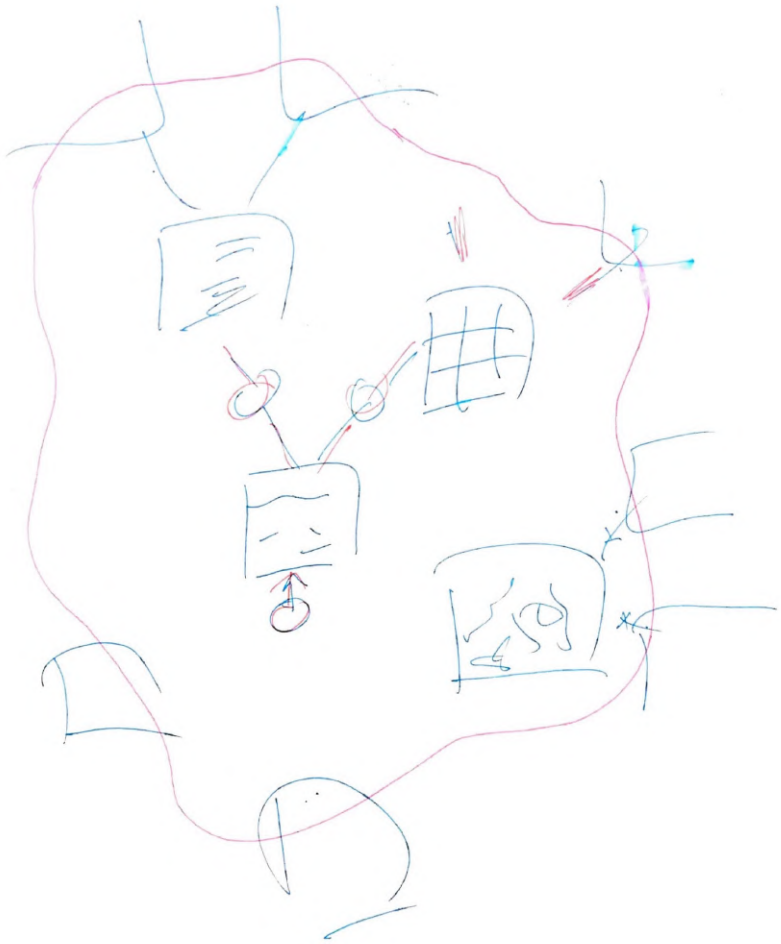


Figure 49: Structure of an exploratory space of a story

how to resolve this. One of them being to allow user to collect tokens based on which nodes they revealed, entered already. These tokens are then used to open new branches. For example, if learning about linear algebra, one would have to expand the branch about matrix multiplication in order to open the branch about, e.g. eigenvalues.

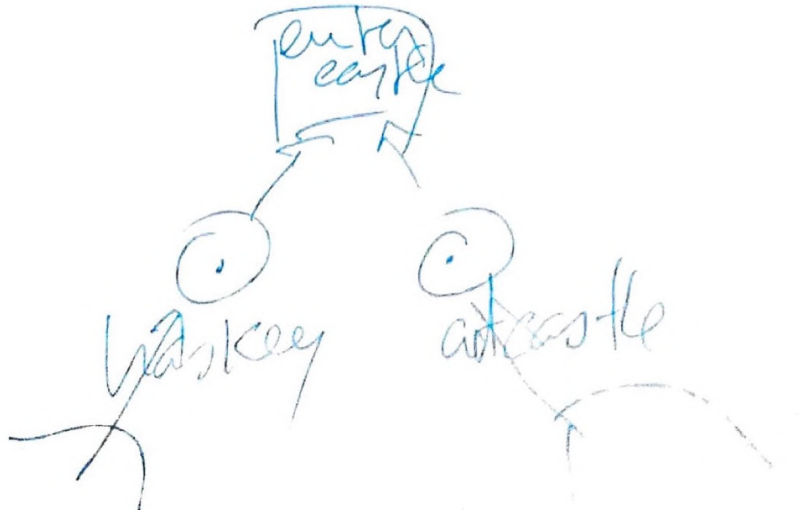


Figure 50: Node dependency

Or in our example, a key is needed in order to enter the castle. This node dependency would be completely independent from the order in which nodes were placed into the story. With such a functionality, it is important however to introduce also a way how to edit the story in order to allow user to add such dependence. Our intention is to preserve the minimal experience which aim is to create a lightweight sensation of writing onto a blank sheet of paper. With an option to add a node dependency such sensation could be broken and the interface could start resemble a more complex planar graph mapping tool. Essentially, it could create a sensation of complexity which is exactly what we intend to avoid. One question would be, how a writer could create a dependency to a particular node? A writer would have to have an option to choose from all the nodes they already wrote. How would they be referred? One can only imagine a long list of textual items and a tedious process of searching and selection through them, to complicate things even more - what about images and other types of nodes? How would those be showed in the list? There would be several steps of creating such dependency and it would clutter the space and whole experience.

5.2.7. Colour Currency

Another idea to avoid having direct references to nodes have been the idea of a color currency. Instead of saying that the node "castle" is dependent on the node "key", we can say:

1. When on the node "key", retrieve 1 blue token
2. When on the node "castle", ask for 1 blue token

This way, when creating such dependency, we would refer only to a color which could be signified as a small circle within a row of such circles, differentiated by their colours.

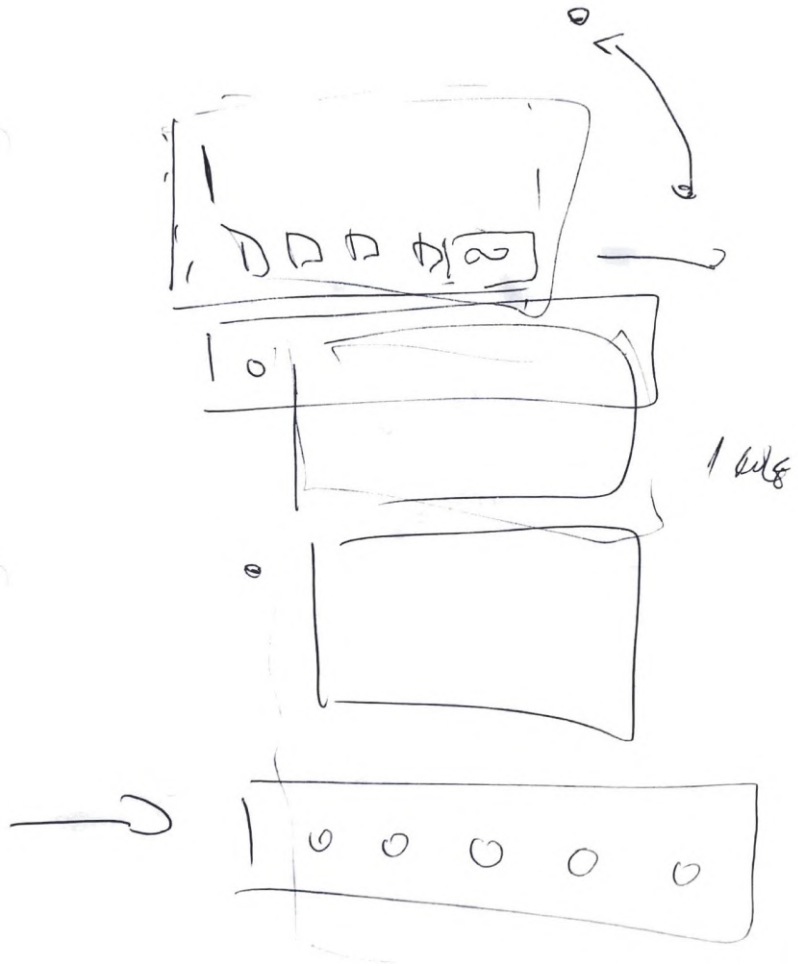


Figure 51: Sketch of the color currency interface

An important thing to realize is that now we deal not with a simple referential relation from one node to another, but we are giving two "has many" relations to a single node. One which signifies colour

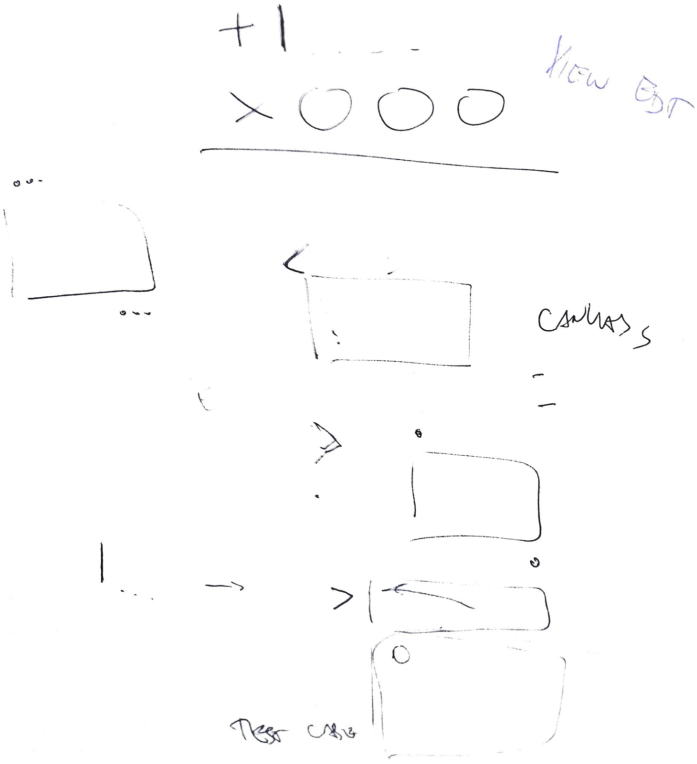


Figure 52: Sketch of the keyboard shortcut (<, >) for adding or requiring color token

requirements for someone to enter the node and another which signifies colour tokens retrievals. We could certainly add a button to editing interface of a node which would allow of editing both relationships' arrays like on fig. 51, but this could interrupt the flow of the writing process - i.e., writing and then having to deal with some popups and windows and selections. Instead we were thinking of a key shortcut which would allow opening of the list for the selection of colour. The necessity is to allow for the differentiation between adding a retrieved colour token and adding a dependency colour token - the list for the selection would stay the same in both cases (almost). We came up with the idea of using ">" and "<" characters to serve the purpose of key shortcuts, ">" signifying retrieved colour token and "<" signifying a colour token that is being asked for [52]. A modifier key such as 'Cmd' or 'Ctrl' could be considered for the combination with the shortcuts to allow writers use "<", ">" characters without seeing the colour token selection window each time. A few moments ago we did say that the list for the colour token selection would stay the same in both cases of setting a dependency colour token and retrieved colour token. This is not exactly true, as we can't ask for colour tokens that haven't been given yet or can we? This is another open question for the debate. If colour tokens are dependent on the linear progression of the story, i.e. as a writer we are in the same position as reader, we cannot create irreversible choices in which we as a reader have to choose between two blue doors with one blue key or colour token. Why? Because in the process of writing, after creating first blue door, we would use our first blue token and we would be unable to ask for it for the second time, because there simply aren't enough colour tokens. Another option that we went for in the process of designing and building our prototype is to allow the writer to be essentially in a "god mode" and to have the affordance for asking more colour tokens that have been given.

What we haven't truly covered is a visual way in which we indicate how many colour tokens are being retrieved and asked for within individual nodes. Certainly following the premise of data relationship - both lists, arrays of colour tokens associated with a particular node, we could just show which tokens the node requires in the left top corner of the node and which tokens the reader retrieves after visiting the node in the right bottom corner of the node as it is suggested in sketches. There are a few issues with this model of information which we show. First of all, the information about which colour tokens are required is not shown until the node itself is shown which makes the purpose of showing that information meaningless as the colour tokens for the purpose of showing that node will be already collected and spend upon showing. The other issue is the fact that it is rather tedious to calculate and sum up all collected colour tokens from various nodes, having

their quantities and type being indiciated within the position of the node itself.

Figure 53: Colour tokens panel

What makes more sense is to create a sort of panel where we see the balance of our colour token currency as in 53. This way, in the act of reading we wouldn't truly need to have an indication of which tokens we receive as the balance itself would change. The idea of colour tokens, even though is very compelling, present iself with a few design and structural challenges, mostly the ability to communicate its complexity in a way that easily understood in the process of writing. We managed to make the step from direct node references to the idea of "colour currency" which is a little more understandable, yet there certainly is a concern of how well it can be adapted to the interface while preserving its lightweightness. The other open questions are; To which extent the reader should be aware of locking and unlocking of certain branches of the story? Should the reader see only the possibility of branch or should they know exactly what they need to open it? The latter one assumes greater control and therefore, likely comfort in using the interface. But isn't the idea of dependencies going to steal the experience of clarity for the process of reading and writing? When reading, how many people want to be guided, play a game and how many want to just get to the information as early as possible? But yet, isn't the fact of making information fully accessible without any obstacles responsible for many of the failures of information consumption nowadays?

5.2.8. Transclusion

We returned to the idea of direct references, especially with the intention of exploring how to treat parts of graphs / stories as another graphs / stories that could be recycled, reused or referred to within other graphs / stories.

The fundamental question is, when referring to a concept from another graph, should we create only a reference link - similar way we mention another account on Twitter? Or should the whole part of another graph be included in the original? The former would provide the affordance of expansion to the reader, the reader would have to be the one who would identify which part of the referred part was actually the one used. We don't exclude the possibility for the reader to show or even place the referred graph into the one they are reading to

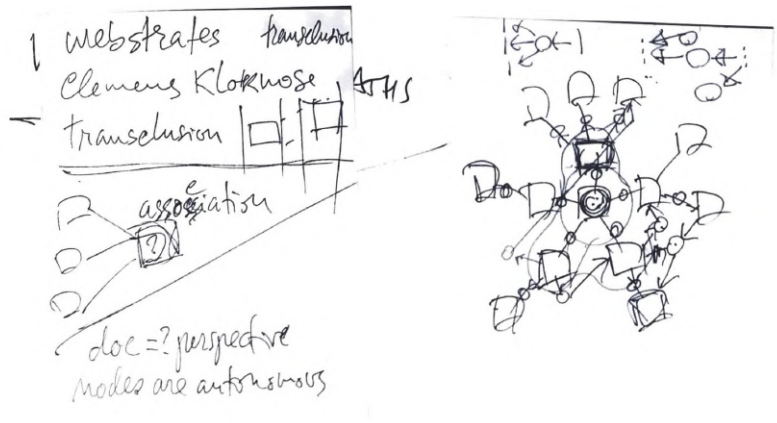


Figure 54: Exploratory network of inter-dependenent nodes

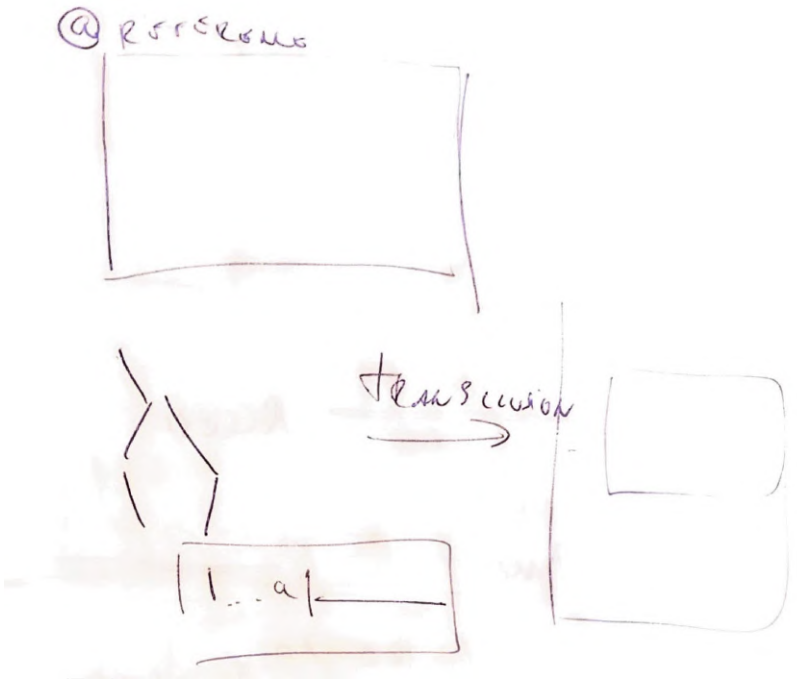


Figure 55: Transclusion

have an overall perception of both the original and the reference. The latter would put more responsibility on the writer, the writer would be the one who would need to find and refer to the exact part of the graph within their original story. This could for example lead to preservation of the state of the referred graph in the original story even if the referred graph changes over time. Similarly it would create greater comfort for the reader who would experience the content in the form in which it was experienced during the writing, without additional loss of data due to the changes or ambiguity of the reference exact location within the referred story. This would require a more complex action on the side of the writer where the referential graph would have needed to be searched for, selected, seen and trimmed into its referential "extraction". A feature which, we assume, would be certainly beneficial for professional writers and users of the app, but not simple enough to be fundamental in the way it affects the way we think about and the process of writing in general.

5.2.9. Spatial Writing

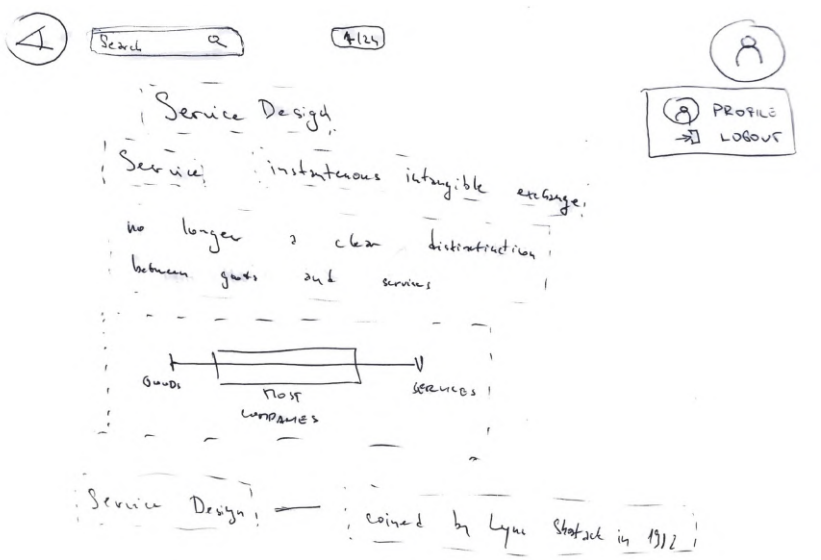


Figure 56: Refimenent for the case of spatial writing

As we hinted before we tried to focus on the most fundamental parts of our design intervention and that was mainly to introduce a two-dimensional, spatial aspect into the practice of writing while preserving the sensation of writing, i.e., not to turn the experience of writing into an experience of designing or mind mapping. The main role is to follow a general conventions of word processors as we know them today, that means, we click - we see the cursor, we can select the text, we can edit

the text, we can hit the enter key and proceed into a new line. These are the basics functionalities which we intend to revolve our design around while also trying to introduce the ability to move the content we write, to connect it and to play it - i.e., to reveal itself gradually in a certain order or based on the interaction of the reader.

5.3. Wireframes

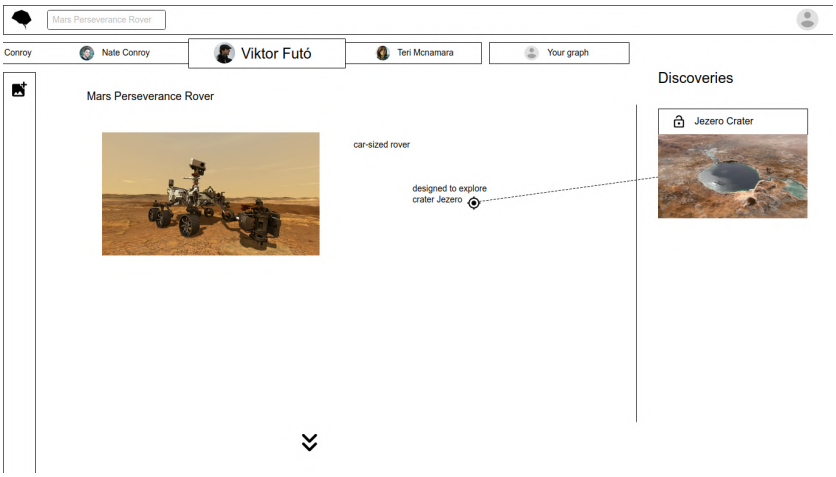


Figure 57: Mars Wireframe #1

When creating our first wireframes (or mockups) we tried to follow the fundamental ideas we suggested in the last sketch. We also focused on designing our interface around a particular use case and we primarily focused on the editing interface as the viewing mode is only a subset of the features for the editing mode. We also tried to resolve the problem of linking various stories or "substories" together and we followed the visual model of recommendations. These recommendations however do show themselves as we progress in the reading of the story being directly connected to the nodes we reveal.

The intention was also to display these "recommendations" as being unlocked (fig. 57, 58), de facto fulfilling the role of node dependencies and therefore introducing the concept of non-linearity.

As we can see, we played with the idea of different perceptions for the spatial organization of the nodes which are in the second horizontal bar in a form of slider (fig. 57, 58, 59). We can therefore slide across various perceptions or (not only) spatially subjective versions of the same story. The option to create a new graph is in direct visual continuation of these perceptions and lead us to an interface in which we essentially forked the original graph, story to our own and we can edit it. On fig. 59 we also illustrate the idea of seeing the original graph

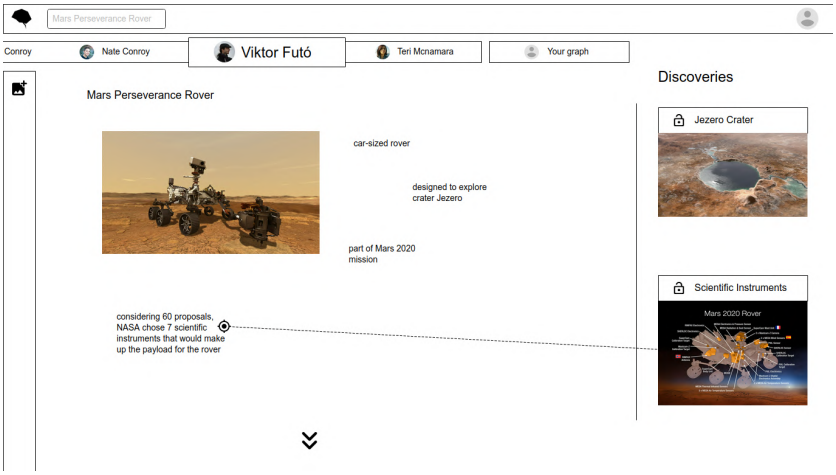


Figure 58: Mars Wireframe #2

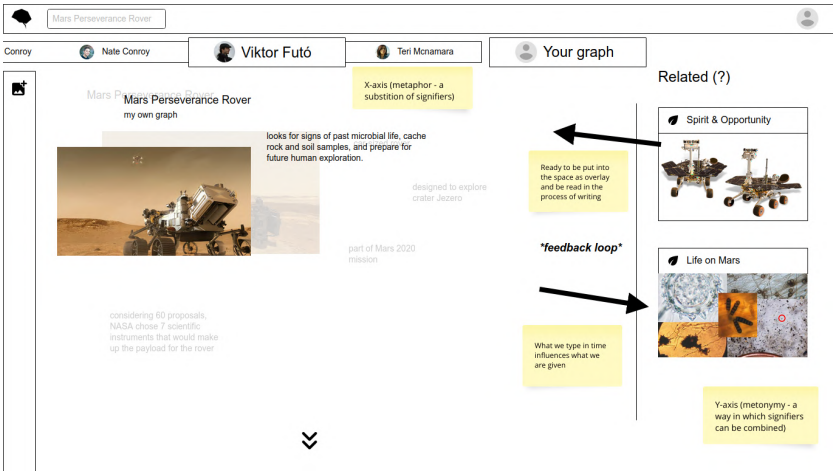


Figure 59: Mars Wireframe #3

in the background, being ovelapped by the actually on which is our own and which is being edited. In editing interface, the recommendations fulfill a slightly different role. Instead of being rewards or unlocked branches, on fig. 59 they behave more like suggestions in our process of writing, allowing themselves to be added into our space.

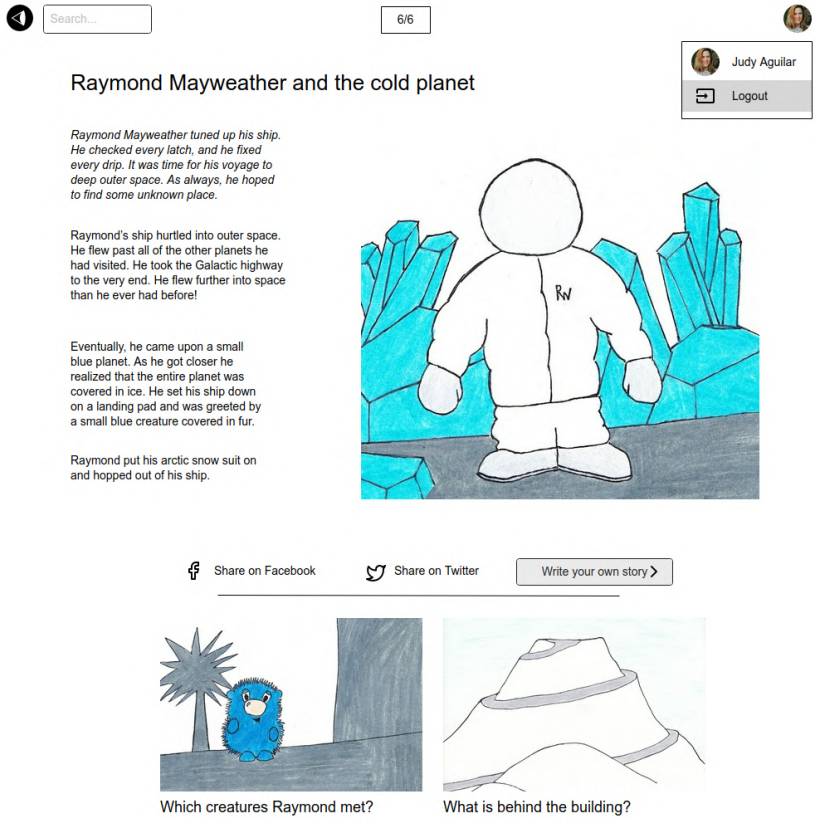


Figure 60: Nonlinear Story #1

In the last wireframe (fig. 60) we proceeded with minimalizing the header for the interface, introducing a counter which allows us to see how far we are in reading our story in terms of amount of nodes. In this particular example a benefit of spatial organization isn't as visible, but what we illustrate here is the recommendation panel that shows itself after reading the whole story (or part of the story). In this recommendation panel in the bottom of the wireframe we can then choose which part of the story or other story we want to continue reading. It's a simple idea that is being used for example in the platform medium.com, but what we wanted to illustrate within our context of research that technically it fulfills the need for nonlinearity as

it allows reader to choose from several options. The assumption is that the stories therefore would be fragmented into small interconnected chunks through which the reader would flow through a similar way it flows through the clusters of related posts on e.g. instagram application.

5.4. Brand Identity

5.4.1. Name

What we understand as a brand is a collection of signifiers that intends to distinguish a company, a tool, a service, a product or another entity from other entities. Brand identity are those distinctions which are visible such as color, design, logo or name. When defining our brand we started by determining what we want to communicate. We took into considerations our practice of writing in which we are intervening, the mapped context of it and our scenario which provided us with a valuable reflection of what kind of people could be are early adopters. Our objective is to disrupt the practice of writing, to provide a new creative form of writing that can increase the clarity and efficiency of knowledge and information consumption. Some parts of our brand has been partially expressed in the process of our sketching - focusing on providing the sensation of writing, being conservative about the first impression, yet providing fundamental and disruptive distinctions to the existing ways of writing. Due to the minimal nature of our design and our intention to resemble paper we chose to follow simple black on white color combination. Within this attitude we brainstormed words which could reflect what we want to communicate. Words such as *clarity*, *paper*, *writing*, *write*, *blank*, *sheet*, *canvas*, *pen*, *nib*, *pencil*, *ink*, *text*, *link*, *brain*, *cognition*, *medium*, *sign*, *language*, *semiotic*, *communication*, *graph*, *story*, *literature*, *lens*, *dip*, *lágrima*, *droplet* gave us a basic palette of our linguistic exploration for the name of our tool.

From these words we played with various latin variations, their ethymology, roots and prefixes to create a proper name. We also helped ourselves through the tool called Namelix which generates various names based on our keywords and parameters of style and length. Even though this tool is not the author of the final name of our tool, it provided us necessary inspiration in a form of not only mixed and composed names, but also with related names which extended our palette. In the end of the day we managed to narrow down the message we wanted to communicate and that being - "seeing the meaning in clarity". The action of seeing could be expressed by *lens*, *ocular*, *vision*, *perception* or more abstractly emphasizing what we can see - *range*, *scope*, *field*. We tried to use the combination of two words instead of discovering a new one. Being particularly inspired by

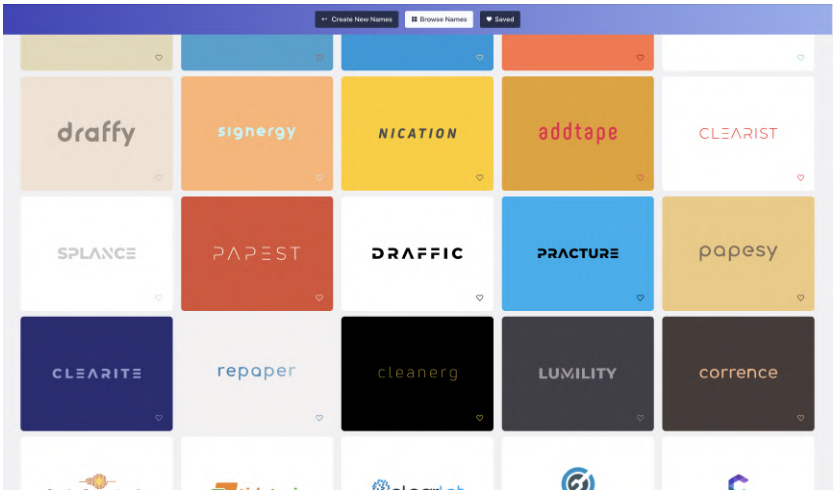


Figure 61: Namelix.com - Tool name generator which we used for the name brainstorming

the naming of "Instagram" - being a combination of "instant camera" and "telegram". On the other hand we explored the ways in which we can express a meaning in one word. Words such as *sign*, *sense*, *signification*, *explanation*, *expression* and their various declensions and roots were meant to be the object of our seeing. But we did not only want to express the sensation of seeing something, but the sensation of epiphany, a sensation of cognitive joy, a satisfaction of neural pathways becoming suddenly spontaneously interconnected and providing a sense of understanding. In this attitude we played with the word *semiotic* as it signified a special kind of linguistic quality - the one that provides meaning to words, the act of creating meaning itself. A combination of "semioscope" has emerged. There was a certain noble and statuesque quality about the word however. The combination of latin "semio" and the letters "sc" further emphasized its latin origin, creating this impression of historical, ancient time alienation as if it was naming something historical detached from an actual reality. We played with the word a little more and decided to ground it with a slovakian or slavic suffix transliteration of "-skop" into final version of our name - *Semioskop*. This was meant to create a sense of approachability and novelty.

5.4.2. Logo

The word logo refers to a mark, a graphic representation of a brand. It's just one part of the overall brand identity and in its design we followed similar steps when coming up with a name [144]. Identifying as the most visual concepts the concepts of eye, brain, pen (its nib), lens, book, writing, a drop of ink. Even though we wanted to adjust logo to

[144] Matt Ellis. Logotype vs. logomark vs. logo: What is the difference?, 2019. URL https://en.99designs.pt/blog/logo-branding/logotype-vs-logomark-vs-logo/; and M. Evamy. *Logotype*. Pocket Editions. Quercus, 2012. ISBN 9781780673943. URL https://books.google.pt/books?id=J_UgEAAAQBAJ

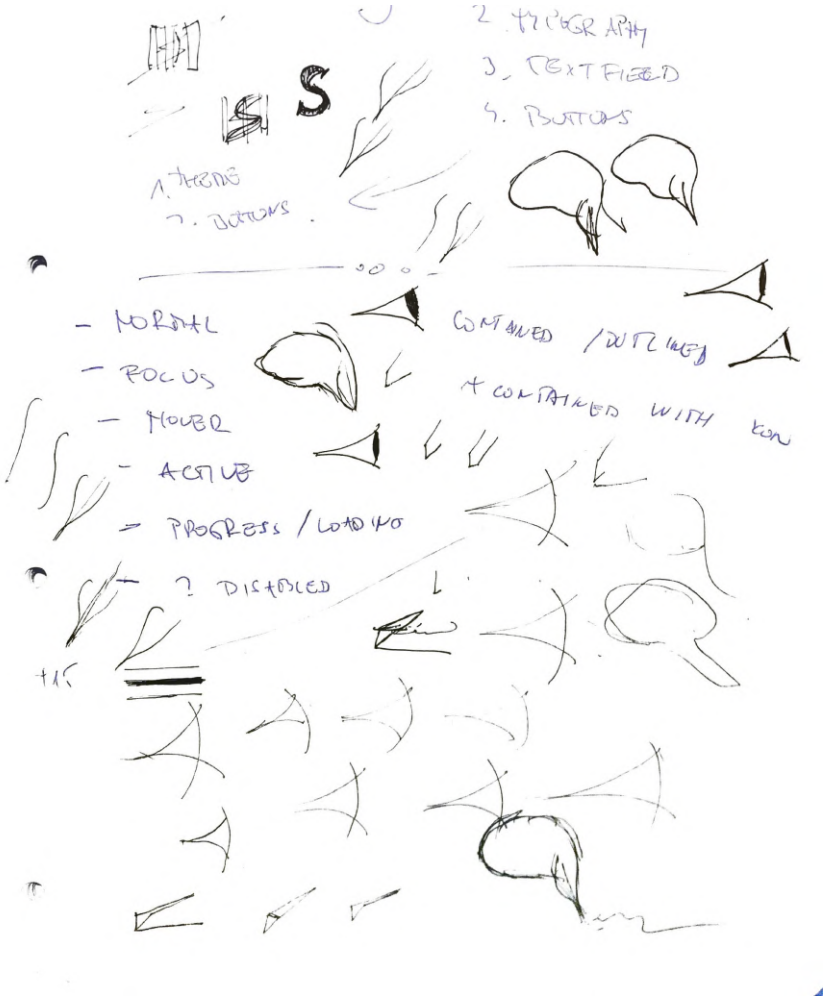


Figure 62: Study #1

the message of "seeing the meaning in clarity", we experimented with all of these concepts in the demonstrated studies. We didn't want our logo to be a simple, obvious picture of a clear material object, rather we wanted to create a certain sense, impression while leaving a significant part of it ambiguous and left to interpretation.

Figure 63: Study #2

In the beginning we did follow a profile shape of an eye / lens, while trying to use only minimal amount of curves, maybe to express the idea of elegance and seamlessness. This we played with even more in the idea of a pen's nib while ocassionally diverging to other ideas. At certain point we also wanted to merge the shape of brain with a pen, idea being for a spinal cord to write, but the shape of brain is not easy to stylize in this minimal visual style.

The mark of a pen breaking into a book has also been played with, reflecting the idea of a new writing breaking the linearity of text as we know it nowadays. Besides that, ideas of a droplet or various visual marks in relation with the lens / eye can also be noticed in the third study. Even though, we did have an idea for the name already, we did challenge it in the process of designing a logo which can be visible in the same picture.

In the end of the sketching we did feel most comfortably with the idea of a lens / eye because it reflected the most the name and the message that we wanted to communicate in the name.

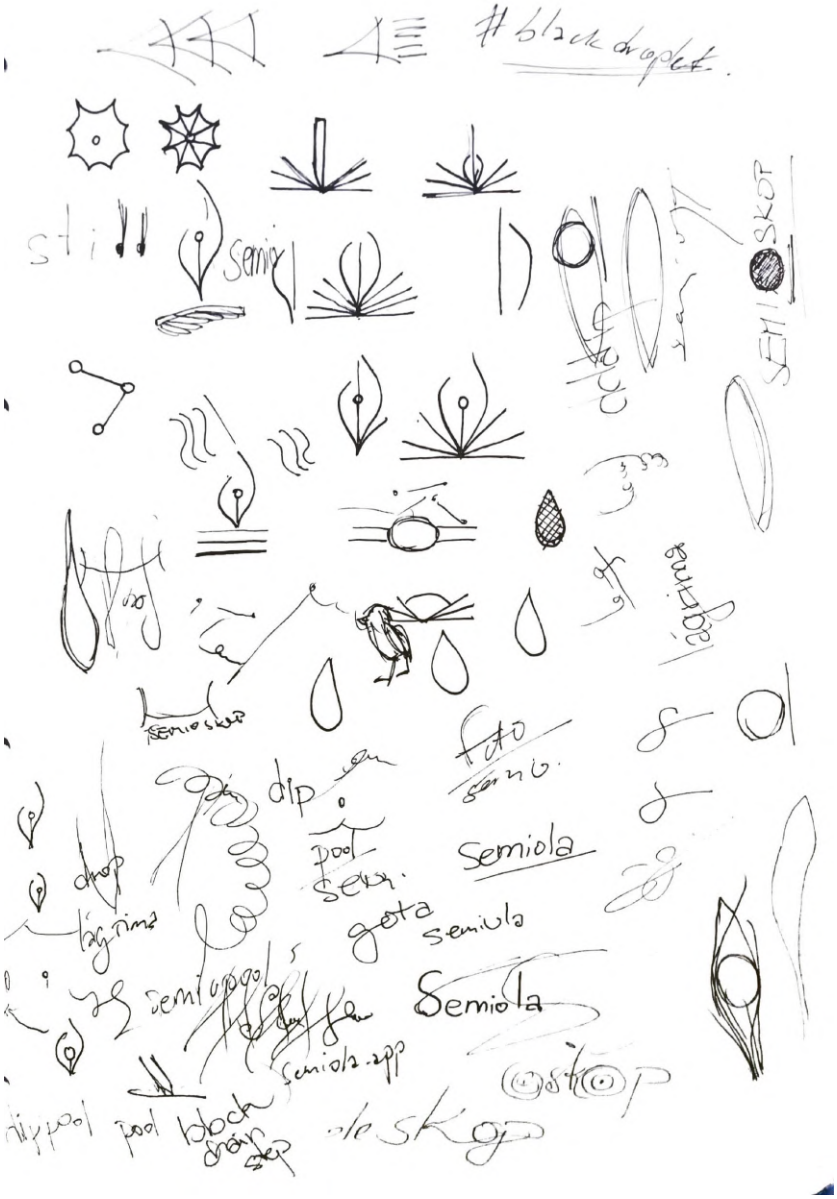


Figure 64: Study #3

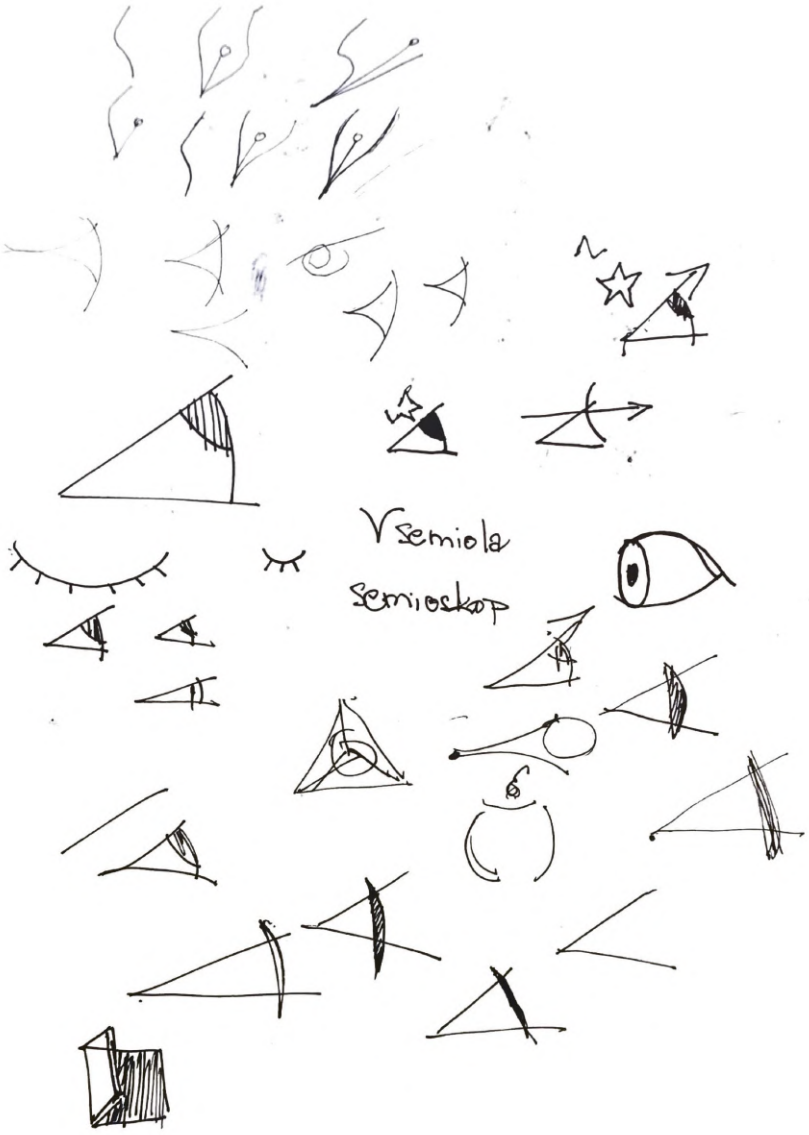


Figure 65: Study #4

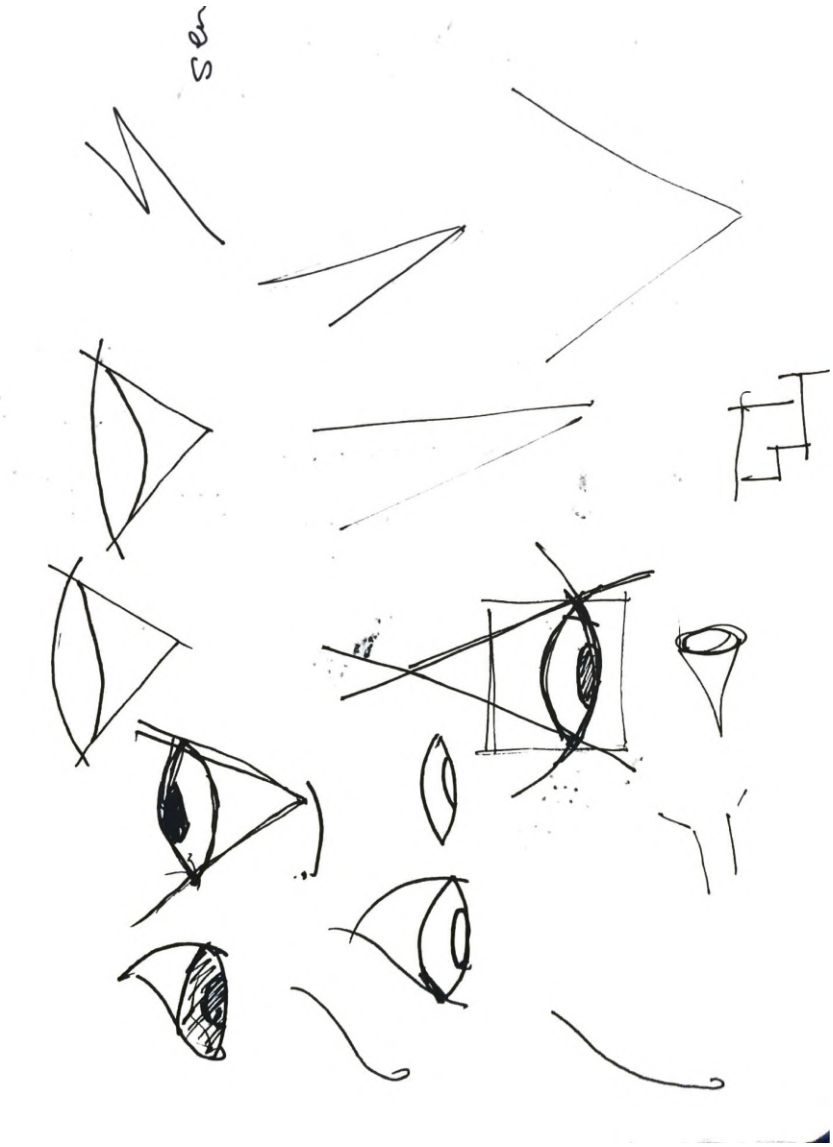


Figure 66: Study #5

We were particularly excited about the idea of a conic or triangle shape opening up on one of its sides - reflecting a new perspective, a new seeing that we can achieve when using this new medium for writing and reading. What we were seeing was not only the two-dimensional aspect of such shape, but the possibility to draw a project of three dimensional cone. That is also a similar shape that a point source of light creates in a complete darkness.

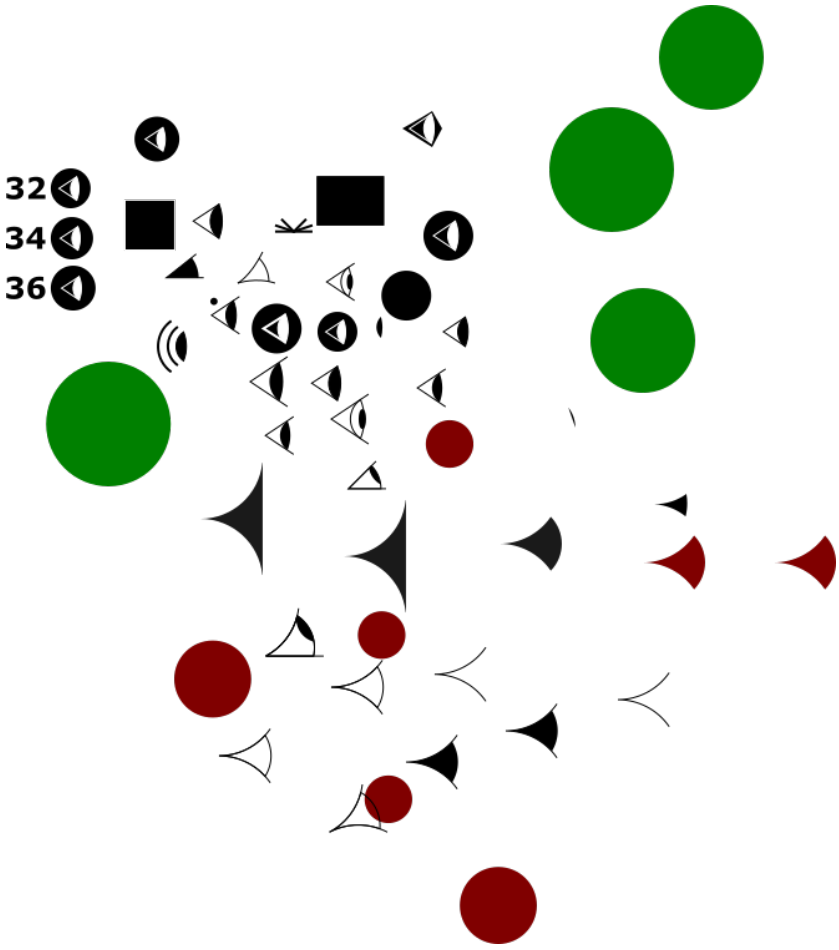


Figure 67: Study #6 - Digital Drawing

This was one of the reason why in the process of digital drawing we ended up drawing this conic shape on the black background - truly reflecting the idea of a light, a new enlightenment that can be triggered with this new efficient way of writing. We began to be really fond of the shape, because not only it reflected this new idea of seeing light, but also it reflected our primary idea of a lens, eye - of seeeing. And with a further imagination, someone could even see there a command space module heading to the stars. With no further saying, this is therefore the final version of the logo of our project [145]

[145] Logotype is shown only for mockup purposes.

Figure 68: Final version of the logomark

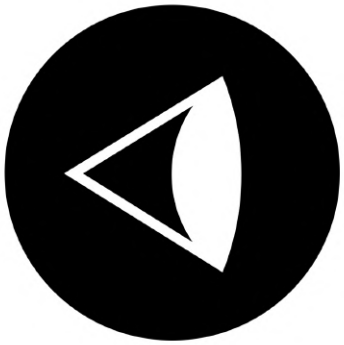


Figure 69: Associated logotype

5.4.3. Typeface

The term typeface refers to the collection of fonts with a unified design [146]. They could have various weights, sizes or styles. In the process of choosing the most convenient font for our typeface, the options in the context of the tool we are creating have been narrowed down. Because we are setting the typeface for the whole app and a default typeface for stories which are going to be written in it, legibility is absolutely crucial. We also made sure that we worked with web fonts, in particular with Google Fonts database so we could test them and implement them immediately in the process of building as we wanted to take into consideration the aspect of interaction itself. For a significant time we were reconsidering the use of serif fonts as we wanted to encourage the aspects of reliability and trustworthiness for all the writers who would write on the platform, in the end of the day we decided for a serif font as it emphasizes tones of modernity, approachibility and cleanliness. Sans-serif fonts are also considered to be more readable and legible in general. Even though they tend to be less readable in longer text, this is exactly what we intend to discourage in our app as our goal is to allow writing of stories created from several fragments of text. Because of the importance of the typography for our application we wanted to

[146] R. Bringhurst. *The Elements of Typographic Style*. Elements of Typographic Style. Hartley & Marks, Publishers, 2004. ISBN 9780881792065. URL https://books.google.pt/books?id=940sAAAAYAAJ

stay safe, transparent and accessible, emhasizing the simplicity while at the same time maintaining the modern outlook. This influenced our initial selection of typefaces in which we compared highly legible fonts of Open Sans, PT Sans, Roboto, Lato and San Francisco which is a successional typeface for Helvetica made by Apple Inc. It provides a few improvements over Helvetica typeface. These mainly are proportional spacing of numbers, so the width of *n*-ciphered number stays always the same. It has higher x-height which also allows counters be bigger and increases legibility in comparison to Helvetica. Similarly, letter spacing of San Francisco is slightly wider than in the case of Helvetica [147]. Our primary objective that determined our selection was to let the written content stand out with its own message and not have the reader distracted by the personality of the font. In the cases of Open Sans and PT Sans the distinctive curvatures on the terminals of their ascenders and descenders caused us to look whether other typefaces aren't more conservative, i.e. less expressive. We similarly could notice the extent in which tails and descenders overflew the x-height of the typefaces. Lato is typeface with round, friendly edges. What came to our attention were softer terminals, more balanced width of strokes and wide counter space in the case of letters like O or Q. The wider counter space in particular affected negatively our perception of coherence of Lato's letter width as we were looking for a more predictable typeface in which the flow of reading could be uniformly attributed to individual letters. With letters being too narrow, this however could negatively affect legibility. Directing our attention to Roboto and San Francisco. While Roboto is being geometric and containing open curves, an immediate distinction is the higher cap size of some of the small letters of Roboto than some of its capital letters. Similarly in letters like capital Q, the tail overflows the height of the baseline, while San Francisco's capital Q appears with the same height as other letters. In this way we can consider San Francisco more uniform typeface than Roboto. With its clean, sleek and modern look San Francisco stands as our number one choice for the typeface, yet we have to add that for the purpose of our prototype we did style our application with assumption that the reader already has San Francisco installed on their computer, if not, we consider Roboto to be the fallback choice, one of the most similar fonts to San Francisco which is available on Google Webfonts. With San Francisco our goal is to stay modern, clean, minimal, provoking boldness, yet neutral - limiting the personality of the font to let the content speak for itself. [148]

[147] David Kadavy. Apple's san francisco font, 2015. URL https://designforhackers.com/blog/san-francisco-font/

[148] What has to be noted is that it's very likely that with the extension of the tool and more visible text fragments, a second typeface is going to be introduced which will distinguish the written, created content and the typography of the interface. Yet with the minimum of interface control features which contain text we decided on employing only one typeface.

Figure 70: Final version of the typeface

5.5. Summary

All the concepts we explored in this chapter were conceived and refined as in the first iteration of designing as well as in the iterations of building, i.e. during the whole design-building process. Here we would like to provide a very brief summary on some of the concepts we iteratively worked with and how we managed to address them in the final realization of our prototype.

5.5.1. Author-Centric Interface

Because of the private nature of note-taking and sensemaking, i.e. their knowledge objects are not meant to be published immediately, we chose the author-centric architecture in which stories are associated individually to specific authors. This allows authors to be in control of their own publishing process and allows for greater comfort and ease in the process of expression, because of the greater role of attachment and better control of what author allows to be seen and to whom.

5.5.2. Spatial Writing & Identity

We identified what is the most significant building block of our interface - spatial writing as it constitutes the most apparent characteristics of our vision. Following the interrelation of reading/writing we did introduce progressive disclosure both in the interface of reader (viewing) as well as in the interface of writer (editing). Besides, as the crucial concept of spatial writing we did allow canvas, plane not to have any boundaries. We followed implementation of these concepts in close alignment of our defined brand identity and from its foundations inferred visual identity which we wanted to communicate.

5.5.3. "Semantic Snowflakes" / Semantic Scaling

Even though we haven't implemented any structural generative rules to organize nodes within descriptive clusters which we called "semantic snowflakes", the concept introduced new perspectives on the notion of scaling. For now the scaling as we understand it is tightly implemented through the action of scrolling that allows us to progressively reveal the nodes of the story. The other perspectives of scaling we consider as potentially highly valuable to explore in the future iterations as the slider and action of scrolling doesn't need to be mapped only to "temporal" scale in which nodes are being revealed, but to other scales as well. This could include scaling through different interpretations of the same topic across variety of authors (depicted in some of the wireframes) or scaling through various levels of content detail. These

scales can be then switched and changes according to the need of the reader (or writer).

5.5.4. Variety of Perceptions

Referring to the concept of moving organizational responsibility on the reader, this has been sligtly extended on in the section of wireframes where the idea of allowing saving or storing how the story was (re)organized for that particular viewer has been explored. The concept has an impact on the architecture of our state later in the implementation where the object for reading and editing were disentangled into their own separate object. The intention being that the object which determines the state of how the story was seen (or modified) by the reader is to be saved and loaded the next time that particular reader reads that particular story.

5.5.5. Transclusion & Linking

More challenging in the terms of implementation have been the ideas of transclusion and interstory linking. The questions have been raised on how the manipulation with pieces or areas of story should be designed. Selecting a part of the story and then grabbing it or referring to it within the existing one would also require the interface in which we can both write and query. Yet, it is questionable what the user's behaviour and perception would be for such actions as the interface of spatial writing already represents novelty. The complexity of the concept, its seemingly secondary bearing in which it only extends, yet doesn't define our primary vision and constrained space and time for this work resulted in a decision to temporarily sideline the implementation and further design iterations for transclusion and linking.

5.5.6. Node Dependency & Colour Currency

The concepts of node dependency (or conditional branching) have been implemented with partial success. The concept of creating dependency by creating a node in close proximity of the other could be demonstrated to work in the final version of our prototype. Meanwhile the notion of colour currency has been worked on intensely and has been demonstrated within one of the buggy iterations of the prototype, yet due to the limited time and increase of complexity of the interface state and implementation it has been omitted in the final prototype in the trade-off of the prototype's reliability.

6. Development

6.1. Interface Design Model

We started the process of development by defining what we call an interface design model. Here we define actions, features which we implemented in our prototype. Each card represents an action that user can take with a particular purpose.

6.1.1. Pan

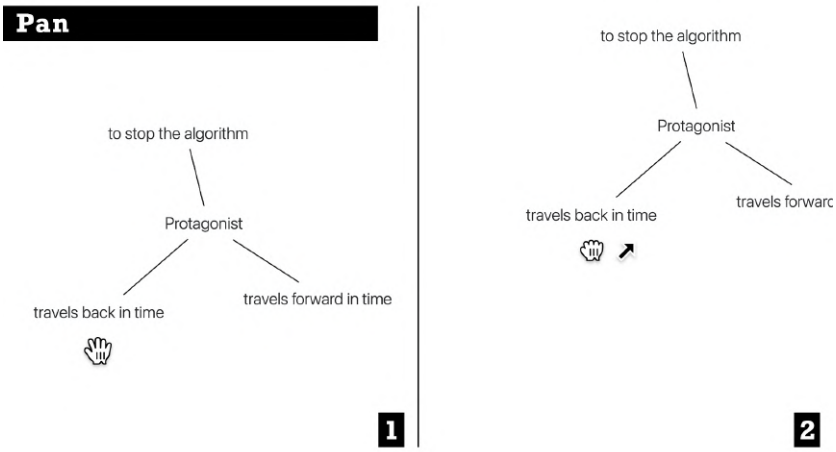


Figure 71: The action of panning

The action of panning is designed for the purpose of moving the whole space easily around in order to see different areas of the space, canvas. The user does this by holding the mouse button down / grasping the space on an empty spot and then moving the mouse around. The canvas is practically infinite, therefore there are no limits to how far can one move the space around. The action of panning works both in view and edit modes.

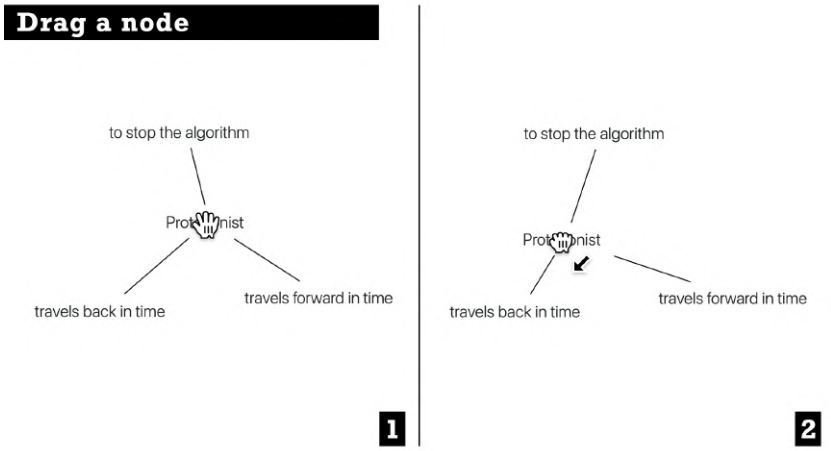


Figure 72: The action of dragging a node

6.1.2. Drag a node

The action of dragging a node is designed for the purpose of moving the node around in order to change the spatial organization of the nodes. The user does this similarly like panning, by holding their left mouse button (or right in case of a lefthander) on the place of the node and moving the mouse around. The action of dragging a node works only in the edit mode.

6.1.3. Create a node

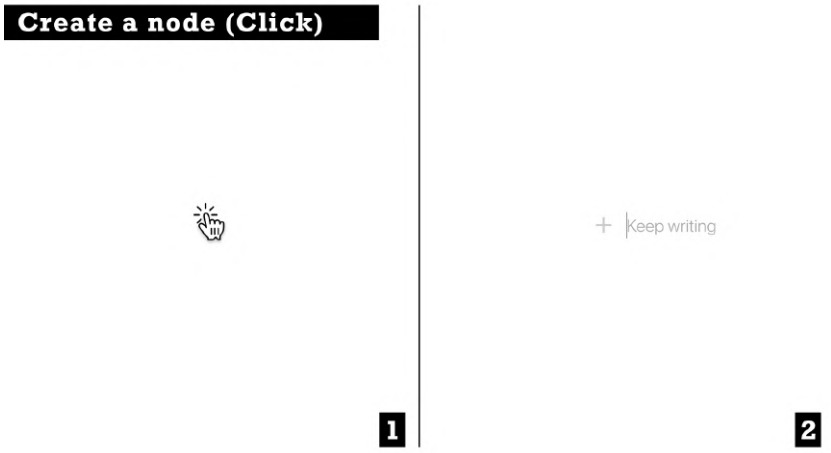


Figure 73: The action of creating a node

To create a node one needs to perform and finish a click on an empty space of the canvas. This works only if user does not move their mouse in the duration of the click, if so, it will perform only a panning of the

canvas. The action of creating a node works only in the edit mode.

6.1.4. Create a node (Enter)

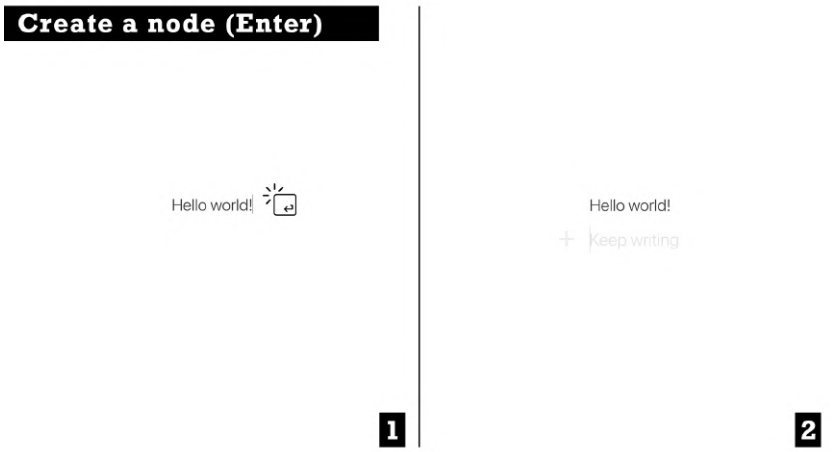


Figure 74: The action of creating a node using enter (newline)

Another way to seamlessly create a new node is to hit the enter key while writing a node. It's not necessary for a caret to be at the end of the textual node, as hitting an enter while caret is being in the middle of the text will cause text to break into two separate nodes. This action also works only in the edit mode.

6.1.5. Edit a node

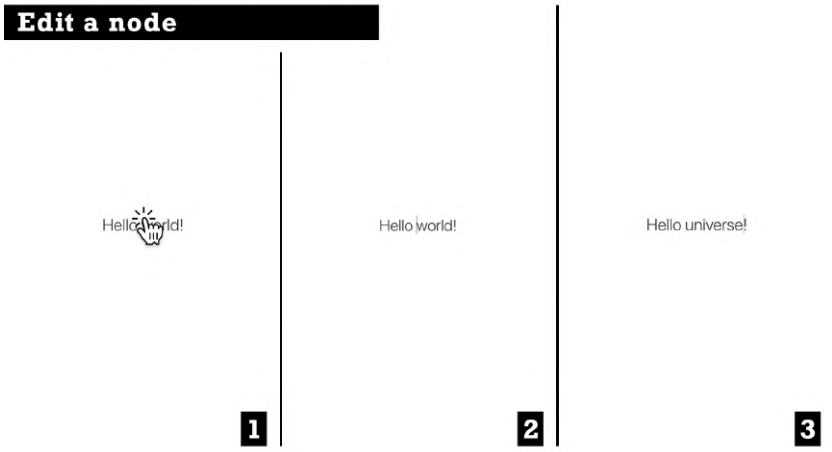


Figure 75: The action of editing a node

To edit a node it is necessary to click on the area of the node we want to edit without moving the mouse. As there is nothing to edit on

the image node, this functionality works only on textual nodes. When in editing mode we proceed by writing as in any other textual input. Again, this action is available only in the edit mode.

6.1.6. Insert an image

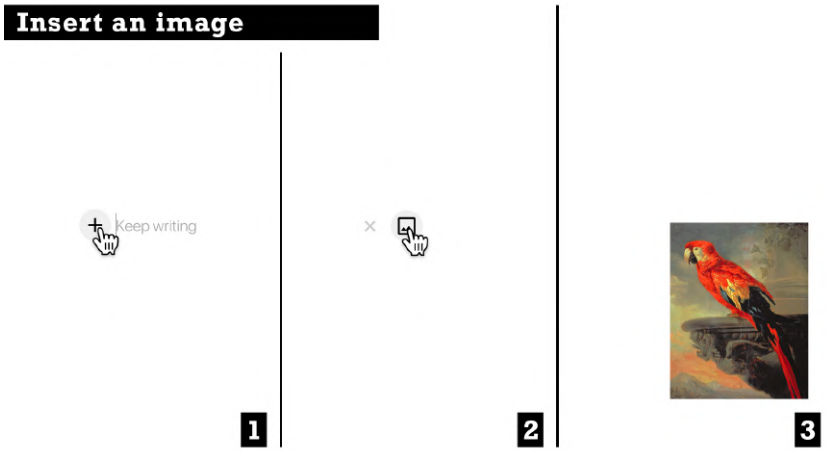


Figure 76: The action of inserting an image

To insert an image into the space, into a story, one has to notice a plus sign on the left side of the caret placeholder when creating a new node. This plus sign is showed only when the "caret node" is empty. Upon click it a menu with options is reveal, in this case only a single option - an icon of an image which upon clicking opens a file browser for the uploading of an image. This action is available only in the edit mode.

6.1.7. Remove a node

To remove a node one needs to drag a node and then release it when the cursor is above the trash area that shows itself only when node is being dragged in the left bottom corner of the screen. To remove a node it is also possible to edit a node and leave it empty. Empty nodes are automatically removed from the story. This action is again available only in the editing mode.

6.1.8. Show / Hide

The implementation of progressive disclosure is mapped to the mouse wheel and the interaction of scrolling up and down respectively. Each scroll down causes a next node to reveal itself and each scroll up causes the last revealed node to hide. This action is implemented both in

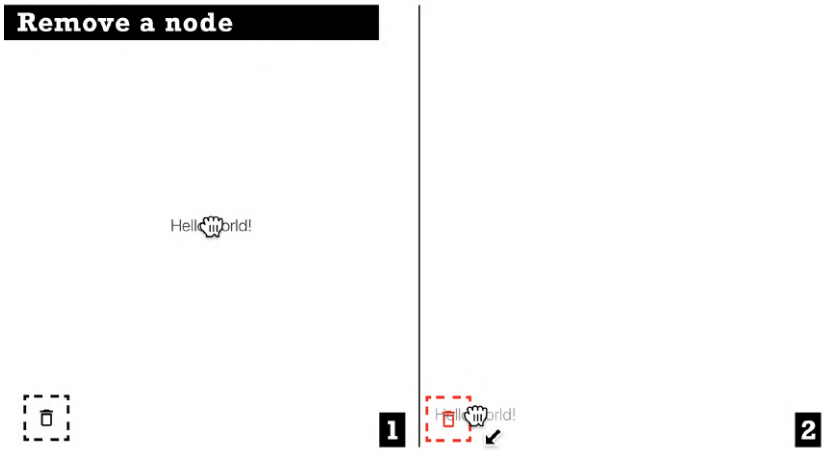


Figure 77: The action of removing a node

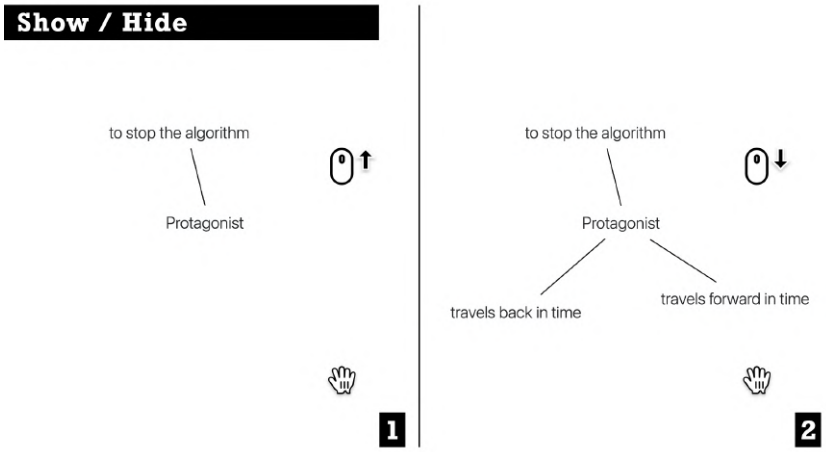


Figure 78: The action of showing / hiding story

view and edit mode. In view mode it serves the purpose of reading, using the same mapping for moving the content up when reading a website that is longer in Y dimension than our viewport. In edit mode the functionality is the same, nevertheless the ability to show and hide nodes - and therefore de facto read - allows us to add new nodes in between of others. When we say "in between", we refer the order in which nodes are revealed.

6.1.9. Resize an image

Figure 79: The action of resizing an image

To resize an image it is necessary to move the cursor on the right edge of the image until it changes itself into horizontal resize symbol. Followingly, it is sufficient to click with the left mouse button, hold the click and move the mouse in order to resize the image. The aspect ratio is preserved. This functionality is available only in the edit mode.

6.1.10. Connection Add

To add a connection one has to switch into connecting mode by using the "Connect" button nearby the node counter. After that a possibility of selecting a node arises which is done by a simple click on the node. Without any need to drag, by hovering over the node an underline border indicates that the node is ready to be connected to. By clicking on it we complete the act of connecting. To cancel the selection one has to click on the selected node again. To toggle back to writing mode, one has to click on the "Connect" button again. All this functionality is available only in editing mode.

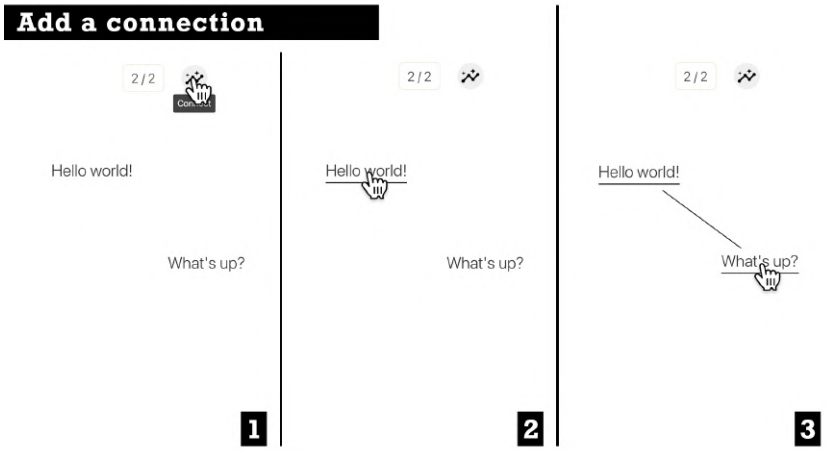


Figure 80: The action of adding a connection

6.1.11. Connection Remove

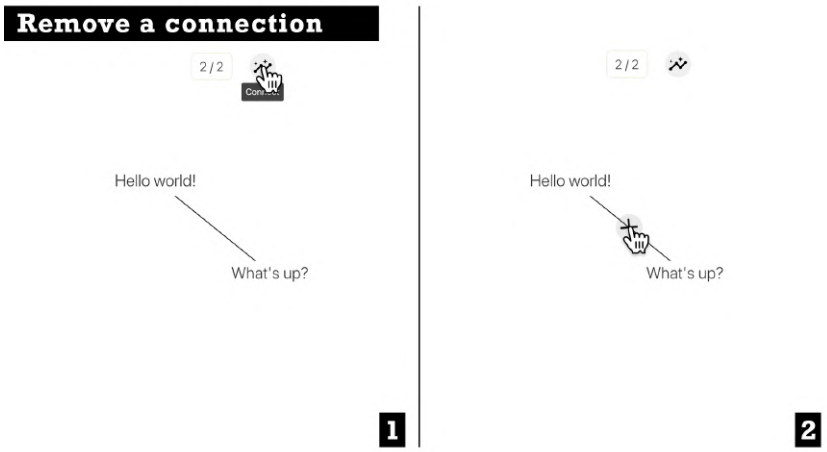


Figure 81: The action of removing a connection

To remove a connection, again, it is needed to switch into connecting mode by using the "Connect" button nearby the node counter. On all connection an "X" button is going to be shown upon which when clicked, it removes the connection.

6.1.12. Conditional Add

We also played with and implemented the functionality of "dependent" node. A dependent node is shown only if a mouse pointer is close enough to its parent or if there are no more "independent" nodes in the story. To add a dependent node one has to move their mouse into close proximity of a node until visually indicated and than create a new

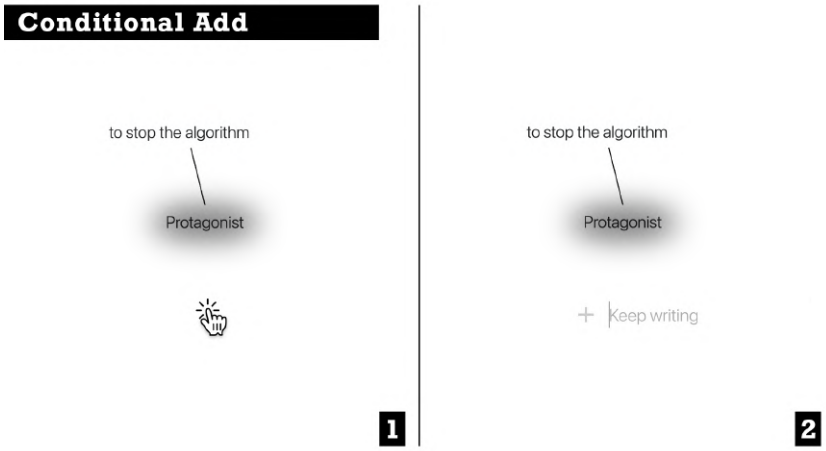


Figure 82: The action of adding a dependent node

node by clicking on the plane.

6.1.13. Conditional Show

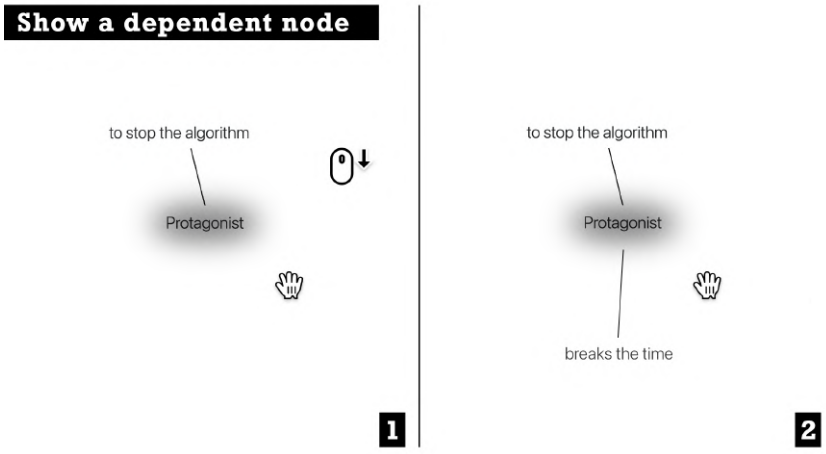


Figure 83: The action of showing a dependent node

As we described already, the action of conditional show allows us to control which nodes are going to be revealed. By default we can assume node "travels back in time" in the original story is about to be revealed, but if we hover our cursor over "Protagonist" node we can reveal a different node - maybe one related to the Protagonist (while others do not have to be). This is achieved by moving cursor close enough to the "Protagonist" node so this option becomes possible.

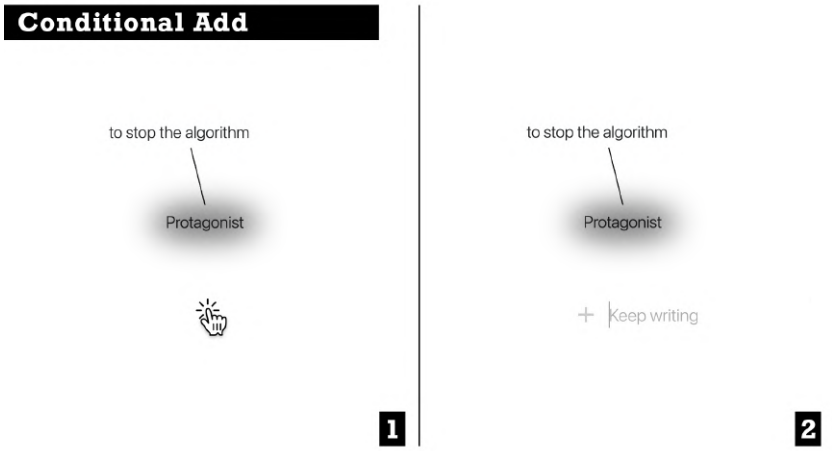


Figure 84: The action of conditionally adding a node

6.1.13. Conditional Add

6.2. Technology & Architecture

When defining our requirements for the technologies we are going to utilize we return to the understand of the activity for which we design our artefact. Focusing on the writing primarily with a further specification on complex and mentally demanding topics at first, we can conclude that the environment of a desktop or laptop computer is ideal. That is for the common sense reasons of time and space requirements of writing - as our brain and body requires or prefers certain environmental conditions such as enough time, silence, relaxed body posture for processing of the information. It's much more difficult to envision writing of a complex or a longer text on a mobile or tablet than on desktop/laptop devices. When approaching the activity of reading it's important to suggest that here we could also include tablet and even mobile devices as environments in which reading is conducted. Nevertheless, to prioritize and organize our development process we are going to set laptops or desktop computers as our primary device targets. Another important decision which steered our development process was the choice of a software platform on which we want to establish our tool. Again we follow descriptions of the practice within which we are trying to innovate. The purpose of stories is to be shared, therefore, ideally we want to choose such a software environment or a platform which could cover not only our needs for reading and writing, but also our need for publishing, ergo distributing our content. Most naturally, our primary environment for such a tool is world wide web and within it a web platform or web application that we intend to create.

6.2.1. Frameworks

When deciding which frameworks and technologies we are going to employ, we follow the basic criteria. First we choose only from technologies available in the environment which we already defined as our desired one. Second, we focus on the commonality of the framework, i.e. the size of the ecosystem, its popularity, the community surrounding it and its extensibility.

6.2.1.1. React

Within this criteria we can clearly identify React as a basic framework for creation of components. React has been developed the community of developers in Facebook with a goal of providing encapsulation for structure (HTML), style (CSS) and behaviour (Javascript) within separate logical chunks of code which we call components. This paradigm provided a solid foundation for the programming of javascript-heavy web applications and its widespread has been observed in 2015-2016 after many years of figuring out the right way to organize client-side javascript code. The alternatives are Google's Angular.js and Vue.js. Both do employ their own new programmable attributes (such as 'ng-*' in the case of Angular and 'v-*' in the case of Vue.js) and support two way binding. React on the other hand pulls all the operational logic into JSX without any additional complexity of new attributes, does utilize Virtual DOM during state updates, i.e. is aligned with the development and emphasizes of W3 standards, has faster learning curve, introduction of fewer new concepts and has only one-way binding, defining only one way to affect the state. All this and the bigger community of react developers lead us to the decision of utilizing React.

6.2.1.2. Vercel & Next.js

When thinking of developing an app we want to make sure that the iteration times of changes and new deployments is as low as possible. For that we would like to utilize the concept of continuous deployment, or in practical terms, deployment being run on one command. Being raised on the practice of Ruby on Rails and its handy `mina` gem for rapid continuous deployment that can also be configured for frontend applications, we did let go of the need for server configuration and instead chose the service of Vercel as our primary platform on which we will host our application. Vercel offers variety of optimizations which allows for example generation of the final HTML pages on the time of deployment, if provided with the same data. This is also what is called *static generation*. Our belief in Vercel however comes from the easiness with which we can create an application directly from our terminal and immediately deploy it. We have been reinforced in our

trust for Vercel discovering the pace of innovation and development within the company and their focus on speed and reliable service. Certainly, there is Heroku as an alternative, but our last experience tells us that it was slow and quite expensive if we wanted to increase the speed of serving our website. It is also focused around the application written in Ruby on Rails. As our application is focused mainly on the interation, it will be written in Javascript, within the framework of Next.js which is supported and well integrated with Vercel service. Next.js also has a good integration with Material-UI library. Material-UI is a customizable component library that offers basic styleguide, its own design system and components for building of the new apps. Material-UI provides us also with a foundation of system thinking and organization of components which we can build from.

6.2.1.3. Google Firebase

For dynamic web applications it has been a practice to have two servers - one serving frontend and another backend in the form of API. Configuration and maintainance of one's own backend server is however costly, moreover if instead developing a stable well-defined tool on the side of frontend, we intend to prototype and experiment. Maintaining own backend code, database and server would cost us twice or three times the same effort. Because of that we utilize the service of Google Firebase which gives a realtime database called Firestore which we can access directly in javascript within our frontend code without the need of configuring any additional backend server on our own. Google Firestore is also NoSQL database which serves our needs of rapid prototyping. The scheme of data can change during the process of design and building and to treat our objects as documents with unconstrained properties gives us another degree of freedom and saves us from another potential headache. Google Firebase also offer its own authentication and authorization services and also CDN and basic limited storage for files which we utilize as well.

6.2.2. Object Modeling

For the process of object modeling one has to have a clear image of how the data model is going to look like. Our data model is being created on the frontend and it heavily relies on interactions and modifications that user could affect it with. In the process of rapid prototyping this is naturally subject of change, making object modeling really a matter of report and illustration than the actual conception. In any way, to better understand data relations and their possibilities we did brainstorm on ways how they can be organized before we dived into actual implementation.

6.2.2.1. User, Profile & Username

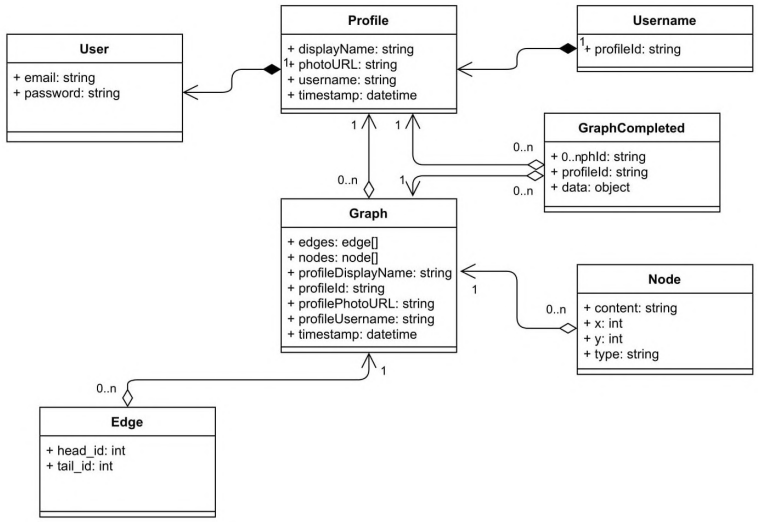


Figure 85: Diagram of an early object model for the prototype of our application

We can see a diagram of an early object model which does not reflect the state of the application as it is now. What is the significant for us to understand that as we are delegating authentication functionality to the Google Firebase service, we do not possess the object of the `User`. Even though it does provide basic information such as e-mail which we can access, it only has three fields which we are allowed to edit. Those are `displayName`, `email` and `photoURL`. We did speculate whether these three fields wouldn't be sufficient to store all the profile information of users, however we encountered first problem when we wanted to store both user's real name and so called *slug* or a nickname for the pretty URL directing us to the user's profile. This is the reason why we had to introduce the object of `Profile` that can be extended and store any profile information or customzation. Within it the `username` stands for what we called slug. Because of the way how Google Firestore conducts is billing, it is costly to search through all the profiles to find the one with given username field. We create our own collection for indexing which is in the diagram represented by the object `Username`. This object only holds an identifier to profile so when user visits a profile page, a profile identifier is directly received. This is due to the fact that we cannot create a unique constraint on the field, attribute of the document. Therefore we use the fact identifier of document has to be unique and by setting out those constraints which are available to us, we can assure mutually dependent existence of `Username` document and `Profile` document tuple. As one could notice, in our diagrams we

do not include primary keys as individual attributes. This is due to the fact that they are not accessible as an attribute is in the document, but are rather special kind of document's metadata separated from its data part. The identifier can however be custom, it only has to be unique. In this way the identifier of a profile object is the same as the identifier of Google's Firebase internal user object, creating a weak association between the two that allows us to, for example, load a profile of the currently logged in user.

6.2.2.2. Graph

Moving on to the object of story which in this diagram we called `Graph`. It is because story structurally is a graph, mathematically being a tuple of sets - one for nodes another for edges. Similarly, graph object has two matching attributes of `nodes` and `edges`. It's important to note here, that even though we identify on the diagram nodes and edges as separate objects, in our application for the purpose of testing and early adoption we are going to include objects of edges and nodes within the document of the graph. This is in the NoSQL database called as embedded documents. Good thing about it is that we can include a whole array of such embedded documents under one key, attribute.

Figure 86: An example of graph / story object in our NoSQL database

We decided to proceed this way to save ourselves headaches from joining and gluing graph objects in the events of loading and saving. A major incentive also was that Google Firestore charges for individual queries. If nodes and edges were to be their own separate collections and they would be referred to keys, one would have to do as many

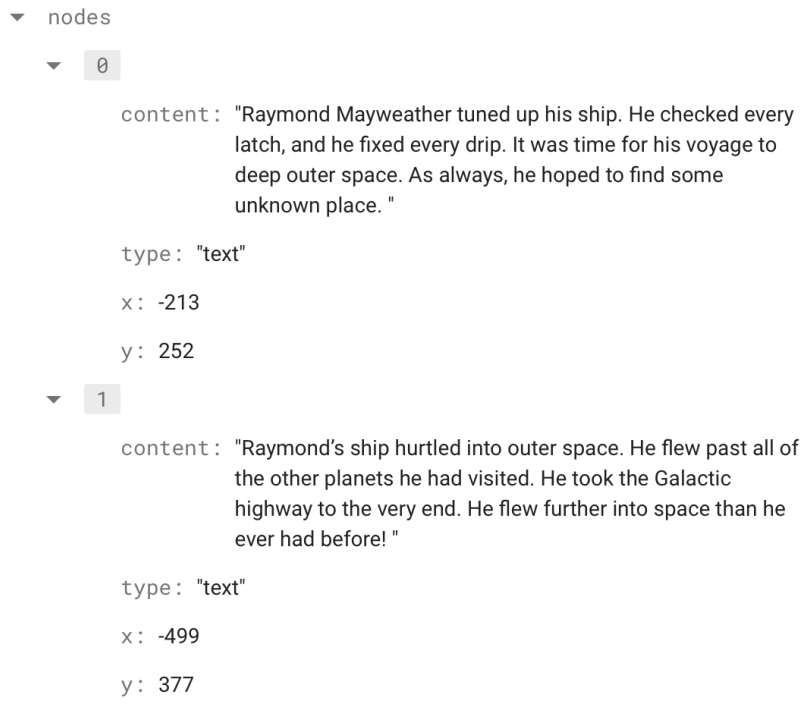


Figure 87: Embedded array of nodes within the graph object in our NoSQL database

queries for one stories as there are nodes. This would happen on each single load, refresh of a story. This way we could risk reaching the limit of available queries in our free program, but moreover, with this kind of architecture we increase the cost for, for now - no benefit. Eventually one day however, we would like to to separate at least nodes from stories and allow multiple stories utilizing the same node(s). The object of `Node` contains attribute `content` which for textual nodes is the content itself and for the images it is the URL to the image. The attribute `type` determines whether node is text, image or a different type. Attributes `x` and `y` stands for coordinates - absolute placement of the node within the plane of the story (graph). As nodes already preserve their position, for the object `Edge` it is enough to preserve only references to nodes it contains. In case the edge is directed, we can identify one of its node as head and another as tail. These references are supposed refer to nodes by their index - a position within the `nodes` array in the graph object. This position can however easily change. Just imagine deleting the first node in the story. The indexes of all of the rest of nodes would decrement by one. This would require an update of the array of edges as well which is costly and inefficient. As we did progress in the building of our prototype and creating its data model, we changed the way we store nodes in the story to a map.

6.2.2.3. GraphCompleted

This early diagram contains also an object `GraphCompleted`. This refers to one of the earlier ideas in which nodes could interacted upon. The state of the nodes after reading would be then preserved in a special object separated from the story, graph itself. Such interactive nodes could be prompts or mini puzzles. `GraphCompleted` object contains primary keys of `graphId` and `profileId` which unambiguously determine the act of reading of the graph by user and the attribute `data` which was an open refernece to either a whole embedded object or various attributes which could be added to `GraphCompleted` object based on the need of the interface and its users. We have to objectively say that the data model on client side does in fact separate state which is determined by reading activity from the unchangeable data of the story itself. This leads to the potential of saving the state of the reading of a graph.

6.2.2.4. Flattening of data

Last, but not least we would like to briefly speak about the duplicated attributes in the `Graph` object. One of the main principle of programming is called DRY - Don't repeat yourself and this is not only followed in code, but also and especially also in databases. Where can exist a reference and a big object can be split into two smaller ones, it has to be done. NoSQL databases and especially Google Firestore prioritize differently. Instead of saving the storage space, by storing one single information only once, it is more efficient to duplicate such information into documents which also use it. This way only a single query is performed and one does not have to search through the whole table of profiles to fetch `photoURL` attribute and show an author's avatar within the card of the story. Certainly, with indexed table such search would be executed and finished with logarithmically lower time, still, creation and maintainance of such tables cost computational resources which Google Firestore decided to constrain and charge. Within these conditions it makes much better sense to allow the existence of a single query which fetches all the necessary information for the object without the necessity of joining or running another queries. Using this principle of *flattened* scheme, we prepare the data for presentation already in the act of storing it. Certainly, the problem could begin if user wanted to change their photo. This can be however solved in two ways. Either we could create a Google Cloud Function which is a function that would run after each modification of the particular part of Google Firestore database. This way we could set that with each modification of `photoURL` attribute, we want all `profilePhotoURL` attributes to be changed as well. Another way how to solve this problem is to save the photo on the same location. If we use Google Firebase Storage, we can

store user's avatar within the same path, overriding the previous one which consequentially gives us the same URL. The URLs on stories haven't changed, yet the image on that URL was successfully modified. Still, for the minimisation of the requirements on the tool, we proceeded with stories without these profile attributes.

6.2.2.5. Final model

For the completion we include diagram that illustrates the state of object modelling within the NoSQL Google Firestore database up to date with our final prototype. In this diagram we use aggregation for the embedded relationships in which nested, embedded documents (such as nodes or positions) are part of their parent document. We also don't use the mark for public/private attribute as all attributes are equally accessible to whoever is reading or modifying them.

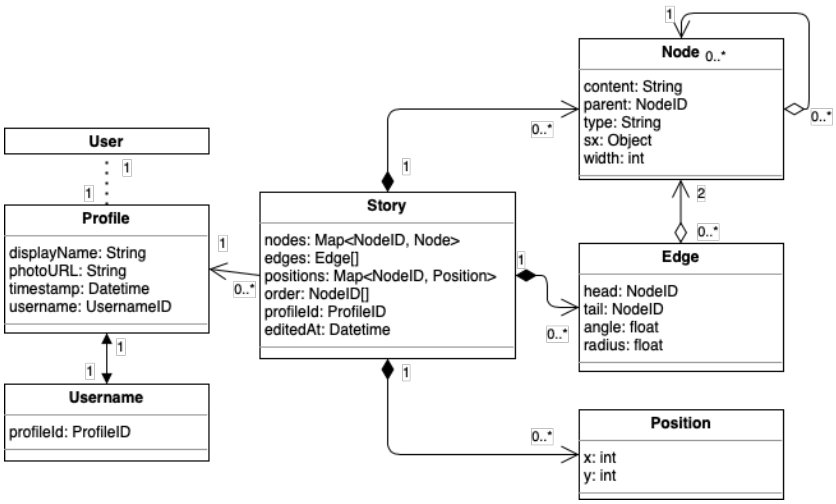


Figure 88: UML Diagram that illustrates the final object model for our application

In the final version of our object model, what has changed is the position of node which has shifted into the object of the story. This was due to the fact that it was more practical to manage the state this way on the client side, but also for the eventuality in which one node could be shown in different stories at once, preferrably with different positions in each of them. With moving from an array to a map in organization of our nodes we lost the inherent property of an array and that is order in which the nodes are being revealed. This is recompensed by the attribute `order` which stores IDs of nodes within an array. The object of `Node` was added `sx` attribute for styling which is of a type - Object or if you prefer, key-value dictionary (or a map). The attribute `width` determines the width in the case of image nodes and the attribute `parent` sets what we call a node dependency. In other way, the node

with the parent can be revealed only if scrolled down close to its parent or if all the other nodes have already been revealed. In order not to have to recalculate the `angle` and `radius` of edges from the positions of their nodes, we store these values as `Edge`'s own attributes.

6.3. Implementation

For the purpose of this work we won't describe every single challenge we faced and resolved when implementing our design, nevertheless we would like to mention a few notable concepts or parts of our tool which were non-trivial to implement or which we believe were crucial in an effort to reproduce our result or a like-minded effort.

6.3.1. User Account

We illustrate the implementation of the user account basic affordances on the code excerpts from the registration page and from the functionality of login. In `pages/join.js` we define the model `user` through the hook we made ourselves called `useModel`. This react hook is an analogy to `useForm` and it provides us with couple of functionalities such as storage of errors, form state through `isSuccess` or `isFail` properties, validation or often written functions `handleChange`, `handleSubmit` which we ideally want to write just once and maybe reuse from a library as we do here. In the example given it accepts two arguments, both in the form of an object. First defines the fields, attributes of our model which we are "creating". Second defines additional options. In our example we utilize two keys and those are `validation` and on the second image `onSubmit`.

The option of `validation` is another object that contains keys of `generalError`, `asyncValidators` and `syncValidators`. The function which receives an error object and transforms it into a message through our `errorMessage` function is passed to the `generalError` key. The `errorMessage` is simply a `switch` statement for various errors. The concept of general error stands for all errors which we haven't covered in all other cases. In `asyncValidators` and `syncValidators` we separate validation functions which are synchronous and asynchronous. Each validation object belongs to a field which it validates and consists of validation function `f` and `message` which is shown in case the validator (validation function) fails. The hook `useModel` runs these validators in the following way: On the first submit it runs as first synchronous validators, if all fields' values passed validation, asynchronous validators start validating. In case even those succeed, the function which we passed to `onSubmit` key successfully runs. After our first submitting, the hook `useModel` starts to validate the values of our fields after each change. This is done within a certain time interval so the user is not

```
user = useModel({ email: "", password: "", username: "" }, {
  validation: {
    generalError: err => errorMessage(err, USER_ERRORS["user/registration-not-successful/title"]),
    asyncValidators: {
      email: { f: emailUniqueness, message: USER_ERRORS["auth/email-already-in-use"] },
      username: { f: usernameUniqueness, message: USER_ERRORS["user/username-exists"] }
    },
    syncValidators: {
      email: [
        { f: presence, message: USER_ERRORS["user/email-empty"] },
        { f: emailFormatAt, message: USER_ERRORS["user/email-without-at"] },
        { f: emailFormatDomain, message: USER_ERRORS["user/email-invalid-domain"] },
      ],
      password: { f: minLength(6), message: USER_ERRORS["user/password-short"] },
      username: [
        { f: presence, message: USER_ERRORS["user/username-empty"] },
        { f: maxLength(16), message: USER_ERRORS["user/username-long"] },
        { f: usernameFormatCharacters, message: USER_ERRORS["user/username-characters"] },
        { f: usernameFormatNoConsecutive, message: USER_ERRORS["user/username-consecutive"] },
        { f: usernameFormatNoBeginEnd, message: USER_ERRORS["user/username-begin-end"] },
      ]
    },
  },
```

Figure 89: `useModel` hook which manages the state of the user model with registration form - `validation` object

distracted with a constant feedback during the filling of the form. Just to more closely describe validation functions. Synchronous validation functions or validators return a value which can be interpreted as a boolean. If validator returns truthful value (`Boolean(value) => true`), the value passed validation, in other way, the error is added to the model's state of errors and triggering react's rerender it displays under the field. Asynchronous validation functions do function on the same principle, just instead of value, they returns the promise which resolves to value.

Within the `onSubmit` callback we can see the actual logic of sending the data to the firestore service. The whole logic of that is to be found within a singular yet long function `createUserWithEmailAndPassword` which takes as its first parameter auth object. We can easily access the fields of `email` and `password` from our `user` model. In the case of successful resolution we see what we already spoke about and that is the entanglement or mutual codependence of Google Firebase's user account and our `Profile` and `Username` documents. Both of them we create at once using the interface of `batch`. Here we also see that the profile document which we are creating has the same identifier as the `uid` of the user object. In the case of successful commit we redirect back to the landing page. In the case of failure we run `fail` method

```
  onSubmit: () => {
    // Request!
    createUserWithEmailAndPassword(getAuth(), user.email, user.password).then(userCredential => {
      const batch = writeBatch(db()),
            profileId = userCredential.user.uid;

      batch.set(doc(Profiles, profileId), { displayName: "", photoURL: "", username: user.username });
      batch.set(doc(Usernames, user.username), { profileId });

      batch.commit().then(() => {
        router.push("/")
      }).catch(() => { // Most likely: FirebaseError: [code=permission-denied]: Missing or insufficient permissions.
        user.fail(errorMessage({}, USER_ERRORS["user/registration-not-successful/title"]));
        getAuth().currentUser.delete();
      });
    }, err => user.fail(userErrorMessage(err)));
  }
});
```

Figure 90: `useModel` hook which manages the state of the user model within registration form - `onSubmit` callback

of user model which takes as a parameter message of a general error. That is showed on the special place of the form, apart from inline errors below the fields. Because we already successfully created user object and even logged in after running `createUserWithEmailAndPassword`, we have to delete the currently logged ijn user as the process of creating a new account didn't run successfully till the end. In case even the basic creation of user account fails, we again run `fail` method of user model, this time using a slightly different function for the retrieval of the error message. In order to better understand the `useModel` hook we include its use in another of our own, yet more specific `useLoginModel` hook. That essentially creates a user model, similarly as we created it within registration page. The reason why the initiation of our user model for the purposes of login is in its own specific hook is that we are using the login functionality on two different places - within the login dialog and within the login page. This time on successful submit we run `signInWithEmailAndPassword` function from `firebase/auth` library and in the case of failed login attempt we run `fail` with the argument of an error message. That consequentially shows within the login form.

The `useModel`, even thought created by us, is part of separate library under the name of `@futo-ui/hooks`.

6.3.2. Story Interface

In this section we unravel the structure of the story interface. When creating component structures we pay attention to find the right balance between modularity, extensibility and reusability, yet to allow each component have a very specific purpose. It is also because of this why

```
import { useModel } from '@futo-ui/hooks'
import { getAuth, signInWithEmailAndPassword } from 'firebase/auth'

import { userErrorMessage } from 'user'

const useLoginModel = ({ success = () => {} } = { success: () => {} }) => {
  const user = useModel({ email: "", password: "" }, {
          onSubmit: () => signInWithEmailAndPassword(getAuth(), user.email, user.password)
            .then(success)
            .catch(err => user.fail(userErrorMessage(err.code === "auth/wrong-password" ? { ...err, code: err.code + "-login" } : err)))
        });

  return user;
}

export default useLoginModel;
```

Figure 91: Another use of `useModel` hook, this time for the purposes of login

this structure underwent several iterations to allow for the functionality to work correctly, in encapsulated and coherent manner, yet to make sense.

The structure of the page which shows the story goes as follows. The uppermost component is `FixedLayout` and it displays the logo and user's avatar with menu (in case the user is logged out - "Log in" button). It is followed by `Loading` which essentially is just a loading spinner showing unless `state.story.profileId` returns true. In other words, unless the story is loaded. Then we have two providers `DispatchProvider` and `StoreProvider`. Context providers in react allows nested components to access the passed value (in these cases - `dispatch` and `state`) using `useContext` hook. This saves space and writing, because without it we would have to pass both `dispatch` and `state` as attributes of multiple nested components (such as `StoryContainer` or `NodeContainer`). The reason why we use two providers is to prevent re-rendering of components which use only `dispatch`. The value of `state` changes much more often, while there are a few components which use only `dispatch` function. If we were to place them together within a common object it would be inefficient. Just to clarify, `state` is a variable which hold the whole state of the interface, including the `story` itself, where are we in reading it etc. The function `dispatch` is a function meant to pass an action to the reducer which then "sends the action to the particular branch or branches of the big state variable". We are going to speak a bit more about this in the next subsection of state management. The `StoryContainer` is the uppermost interactively functional and visible layer of the story interface, it provides plane with grabbing / panning functionality, clicking and creation of nodes and also listens for events which cause revelation and hiding of the nodes. We can take a closer look on the part of `StoryContainer` component.

The special hook `useEffect` in react serves the purpose for the code which is supposed to run just after the contents of the component

```
// Renders
const renderNode = key => { switch(state.story.nodes[key].type) {
  case "image": return <Image id={key} />;
  default: return <Text id={key} />;
}}

return (
  <FixedLayout>
    <Loading ready={state.story.profileId}>
      <DispatchProvider value={dispatch}>
        <StoreProvider value={state}>
          <StoryContainer>
            <StoryAlign>
              { state.story.order.map(key =>
                <NodeContainer key={key} id={key}>
                  {renderNode(key)}
                </NodeContainer>
              )}
            </StoryAlign>
          </StoryContainer>
        </StoreProvider>
      </DispatchProvider>
    </Loading>
  </FixedLayout>
)
```

Figure 92: Rendered contents on the page `pages/s/[id].js` that shows a story within non-editable interface

```
// useGrabbing
const handleMouseDown = e => e.button === 0 && e.currentTarget === e.target &&
  dispatch({ type: "grab-start", handle: "container", x: e.screenX, y: e.screenY });
const handleMouseMove = e => dispatch({ type: "GRAB_MOVE", x: e.screenX, y: e.screenY });
const handleMouseUp = () => dispatch({ type: "GRAB_MOUSE_UP" });

useEffect(() => {
  if (state.grab.handle) {
    window.addEventListener('mousemove', handleMouseMove);
    window.addEventListener('mouseup', handleMouseUp);
    return () => {
      window.removeEventListener('mousemove', handleMouseMove);
      window.removeEventListener('mouseup', handleMouseUp);
    }
  }
}, [state.grab.handle])

// usePlayer
useMouseWheel({ up: () => dispatch({ type: "PLAYER_PREV" }), down: () => dispatch({ type: "PLAYER_NEXT" }) });
```

Figure 93: Panning and playing functionality in `StoryContainer`

have been re-rendered. The second parameter of `useEffect` specifies dependencies. In other words, in this case, what is in `useEffect` is going to run after such a re-render of the component in which the value of `state.grab.handle` changed. `state.grab.handle` indicates whether we are grabbing (holding clicked mouse upon) the plane, specific node or nothing. If the value of this state variable gives `true`, i.e. does exist, we add listeners for `mousemove` and `mouseup` events. These then dispatches the actions of `GRAB_MOVE` and `GRAB_MOUSE_UP` which affect the state - moving around iether node or the whole plane. It's important to notice that `useEffect` upon each run would add new and new event listeners to the mentioned events. Therefore it is necessary to remove them in the unsubscribe function which `useEffect` returns and which is run just before the component is re-rendered. The excerpt of the code also contains `handleMouseDown` handler which is triggered by the `mouseDown` event on the container itself. The binding to the component or element we can't see, but what can we notice is that grabbing of the plane - panning starts only if we grab by left mouse button and only if we grab the plane itself, i.e., it wouldn't run if we grabbed a nested component of the plane such as node. Finally we use special hook `useMouseWheel` which allows us to pass functions which are called when user is scrolling their mouse wheel up or down. Returning back to our story interface structure we proceed to `StoryAlign` component which is a presentational component (without any interactions on their own) responsible for showing alignment, animated movement and panning of the plane. To briefly explain all three of them; By alignment we understand the alignment of `[0,0]` point of the plane which can be e.g. left-top, but also could be right-bottom. In our tool it is set to center-top. Animated movement of the plane is done through CSS transition on the property of `transform` and panning is displayed through absolute positioning and CSS properties `left` and `top`. In the innermost part of story interface structure we iterate through the `order` attribute of the story (to show nodes in order). `NodeContainer` is mostly a presentational component, with one exception where it, through `useResizeObserver`, observes the change of its dimensions and send them through `dispatch` to the state. `NodeContainer` handles position of the node and than perks such as selectability of the node or its opacity (when dragged above the `Trash` for example). Based on the type of the node, a concrete specific node type is rendered in the function `renderNode`. These specific types, similarly as other components, handle their own interactions. We can compare the structure of story interface with the structure that is editable. Starting where we ended we can notice the use of `TextEditable` and `ImageEditable` components which apart from `Text` and `Image` contain interactions which affect the and modify the story. `StoryNotification` component serves the purpose of

indicating that the story has been saved in the process of editing. The process of autosave is triggered with each modification of story and to prevent constant saving it has a debounce time of 2 seconds.

```
// Renders
const renderNode = key => { switch(state.story.nodes[key].type) {
  case "image": return <ImageEditable id={key} />;
  default: return <TextEditable id={key} />;
}}

return (
  <FixedLayout toolbarLeft={
    <StoryNotification show={state.autosave.notification}>{state.autosave.pending ? "Saving..." : "Saved."}</StoryNotification>}>
    <Authorize ready={Boolean(state.story.profileId)} redirect={storyPath(state.story)} uid={state.story.profileId}>
      <DispatchProvider value={dispatch}>
        <StoreProvider value={state}>
          <StoryContainer onMouseUp={handleContainerMouseUp} sx={{ cursor: "pointer" }}>
            <StoryAlign>
              { state.story.order.map(key =>
                <NodeContainer id={key} key={key} onMouseDown={handleNodeMouseDown(key)}>
                  {renderNode(key)}
                </NodeContainer>
              )}
            </StoryAlign>
            { state.grab.dragged && state.grab.handle === "node" && <Trash /> }
          </StoryContainer>
        </StoreProvider>
      </DispatchProvider>
    </Authorize>
  </FixedLayout>
)
```

Figure 94: Rendered contents on the page `pages/s/[id]/edit.js` that shows a story within editable interface

The component `Loading` has been substituted by a little more complex component `Authorize`. `Authorize` itself contains the `Loading` component, however instead of being a simple boolean whether to show spinner or not, it does check if the user is logged in and if they are authorized to edit the particular story. This is done by comparing the `uid` or `profileId` from story (`state.story.profileId`) to the `uid` of the currently logged in user. The fact that we decided to identify profile document by the same id as the user did simplify a few steps in here. Just before the enclosing tag of `StoryContainer` we see the component of `Trash` for deletion of the node. `Trash` is showed only if something is being dragged and that something is node. Apart from all that we also two more interactions. We see `handleContainerMouseUp` which adds a node on the plane if mouse button is being lifted. And we also see `handleNodeMouseDown(key)` which initiates grabbing of the node. Both actions aren't part of shared `StoryContainer` component, because they are not meant for the interface of reading / viewing the story and they are pulled completely upwards in the structure where a distinction between editing and viewing is mantained - to the page.

6.3.3. State management

React is a framework inherently focused on the state. With its one-way binding mechanism, to cause re-render a change of state has to occur. If dealing with primitive states which hold simple values such as string or integer, it is enough to let the state stay in its own separate component. When we start to work with the whole object of state values which are more over affecting one another, a new architecture has to be implemented. Most commonly the state is "pulled up" from the nested components to their parent. Through handlers which lead to the parent is how modifications in the state are conducted. Yet, to sow components with the same handlers over several layers of nesting is not only tedious, but creates unnecessary clutter and increases the chances of a mistake. This can be prevented by utilizing what is called a reducer. Reducer returns besides the state, also a `dispatch` function to which we can pass whichever object we like. This object does inform the state how it should change. Therefore the logic of state alteration is moved up, to the state itself and doesn't have to be maintained in components.

```
const useRootReducer = (reducers = {}) => {
  const rootReducer = combineReducers({ effectsReducer, grabReducer, renderReducer, storyReducer, viewReducer, ...reducers }),
        [state, dispatch] = useReactReducer((state, actionArg) => {
          let actions = arrayize(isfunction(actionArg) ? actionArg(state) : actionArg);

          const runActions = (actions, state) =>
            actions.reduce((accState, seedAction) => {
              const actions = actionsCreator(accState, seedAction);
              return empty(actions) ? rootReducer(accState, seedAction) : runActions(actions, accState);
            }, state)

          return runActions(actions, state);
        }, null, () => rootReducer({}, {}));

  // usePresentReady
  const { height: containerHeight, width: containerWidth } = state.render.container,
        { height: nodeHeight, width: nodeWidth } = state.render.nodes[state.effects.onPresentReady.key] || {};

  useEffect(() => { containerHeight && containerWidth && nodeHeight && nodeWidth && dispatch({ type: "ON_PRESENT_READY" })
  }, [containerHeight, containerWidth, nodeHeight, nodeWidth]);

  // useTimeoutEffect
  const timer = useRef(), { timeout } = state.effects.onTimeout;
  useEffect(() => { if (timeout) {
    clearTimeout(timer.current);
    timer.current = setTimeout(() => dispatch({ type: "ON_TIMEOUT" }), timeout);
  }}, [state.effects.onTimeout.timeout])


  return [state, dispatch];
}
```

Figure 95: `useRootReducer` - the infrastructure for our interactions

As we did continue implementing our tool using this approach, the complexity of `dispatch` calls was rising. Suddenly, within one action

we called 3-4 dispatch calls and some parts of these chunks were even similar or the same. Could we allow dispatching a single complex action which could than expand to multiple complex or primitive actions and affect various branches of our state? Also, we want to be sure that in the act of dispatching we are receiving an actual value of the whole state without any racing condition which could affect the state just after we saved it, yet before we modified it through our `dispatch` call. All these issues and questions is what lead us to creation of our own reducer. We maintain the separation of reducers in order to preserve their modularity and eventual independent development. Yet this goes against our need of affecting different reducers - branches of our state at once. In `useRootReducer` we combine them using similar technique of `combineReducers` as in Redux, i.e. `combineReducers` just takes the whole argument which is an object and rename all the keys in a way that they won't contain "-Reducer" suffix. We then proceed to define standard react reducer. In this case `useReactReducer` is the same as React's `useReducer`. In the reducers itself we accept action to be either an object of the action (`type: "SOME_ACTION", value: "somevalue"`), a function that returns action object or an array of action objects (or a function that returns an array of action objects). In first line we make sure to unify these different types of arguments into a single format - an array of actions in `actions` variable. Then we define a function which takes an array of actions and run them on state. After each action we obtain a new state in `accState` through functional `reduce` method, therefore we avoid any possibility of inconsistency in which we would be receiving an old state. Then we take a single `seedAction` and for the given state we run it through `actionsCreator`. We are going to return to `actionsCreator` in a bit, for now we can imagine that it is a big grinder which converts complex actions to smaller actions until it doesn't have any actions left. That we are exactly checking on the `return` line where in the case of `actions` being empty, `seedAction` has to be a primitive action that can run through the branches of our states, through the reducers we combined in `rootReducer`. If `actions` is not yet empty, we run it through our grinder again. The lonely `state` variable is only a second argument for the `reduce` method as an initial state. We pass two more arguments to `useReactReducer` and those are `null` for the initial state of the reducer and `() => rootReducer(, )` for the lazy initialization of the state. This is a trick we use in order not to duplicate partial default states from individual reducers into one big default state. We simply call rootReducer with an empty state and empty action and we receive all those default values collected within one object which is a default value we prefer for our state. `useRootReducer` also contains two effects and that is namely `usePresentReady` and `useTimeoutEffect`. Given certain con-

ditions, these effects trigger their own dispatch which then can cause modifications within the state. The purpose of `usePresentReady` is to wait with certain actions until we have written dimensions of our nodes into the state. Only in such case we can, for example, transition the plane onto specific node. `useTimeoutEffect` works similarly, but it is caused by us. We use `useTimeoutEffect` with autosave where we want to dispatch an action with a delay, i.e. after about 2 seconds from the last autosave, we want to hide the autosave notification. We already noticed in story interface two kinds of actions. One kind is written with uppercase and underline, another uses lowercase and dashes. This is not a coincidence and these two notation distinguish complex actions and simple or primitive actions. In `useRootReducer` we successfully identified what we call grinder - a grinder for our actions. So this grinder transforms or expands complex actions into primitive ones and these cannot be ground anymore - these are the ones which can go to combined `rootReducer` and affect their specific branches of the state.

```
case "NODE_ADD": {
  const { content, x, y } = action, key = newNodeKey(state.story.nodes), order = newNodeOrder(state),
        sx = empty(state.story.order) ? { fontSize: "2rem", fontWeight: "bold" } : {};

  return [{ type: "story-node-add", key, content, order, sx: { ...sx, maxWidth: 400 }, x, y },
          { type: "view-show", keys: [key] }, { type: "caret-focus", key }]; }
case "NODE_ADD_BELOW": {
  const { content } = action, { x, y } = state.story.positions[action.key], { height } = state.render.nodes[action.key];
  return [{ type: "NODE_ADD", content, x, y: y + height + 10 }]; }
case "NODE_CHANGE": {
  const { content, height, key, placeholder, sx, t, width } = action;
  return [{ type: "story-node-change", key, content, height, placeholder, sx, t, width }, { type: "autosave-trigger" }]; }
case "NODE_REMOVE": {
  const { key } = action;
  return [{ type: "story-node-remove", key }, { type: "view-node-remove", key },
          { type: "render-node-remove", key }, { type: "autosave-trigger" }]; }
```

Figure 96: `actionsCreator` - the dispatcher and organizer of our interactions

We see an excerpt of what we call `actionsCreator`. `actionsCreator` is basically a big switch statement which for a given complex action, returns an array of more actions. If action is not found, it returns an empty array. In this particular cut we can see the complex action of `NODE_ADD`. It receives the `content` and the position of the node from `action` variable, it generated a new key, new `NodeID` as we described in object modelling and in the case we are in the middle of the story, it remembers the order or the temporal position of the new node. In case it is a first node, it sets formatting to title. Followingly it then returns an array with 3 primitive actions. The action `story-node-add` adds the data of the node to the object of the story, the action `view-show` makes sure that the new node is revealed and remembered as revelead and the action of `caret-focus` focuses our caret on the place of a new node, preparing us for writing. To better illustrate the principle we are going

to run through a few examples. The complex action `NODE_ADD_BELOW` receives the `content` of the new node from the `action` object, then it receives position of the node below which it is going to be placed, it receives the height of this node and then it runs the complex action of `NODE_ADD` within this particular position. The action `NODE_CHANGE` receives all the parameters of the node from action, then changes the node in the data object of the story and triggers autosave. Similarly, the action `NODE_REMOVE` removes the node from the data object of the story, from the view object that remembers data about the reading activity and from the render list which contains dimensions of the nodes. Then it triggers the autosave.

6.3.4. Transitions

One of the mathematically slightly more challenging concepts to implement was the transition movement, i.e. the movement of the plane that is caused by node overflowing the viewport. The calculation of how much should the plane move is handled by a single `presentCoors` function which is defined and used in `app/story/state/actionsCreator.js` file responsible for sorting out dispatch calls for various actions which purpose is to modify the `state` variable.

```
const presentCoors = ({ render, story, view }, key) => {
  const node = story.positions[key], rnode = render.nodes[key], { container } = render,
        { left, top, right, bottom } = delta( // Is overlapping if left < 0, top < 0, 0 < right, 0 < bottom
              rect({ x: node.x, y: node.y }, { height: rnode.height, width: rnode.width }), // Before rect -> rectRel (with align)
              sum(rect(clientToCoors({ render, story, view }, { x: 0, y: 0 }), { height: container.height, width: container.width }),
                { left: 24, top: 64, right: -24, bottom: -24 })); // PADDING

  return delta(view.present, {
    x: left < 0 && 0 < right ? avg(left, right) : Math.min(left, Math.max(0, right)),
    y: top < 0 && 0 < bottom ? avg(top, bottom) : Math.min(top, Math.max(0, bottom))
  });
}
```

Figure 97: `presentCoors` function which calculates new animated shift of the plane

The function `presentCoors` accepts three objects which all are parts of the state variable. Those are `render`, `story` and `view`. `render` stores the dimensions of the whole viewport and dimensions of individual nodes. These are obtained only after rendering, hence the name `render`. The function `presentCoors` needs the node's position (node to which the plane is going to move to), dimensions of this node and dimensions of the whole container or viewport. From the dimensions of the node and its position it calculates the rectangle object consisting of values `left`, `top`, `right` and `bottom` which uniquely defines a rectangle within the absolute coordinates of the plane. The function `clientToCoors` with its current parameters then calculate the vector of "how much and where should the plane move so the point `[0,0]` is on the left top corner of the viewport". A similar kind of rectangle is calculated

from this values and dimensions of the container. And to this rectangle padding is added, i.e. shrinking the rectangle itself to a smaller one. This padding essentially stands for "how much movement to the left and top should the node make to reach that particular edge of screen". It's important to notice that with this formulation, the values for `right` and `bottom` are negative. By substracting the final viewport rectangle from the rectangle of the node we receive an overflow rectangle. In the final returning statement we substract this overflow from the current shift of the plane. Put differently, we substract either left (top) or right (bottom) overflow or in the case of both sides being overflown, the average of their overflow.

7. User Experience Evaluation

7.1. Goals & Method of Evaluation

To acquire data and insights based on which we could improve our tool to fit the needs of the user we proceeded towards user experience evaluation. Foremost of all, it is important to clarify that this is not a usability testing where we have a specific set of actions which we track user to fulfill and map the times in which they achieve them. Even though, there were occassions in which we did guide users towards exploring and finding a specific feature, it was rather rare and mostly we were facing ambiguities within which we were expecting users to find their own interpretations in. Moreover, we were also interested to understand the overall impression, sensations and experiences which users did go through when engaging with our tool. Given the state of our implementation we decided to proceed with evaluation exploring the stable version of our prototype. The prototype encompassed an introductory story (fig. 98) that was supposed to introduce the reader to the topic of what we are exploring and what the tool is about.

This story was purposefully written with broader semantic gaps and in a free spatial (dis)organization to let the reader wonder and discover what exactly they are reading - to purposefully allow the reader to fill these gaps with their own subjective interpretations. In the second part of the evaluation, which user was guided to from the introductory story, we proceeded to writing in which the user, without explicitly requesting them, was lead to write their own story. In this part we explored user's ability to discover particular actions, employ their own techniques of creation/writing and the context in which they situated the tool based on their behaviour and content they created.

In the prototype which we were evaluating we purposefully left out what we called in interface design model node dependencies. We based this decision on the instability of the node dependency feature and lack of readiness for evaluation which could affect the overall impression of the tool and other evaluated concepts. We also decided not to include the feature of connections and proceeded with a lighter, yet stable and minimal version of the prototype which was supposed to allow us

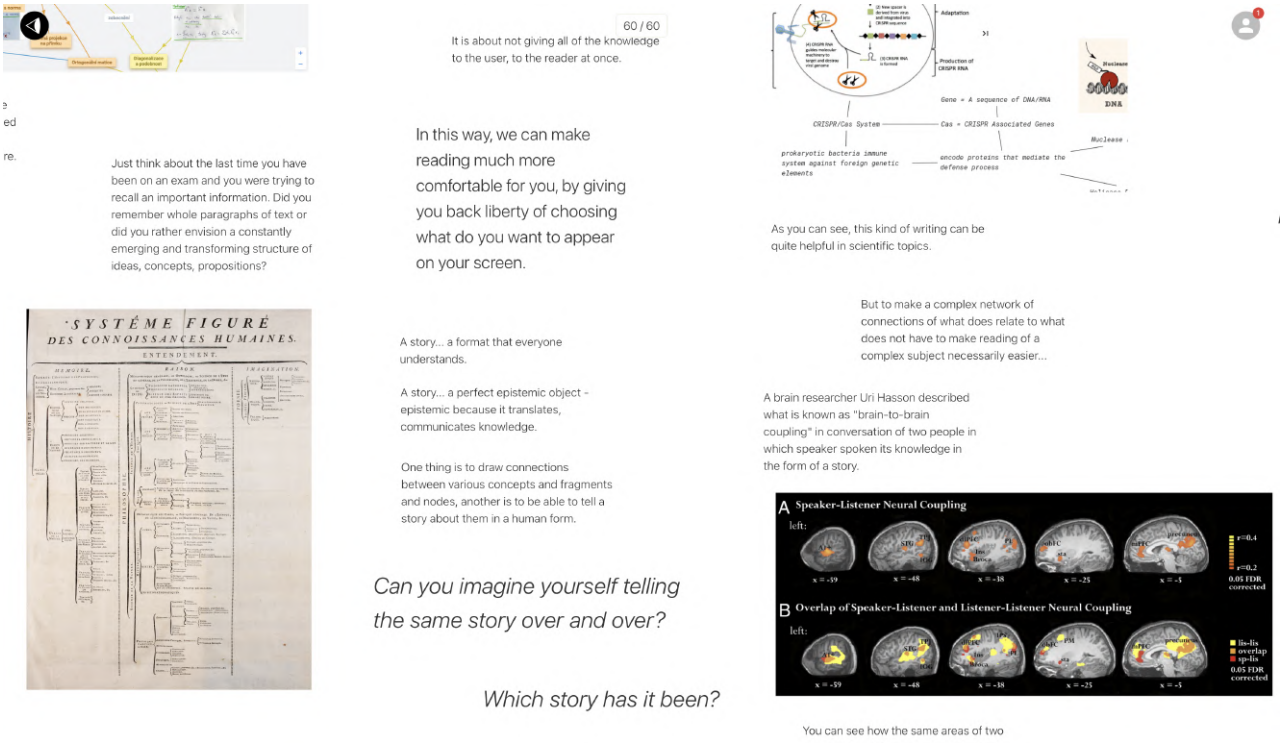


Figure 98: Landing page of our prototype - an introductory story describing our project and at the same time showcasing a story that we can create using the tool

Figure 99: Writing interface being tested during one of our tests

to better understand the activity of writing in its minimal free form without further visual cluttering.

7.2. Evaluated Concepts

The goals of our evaluation were to understand users' reactions and experiences on particular key concepts that we were testing or their interpretations of individual parts of the interface or even the use of the tool as a whole. In the following section we describe these concepts and their particular goals.

7.2.1. Progressive Disclosure

Progressive disclosure is what we understand as an affordance for the user to control the progress of reading, revelation of the content. We decided to proceed with a simple action of linear reading, revelation mapped upon the interaction of scrolling as it is described in our interface design model under the card "Show / Hide". This action subsequently causes viewport of the web application to move, to therefore preserve the fragment, the node within viewable area in case it is overflowing beyond. We focused on acquiring information on user's expected and unexpected uses of scrolling and their impressions. The expected benefit is not to overwhelm reader with all the information, but to provide them in a "guided", progressive manner. This is the assumption that we were evaluating and also the overall use of the feature. Even though our story was in majority of cases organized in left-to-right and top-to-bottom reading directions, we did purposefully added a few places within the story in which the progression of reading and revelation of the next node wasn't immediately obvious in order to capture the response of users and understand the level of struggle it causes for them.

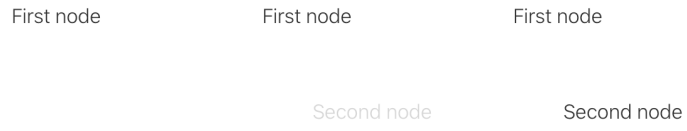


Figure 100: Progressive revelation of nodes within a story

7.2.2. Dragging & Spatial Organization

A key concept we focused on was the dragging, moving interactions with the plane and nodes, the context of their use and differences of expectations in reading and writing interfaces. While in writing interfaces we can only drag the plane, in editing, we can drag both the plane and nodes. Within this concept we also intended to explore the spatial organization of our introductory story, how much it matters, what kind of responses and interactions it causes. As we hinted with the previous concept in the idea of purposefully misplacing nodes, parts of the story on unexpected places - this also served evaluation of the dragging as it could be used to visually access the area of obscured nodes.

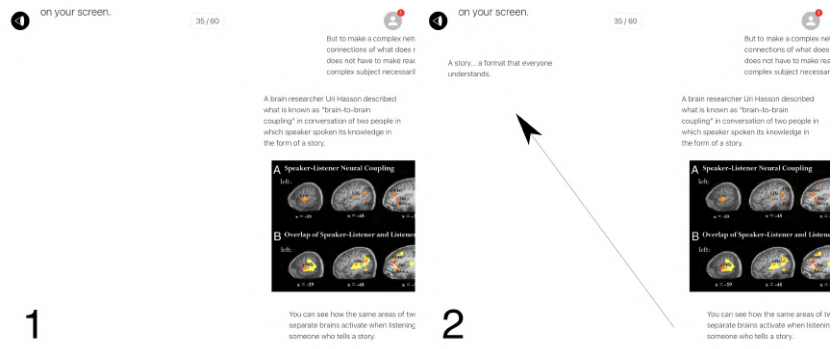


Figure 101: Progressive revelation of nodes within a story

7.2.3. Identity & Communication

One of the most important aspects we did explore in the process of prototype evaluation was the theme and context of the use of the tool. In the design of our prototype we tried to be as much agnostic as we can in order not to give out a certain contextual clue for the user and rather let them invent their own contexts in which they can use the tool. We also did not provide an explicit description on how to use the tool or what is it for, rather we introduced users with our own research pathway using the format that the tool itself allows us to create. Even though we did suggest the contexts of mind mapping, storytelling, a tight relation between reading and writing, we did remain within the level of ambiguity that allowed for users' own interpretations - and that is exactly one of the goals of what we were looking for.

7.2.4. Writing in Stories

As another key concept within our prototype we identify the action of writing itself, especially how well we can affect and encourage the

writer to write in a form of a story. Upon creating a new story we are greeted by a prompt / text placeholder which is supposed to encourage the action of writing and eventually can guide writing to preserve the genre of a storytelling. We particularly explored the actions of adding new nodes upon hitting enter, adding an image node, adding a text node upon clicking anywhere in canvas. We were also eager to understand new freeform genres of writing which people chose and what they wrote about. Another intention was to understand variety of combinations of individual interactions in the process of writing.

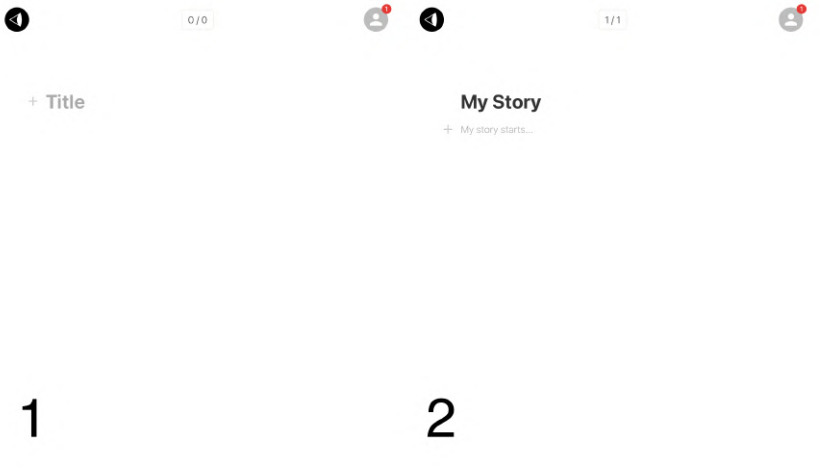


Figure 102: Writing interface of our prototype

7.2.5. Connections

The affordance of connecting two nodes is purposefully not included within the prototype to better understand if it is expected and what are its benefits, yet it is a concept we inquire about in our evaluation process. We were particularly curious to find out if there is a need for visual connections at all and if yes, what kind of benefit would they signify. We were examining this by finding out if there are users who would find themselves in the need for such affordance and what kind of purpose would it serve for them.

7.2.6. "Pre-nonlinear" Insertion

We try to introduce non-linearity by diminishing the boundary between reading and writing. In other words, we allow user to read - scroll through the content, let them reveal and hide the nodes also in the editing, writing interface. A new node can be then inserted in the middle of temporal progression of reading without the need of reorganizing the order of or removing of multiple nodes. In the prototype evaluation

we do model the need for such interaction and observe how quickly users are able to discover this possibility.

7.3. Evaluation Protocol

Our evaluation protocol relied heavily on subjective actions, explorations and interpretations of the user. Therefore we allowed user not to be constrained by having to follow a certain task, but to have freedom in exploring the tool and finding their own understanding of it unless an intervention was necessary if we considered that we haven't explored one of the evaluation concepts sufficiently. In this free form we however included specific questions within the introductory story. We asked in particular to better understand user's previous use of mind maps and their storytelling activity. These questions however did also serve as entry points for conversation.

We focused on collecting the answers of the following questions in particular:

- Have you used mind mapping before?
- If yes, for what?
- What did you like and what did you not like about mind maps?
- Can you imagine yourself telling the same story over and over?
- Which story has it been?
- Can you imagine retelling, explaining a complex, professional topic of yours in a form of a story?

Our intention was not only necessarily to collect exact answers, but rather to have a broader understanding of the user's relationship with these activities and their personal contextualizations. In the end of the reading part of evaluation we did place the following questions:

- What would you use this tool for?
- Which feature do you miss the most?

These could have been answered before writing, in the case the user was inspired to answer already, but it was expected that most of the answers would be given after the experience of writing. Given an agnostic design of our prototype in which features are not as visibly organized (e.g. in toolbar), we did expect the question to incentivize the user into more vivid imagination of the context of the tool's use. Within the process of evaluation we did pay attention to the fact that all of the key concepts were addressed. Most of them, being discoverable,

didn't need our intervention, however, in a few occurences we had to explicitly ask, for example about the benefit of seeing lines, connections between the nodes. We did also intervene by giving hints or describing a context of the need for a particular affordance in situations in which users struggled to discover them.

Most of the evaluation sessions we did were done online which allowed us to record the interactions. Those which we were conducted in person were recorded using audio recorder, apart from the first one which unfortunately hasn't been recorded at all. In all cases we were also taking notes, focusing mostly on the answers of our evalution questions, but also particular themes of struggles, curiosities or inquiries - simply concepts with which users spent a reasonable amount of time. In our note-taking we however did try to record almost all events.

7.3.1. Evaluation Sample

We did our evaluation with 12 people of 21-36 of age, most of them being professionals in their respective fields and from various ethnographic backgrounds. We summarize their background information in the following table:

No.	Gender	Age	Nationality	Training
1	M	26	Portuguese	Design & Multimedia
2	M	36	Portuguese	Design & Multimedia
3	F	28	Portuguese	Design & Multimedia
4	F	24	Brazilian	Psychology
5	F	27	Colombian	Forest Engineering
6	F	24	Colombian	Community Management
7	F	27	Slovakian	Medicine Doctor
8	M	23	Portuguese	Design & Multimedia
9	M	27	Slovakian	Microelectronics
10	F	29	Croatian	Architecture
11	M	21	American	Cognitive Sciences
12	M	34	American	Business Development

7.4. Analysis & Reflection

After collection of the data we proceeded to separate individual insights, comments, experiences of users into identifiable units which we then organized within an table. This table is to be found within the annex, in the end of the work and it supposed to serve as a preliminary set of notes. In identifying the patterns and insights from the table we

primarily focused on addressing the concepts we were evaluating as described in previous section, but we also discovered new patterns, insights which we commented on in next subsections which reflect the structure of concepts we were evaluating. After the identification of patterns we proceeded by verifying them with the recordings of our evaluating session and quotations of the participants. The themes or topics that emerged through the repetition of related or similar units indicated a pattern - an opportunity for a meaningful intervention.

ID	Age	Profession / Field	Mind Maps (Do you use mind maps?)	Have you ever found yourself repeating the same story over and over?
#1	26	Student (Design & Multimedia)	- not really	- doesn't remember such occurence
#2	36	Professor (Design & Multimedia)	- concepts, sketches (paper) - or big projects (software) + organization - difficult to navigate	- hmm, yes - lack of enthusiasm
#3	28	Researcher / Teaching Assistant (Design & Multimedia)	- in the form of artboards	- yes, with variation it gets better
#4	24	Psychologist	- yes, htp test, mapping traumas, questions (of patients)	- somewhat, yes
#5	27	Forest Engineer	- yes, resumes, explanations - context is essential	- yes, more or less
#6	24	Student (Community Management)	- nope	- yes, more or less - retell to myself to remember better
#7	27	Medical Researcher	- brainstorming (for myself) - bullet points - social / political topics - reverse search is tedious	- yes

Figure 103: The preview of our table which served the purpose of identification of patterns. The full size of the table can be found in the annex.

7.4.1. Mind Maps

When it comes to familiarity with the practice of mind mapping, we could characterize our sample as the sample of people who are in majority familiar with the practice of mind mapping and have used it in their particular thematical or professional setting. We could have also noticed certain unique distinctions in which people perceived the practice of mind mapping within their particular contexts. From the sample of twelve, 8 people expressed that they in fact have used or are using mind mapping as part of their practice, i.e. from their own will, 1 person described the use of mind maps within a particular academic context where they were incentivized to do so in a collaborative setting and 3 people expressed negative.

The distinctions became apparent in the way people were contextualizing their use of mind mapping. In particular the responses on the question of the use of mind mapping varied with the contexts of participants' professional backgrounds which was often pulling the relatively abstract idea of mind mapping into their broader interpretation of sensemaking.

> "Yes, couple of times. Sometimes for bigger projects that need better organization (...) of the structure. (5:18)" - Participant #2

> "Not like this, but yes, in college we were testing each other (3:56) We were looking for traumas and we had to draw whatever interviewers where telling you and there are some questions that kind of reminded me of mind mapping. (4:47)" - Participant #4

> "Usually it is for resumes, trying to explain any topic that we were talking about in the course or to explain a process in my office (1:48)" - Participant #5

> "With brainstorming I use mind mapping, but it has a more of linear form (...) so it has a form of bullet points or such small spiders for learning too. (2:27)" - Participant #7

> "I like to draw circuits, I'm not sure if it can be totally, like 1-to-1 compared to mind mapping, but I have rather tendency to go for UML more, because often... it also depends on the context and which ideas I am trying to interpret (10:11). Often when I draw something like this it depends on what work I am doing, that it is some sort of system. (10:53)" - Participant #9

> "First school assignments and maybe occassionally some design activity. (2:23)" - Participant #11

> "I find myself doing it when I am just sort of going through thoughts or collecting my thoughts. But it's not that I am going to sit down and say 'Okey, I'm going to build a mind map about X'. It's more about... I'm thinking about something and I want to start creating some sort of reference points visually to some of the ideas. (5:58)" - Participant #12

Another meta information is how much were people willing to share and talk about the topic of mind mapping. We will find later that those who were interested to talk about mind mapping more from their own personal experiences and were able to clearly call out advantages and disadvantages were the ones who were also able to find and use certain features faster or were opinionanted on how should the tool improve. 5 people in total from the 8 who have used or are using mind maps have been able to identify also advantages or disadvantages of mind-mapping, in 2 cases the main advantage being the exposition of relations.

> "I like that I can directly express those relationships. (20:30) I feel that it is easier to express relationship in this way than describing them in the text. (20:55)" - Participant #9

"I like that it was very associative and you can really freeform, add things as they really unfold out. (2:33)" - Participant #12

Others mentioning also sense of organization or spatial expression.

"I think what I liked it was... to have a sense... or not a sense, it is actual... it was a sense that all the information was organized in a certain way. (6:22)" - Participant #3

"I think the part that I like is that it gives me the outcome that I desire in terms of creating that spatial orientation to things and ideas and how they may connect or diverge, converge (7:19)" - Participant #12

As the most common disadvantage was the topic of too much abstraction (ambiguity) which was implied in 3 cases:

"Maybe you need an introduction to speak a little bit about the main topic. You can solve everything in just one structure, but the main definition could give the right idea how you can read all the structure. If you don't have an idea, you don't know how to read that." - Participant #5

"...but it depends also on what it is there (21:26) If there are only images and lines between images (21:37) ... it maybe already loses that universality (21:47)" - Participant #9

"I think what I dislike is that layout is super difficult to make a nice one that really is useful later on. It's also very abstracted. (2:48). The notes of the mind map abstract out the ideas, they are very reductionist and you end up putting keywords out there and not putting the actual ideas down (3:01)." - Participant #12

The other disadvantage was the issue of navigability / searching mentioned in 2 cases:

"...but on the other side it was probably difficult to navigate in that very big tree of information (6:43)" - Participant #3

"With backward search they are sometimes... (3:29) that if there is that classical spider which is shown as an example of how a mind map should look like, it is sometimes chaotic for me during backward search. That when I sometimes tried it during some seminars it appeared difficult to reverse search some part." - Participant #7 (3:37)

We can see how abstract is our understanding of mind mapping. There is a level of introspection that was needed in each of these answers which emphasizes non-systematicity or in other words lack of planning. In the activity of mind mapping one is trying to express a spontaneous burst of ideas without a clear structure of actions in their mind. We also see how the perception of users' problems might differ. Some people also did struggle with expressing the problem for the first time.

7.4.2. Stories

When addressing the topic of stories, 11 people out of 12 were able to clearly identify an occurrence in their lives when they had to repeat the same story again,

> "I mean, yea. I think it probably happens with everyone (24:26). Something that happens... An important event in your life that happened and you tell your... even not just your inner circle of friends (24:36)" - Participant #3

> "Of course I can, ahah (9:28). I don't mind speaking the same story over and over if I have good listeners and if, if it's something... if it's broader message that I want to share with people (...) and of course, like, if I'm speaking about my work or my professional work or whatever I also don't mind speaking over and over because... I try if I see the point of my story, I'm gonna try to reach as much people as I want to (15:55)" - Participant #10

> "So that question... I would think of stories that I can tell at social gatherings, anecdotes and little things like that. Sure I tell them over and over. (11:55)" - Participant #12

Only two people expressed their hesitation with the practice of retelling the same story, commenting that one can slowly lose enthusiasm or focusing on implying that it would be exhausting if the people did not care about it.

> "This is a tricky question, because it's not about the tool, it's more about my capacity, my skills of expression itself (9:43). As it was in the past, I used to work on the project (...) we also tried to create a startup and then we participated in an event in huge different kind of context. We talked a lot with users and different kind of contexts and in certain point I was very tired of that, of that communication and I was being (...) not very efficient in my communication as I kind of lost enthusiasm to express that story again and again. (12:18)" - Participant #2

> "I wouldn't say I would imagine myself telling the same story over and over again, especially if it's a very complex thing, because people mostly do not care if it's difficult, complex things (15:26). They have to like that kind of information otherwise (...) you would not be able to do it even if you want to (16:29)." - Participant #8

One person wasn't able to remember an occurrence of telling the same story again and again. When it comes to the context of retelling a story, 6 people out of 11 primarily identified the context to be of personal nature, telling personal stories to a friend or on family gatherings and 5 people primarily spoke about their professional context of telling a story. 7-8 people initiativelly agreed that they can imagine themselves explaining their professional topic using the form of a story.

We also include a few notable comments from some of the people, like the fact that the story gets better each time it is repeated;

> "Every time that I tell the story I think I eventually change the way that I tell it. Or sometimes I feel like that detail that I told to 2, 3 or more people is not important to the story and I remove it. (25:37) I think (it gets) better definitely, because the most important will stay (26:08)" - Participant #3

The occurrence of a practice in which telling a story serves the purpose of sensemaking and learning - being in conversation with yourself to repeat an information;

> "I don't remember something specific, but yes, it happened to me (12:53). Personal things, data that I learned. It's like, I have the information there and I repeat it again so I don't forget it (13:45)" - Participant #6

And the necessity for the human connection in the practice of telling the story regardless of whether it is personal or professional;

> "On the personal side - zero annoyance, because usually it is about connecting with other people and it's important to tell those stories and to give the people chance to learn about you. It's an act of sort of connection with another human, so for me that would be zero annoyance. On the business side it is very annoying to sometimes go into a meeting and sort of know that it's not going to be a high-value meeting, because just the experience and instinct... Because the person might work for an organization that you feel like potentially can help your media outcomes and desires to do whatever you want to do in business or it's like 'Yes, this person has introduced me, of course I'll tell them about our story and let them know about what we do' - so those are very high annoyance. (14:07)" - Participant #12

> "I've always wished there was an easy way to sort of... tell a story either in a, you know, very simple thinking, like: Why can't I just record me giving this 15 minutes slide decks presentation sending to them? But I think the minute you take the human element out of it then most people are like: I'm not going to waste my time watching a 15 minute video of somebody talking - I rather just talk with you. (16:08)" - Participant #12

7.4.3. Progressive Disclosure

The concept of progressive disclosure was specifically mapped to the user's action of scrolling. Scrolling down did reveal nodes on the screen while scrolling up was supposed to hide them again. The suggestion to scroll up and down that was intended to introduce users to this functionality in the beginning of the story did prove itself helpful in all the cases. What however caught us by surprise was the fact how many people do use touchpad instead of a mouse which haptic sensitivity for scrolling is much different. For 6 users it did affect the experience negatively. The **touchpad wasn't sensitive enough** and small movements caused too many nodes to reveal or hide themselves at once. We can see that on our recordings in times approximately around the times of the quotation we chose to provide as evidence. The

effort to control it was frustrating, because of the lack of sensitivity for the touchpad. The experience wasn't as much verbalized, but people with whom we were evaluating either apologized for using touchpad or mentioned it, or, in a later cases, we asked explicitly if they use touchpad if we saw that they did have a visible struggle.

> "I feel like I am doing something wrong here (0:40). It's kind of confusing to me, like I can feel like I'm doing something wrong (1:19). I feel like I am missing something everytime I scroll down (1:36)" - Participant #4

> "For me it is easier, because I got this one (showing external mouse), but if I don't have my mouse that could be a little bit difficult to know what is happening, because I just... Okey, in this moment I'm not using my external mouse and I don't know what I am going to do, it's like... okey, I have click and I don't have (know)... what should I do (11:44)" - Participant #5

> "I'm sorry, but with the touchpad it is a bit bad (1:48) ...but I feel a bit lost, a little from how it moves because I also don't understand it (2:45)." - Participant #6

> "Is this supposed to be this fast or I am just doing something wrong? (1:20) Okey, I'll try with mouse even though I don't like mouse that much (2:09)" - Participant #10

> "Yeah, so I'm having difficulty navigating as this is going through quickly (1:46). So, on my computer I use kind of two fingers to scroll up and down, but I'm going very slow, but it's just moving incredibly quickly (2:01)." - Participant #12

It has to be said, this wasn't only because of the touchpad itself, for example in the case of participant #4 at 0:40, the quote happened at a time when a rapid movement from one area of the story to another one was happening in a quick succession of node revelations. While using touchpad caused quick revelation of multiple nodes, the fact that at one transition the whole screen had to move by at least 1 unit of its whole width to the left was as much as contributing factor to the overall initial experience of being lost and confused. This is also something we want to avoid with our interface - to create smoother transitions between changes of context as opposed to, for example links which change the whole page to something different, without us having a clear reference point to the previous one unless it exists in a different tab. The idea of tabs however fractionates our experience. Some users also expressed the need to return to the beginning or suggested a different way of browsing the story.

> "Oh, it was (would) be nice if you... (pressing left and right arrows in the expectation of revealing and hiding the nodes) (24:46). How can I do it now to start from the beginning? (29:40)" - Participant #2

> "If I click here (pointing on the first number of the counter), maybe (I) just want to go to the beginning... how can I do that? (1:07:57)" - Participant #5

> "...and maybe even some player for it would be... to reset or autoplay even (28:20)" - Participant #11

For 3 users the imbalanced mapping of scrolling to an interaction of revealing and hiding the nodes did affect the experience, but not as significantly as they either did choose to use the mouse willingly or became somewhat comfortable with the touchpad, other 2 people haven't expressed any problems and 1 was using the mouse all the time.

7.4.4. Dragging & Spatial Organization

When it comes to the interaction of dragging, was happened to be insightful observation was the perception with which users were reading our story. Only two participants (#6 and #9) did try to pan - drag the plane in the context of reading, basically immediately after the evaluation began. Here we have a table of majority of discovery times for panning - dragging of the whole plane, canvas:

Discovery Time	Recording Time	Activity	Participant
00:23	40:58	Writing	#5
00:57	20:07	Writing	#2
01:00	33:43	Writing	#4
01:10	01:10	Reading	#6
01:35	01:35	Reading	#9
01:45	17:21	Writing	#7
02:38	25:46	Writing	#10
04:50	23:50	Writing	#8
09:13	23:26	Writing	#11
22:11	22:11	Before Writing	#12

The table contains discovery time which counts from the beginning of either the activity of reading or writing and recording time which stands for the absolute time of the event within the recording of participant's session. The activity of reading starts in the time of the start of recording, while the activity of writing starts in the moment of the first generation of a new story. Only in one case of the participant #12, the panning was discovered just before the activity of writing began on the landing page of the tool.

It's important to express that this table is purely informative and it should not be confused with the usual task performance from usability

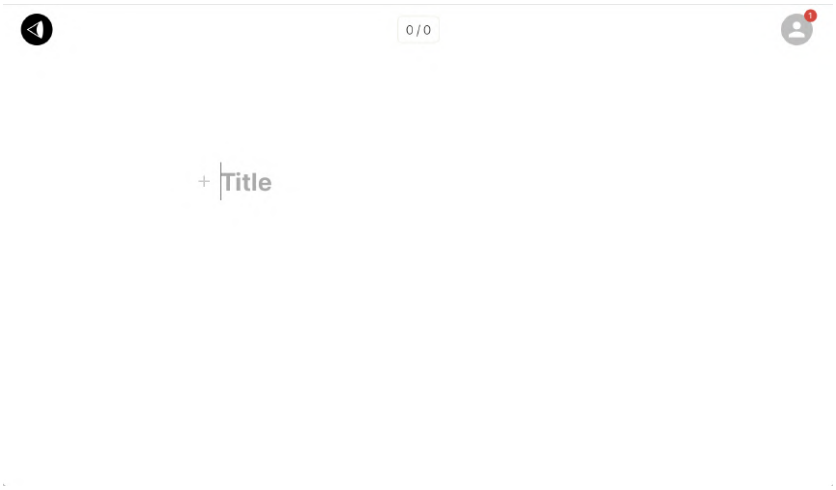


Figure 104: The interface which participant sees when the writing activity starts to be tracked

testing. In our case there was no task given to participants and they were given liberty in freely exploring the tool as they wished. We can see that in times of participants #8 or #11 who discovered panning only after they wrote a significant part of the story or they did think it through. The initial assumption was that participants are going to be dragging the plane freely in order to move across the space of the story. Many however, in order to return to the previous nodes used the functionality of progressive disclosure, scrolling all the way up and down in order to let transitions move the viewport to the focused content. One can assume that **many participants saw the story more as a presentation than a participative space** in which they can freely interact. We speculate that changing background to, for example, grid could create an impression of collaborative plane and encourage therefore users to use dragging. However, our priority is to maintain the minimalistic impression of a paper even if functionalities appear hidden in order to correctly contextualize our tool. We already hinted how some of the participants described initially a slight confusion when we were evaluating progressive disclosure. Our assumption that the quick pace of nodes that are being revealed in relation to the scrolling interaction is not the only one factor in the cause of such confusion or the sensation of being lost. Besides the content which might appear from the first sight as challenging to interpret, the parts which did go **against its main flow** or a **long-distance transitions** have been expressed and noticed as main reasons for the **disorientation and dissatisfaction**.

> "Oh, there is... interesting. Cause my mind's focus is here and this step I almost missed it. (8:56)" - Participant #2

> "I don't like when I need... I'm just simply used to, what in other cultures

> can be a different convention, to read from left to right, from top to bottom, so when there appears another layer somewhere else than more on the right and more on the bottom it is for me a bit chaotic to (find) where should I keep looking (10:05). I know that somewhere around the node #30 or so, was that there appeared some text from the left while it wasn't some sort of a new layer, but some addition to the information so there it came to me utterly interfering why it is appearing on the left (10:38)." - Participant #7

> "Hmm, I'm having... I wonder if it is because my scroll wheel is discrete... it has... Oh, I see. I think the, the camera movement here is a..., it jumped back so I guess it was disorienting (1:19)" - Participant #11

> "Uh... so did this... So I jumped up here and it's this? Maybe it should flash because it took me a second to realize that this was the salient slide (7:07)" - Participant #11

The idea of a flash or a different visual notification or indication have been noted as what could potentially inform the reader where the last node has been revelead.

7.4.5. Identity & Communication

To understand the interpretation & contextualization of our tool in the eyes of our users we collected information on the possible use of the tool and keywords they used to describe it. The list of following unique descriptions was collected:

- It makes you feel the concepts you are reading
- Feeling of freedom / Brainstorming in a free way / To express more
- Scattered mind
- Seeing the big picture / Seeing an overview
- Explain yourself better
- Data presentation
- Motion in text
- Guides through the concept
- This is what is in my mind
- Photostory / Filling the gaps
- Memory buildng technique

These descriptions or keywords were collected as the most unique ways in which people tried to describe the tool. They do give us better context and understanding of people's relation with the tool and the labellling they use for it. It also allows us to improve the way in which we communicate the artefact as a tool for storytelling, expressing, explaining, presenting & guiding.

When it comes to defining the identity through the actual use the answers were varied. We could identify only one group with 3 participants implying the activity of taking notes:

> "I would use it for reading, for studying, for taking notes of I don't know... what I need to do today or if I find it useful for one thing I would find probably another way to use it for another thing (20:01)." - Participant #10

> "I think you could very trivially add LaTeX to this and I think that would automatically... I think that would be super interesting to try some lecture notes in here (47:16)" - Participant #11

> "It feels like a place to sort of collect your thoughts (35:15)" - Participant #12

As we can see, even here we can find different shades of note-taking activity - taking lecture notes is not the same kind of activity as collecting one's thoughts. In this case it's important to mention one of the participant's vision of include the support of LaTeX into the tool which is also one of our future intentions. A different perspective on note-taking provided another participant which managed to emphasize the free form in which the text can be moved across the plane, suggesting that such an activity goes beyond the conscious action of taking a note and rather is located much more in the unconscious area of sensemaking;

> "I don't think that for like a... a person that is trying to write his notes it would be good because it would be distracting more than being a strictly as a... Like, note should be... note is for you to remember what you are to do and not to play around with the text and... that's a thing you can do so you can have that... 'Okey, I will go, I will try this time and I move it a bit' and you can unfocus what you should do, but I think for that it would be really good (38:13)" - Participant #8

Another use that was implied in 2 occassions was a sort of therapy - or in this context the already mentioned activity of sensemaking:

> "I do something with my patients, kids especially, that is drawing their life line. Not drawing, but... retelling their story and I think they would love that (22:08). I have this patient, she was adopted and she just hang up. She is 9 years old and she's an online patient that's why I am thinking about her right now (22:36)" - Participant #4

> "This could be helpful to... to describe what is happening inside my head cause sometimes I start to talk about for example love, then I realize I'm talking about love between the people, love like a feeling and what is wrong with the love. It's the same topic, but there are different ideas that in any point need to be concentrated in one point and I need to know where is that going to happen because you cannot make a huge tree, it's like a circular problem - you start here, they start to grow, to grow, to grow, but you need to close the idea in the main topic, not like a huge one... no, it's like to, try to close your ideas to main idea. That could be really helpful to have conclusions about something (31:07)." - Participant #5

While participant #4 describes a real case of a young patient drawing their life, participant #5 sees the tool as being useful in their activity of writing with the purpose of clearing up or organizing their mind.

Other unique uses mentioned were creation of artboards and mood-boards;

> "I have to say that I quickly imagine this... it's like in a... more of a... moodboard style. That you have like... you're doing a design project and the idea of how your creative mind goes from first idea to another or something that you have to do.... and you start here and you see the image and you... certain image leads you to another idea and probably becomes sketch or something and then you have another image that inspires you to... trying to figure out what you want to do and this is like a... huge board where I could draw the process (16:48)" - Participant #3

design, sketching and being expressive;

> "I would use it for whatever I have a feeling for writing down I could use this. Because it's... I like that you can click and pan and do everything. It would be great for me personally that if somebody is using it on tablet that you can also draw across it and sketch (46:37)" - Participant #10

creation of manuals recipes, guides or tutorials;

> "For example, I would know how to use it relatively simply for some recipe because evidently it pushes you into that it is linear and you always see what in given moment is enough for you and what was before, so yes, it can for example be... if you had some guides how to do something. You begin, you would have this in the beginning, here would be the second step... second step would be that you should get these things, third step that you already have them, do with them this, fourth step... So for example for some tutorials or user manuals (44:29)" - Participant #9

making a discourse (through publishing of or presenting a story);

> "I have been thinking all this time that this could be really useful to make a discourse I think (27:37)" - Participant #5

or to be used as a tool for comedians (to prepare material) and writers;

"I think, if I were a writer it would be very good as a way of a... getting... it's like... how do I say it. Text doesn't come sometimes like very... like machines use. Sometimes you are lost, you don't know what to write and writing things and moving them can sometimes make something in your mind that tells you that 'Oh, this should be this way'. For a writer, or a comic (comedian) for example in his writing is... I think it would be a really good tool, I guess (37:16)." - Participant #8

or even a tool for showing trips / slideshows. It's important to add that we did distinguish between the actual use of the tool of that particular person and a suggestion of who could use the tool. The latter being less relevant to us as it contains an assumption and doesn't reflect the needs of the person with whom we are evaluating.

7.4.6. Writing in Stories

There haven't been any particular problems with the activity of writing itself. With functionalities like adding a new line or adding of images, besides some technical issues in the beginning of our evaluation, there haven't been any particular, unexpected observations of their use. What we focused on was what people were writing and if there was a way to encourage them to write in a form of a story. Placeholder did manage to generate engagement:

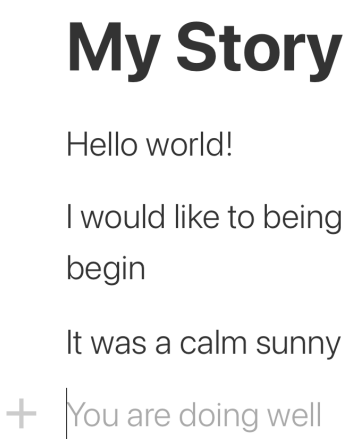


Figure 105: Placeholder / Prompt which was guiding the user through the experience of writing

"You're doing well, oh... (laughter). Thank you! I am just answering. I don't know if this was there before, but it was really cute (10:36)" - Participant #3

"Ooh, you're doing well. How lovely! (31:19)" - Participant #6

"Oh, 'You're doing well', thank you. Ahah, your friend does speak to me. 'You're doing well as well thank you' (writing). That's lovely, I love it. (23:36)" - Participant #10

Many participants chose to write something random like spontaneous poetry or nonsense which did not create any meaning at all. This was probably also due to the forced practice of writing in the context of our evaluation.

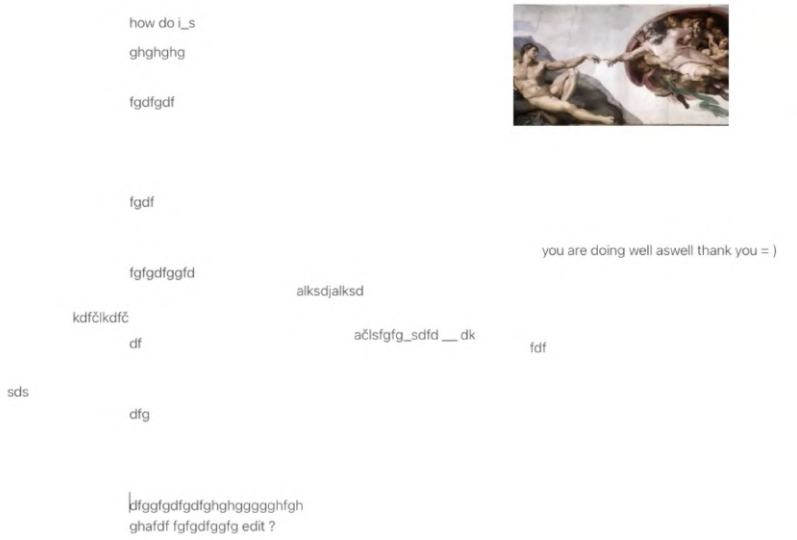


Figure 106: Random content being created during the evaluation process (Participant #10)

The participants who started to write something more concrete or specific **from their own genuine context of the practice** were in fact the ones which answered positively and extensively on the questions about their **familiarity with the activities of mind-mapping and storytelling**. We identified three of them: Participant #5 exploring the topic of their literary writing process (40:36),

participant #11 exploring writing about the topic of their own thesis (18:18),

and participant #12 exploring writing a PR presentation, a "business" story of their company (23:19).

7.4.7. Connections

The connections were purposefully left out from the prototype we evaluated and we identified at least 3 cases where participants started to speak about them or were missing them from their own initiative:

"Maybe connectors like dots could be good. For people like... You are presenting a lot of ideas and you don't know where this appears so if

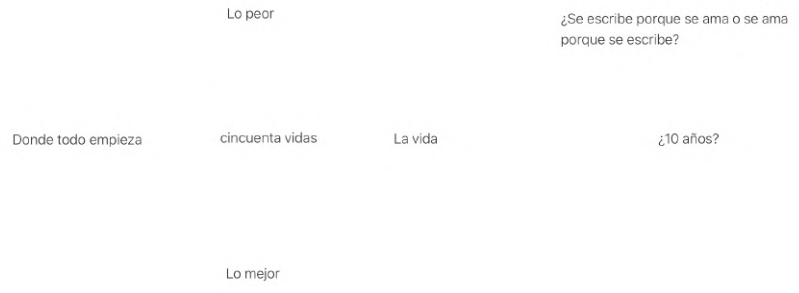


Figure 107: A process of sensemaking in the practice of literary writing (Participant #5)

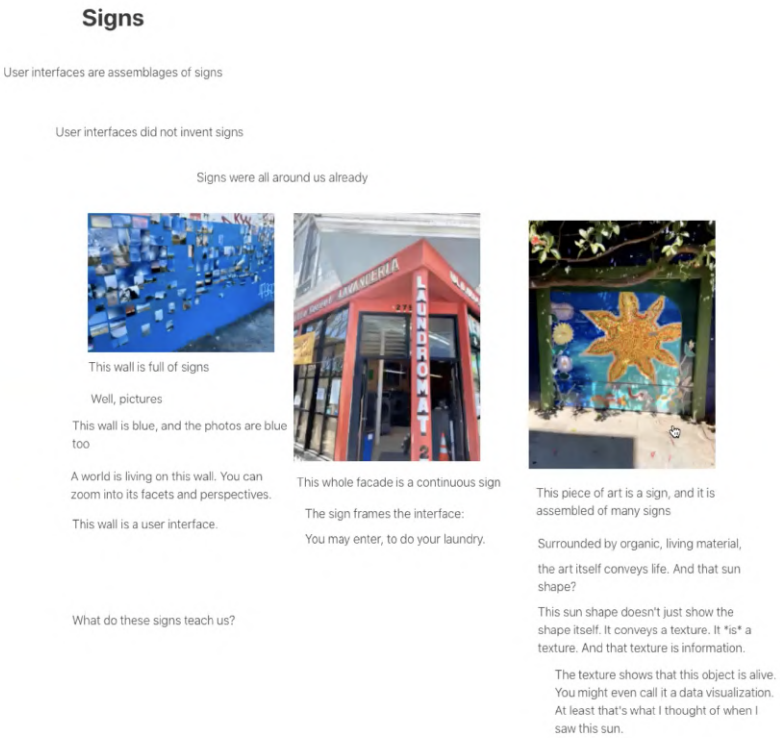


Figure 108: An activity of communicating a research topic (Participant #11)

Figure 109: An activity of presenting a company (Participant #12)

you (are) just lost inside your mind for a few seconds, you don't know where did you come from (1:04:18)." - Participant #5

"...in truth, if I can do something else with it. If I can add there some bond between the elements because right mouse button does not work, the middle on... (34:46) ...so this comes to me as a little unlucky because that bond cannot be somehow displayed, visualized there (43:54)." - Participant #9

"The one thing that I would like to see is the ability to draw connections, or arrows or some sort of... some shapes, just something else to be able to assist the spatial folks who don't see things just temporarily (35:19)" - Participant #12

Other 5 participants have been expressing themselves positively about the idea of connections when asked about their benefit. They often were associating the **benefit of lines with the facilitation of spatial orientation**:

"I believe that it's through these connections where you can find things about people and discover things about people and maybe help them and maybe understand how the human brain works or how that specific person works and... yea, I think yeah (09:29). Cause it kind of makes me see the big picture when I see lines. Like, I can see the thing go from one point to another (11:17)" - Participant #4

"...and you can draw a line like; This goes there and this goes there (47:56) ... it's showing you where you should read the next... because... it is like... what is the... It was also on the front page, like... There is an issue with the mind maps, because you don't know where to start that's why you

> have a connection, that's why you have an arrow to show you where to read. There's... Then if it's very clear what to read next, there is no issue if everything is on the same page. Literally, it's just leading... a leading line to where you should read (48:31)." - Participant #10

> "If it was very settle and very like... faded out I think in this case you want, you want the text to be primary. I can see like a little, looping bumblebee type lines where's like... (noise of a bumbleebee)... like kind of woven in and if you see it very subtle and... I think that would actually be very useful for cases like on your homepage where there are certain progressions like... here... here to here (showing a long-distance transition). I think there a line connecting them would be quite useful to have it... to direct your eye. It's like... here and it flies up here. Othwerwise I wasn't immediately sure of which piece of text is new (55:06)" - Participant #11

This has been a sufficient evidence for us that addition of lines, connections and the ability to create a structure are beneficial to the tool.

7.4.8. "Pre-nonlinear" Insertion

With "pre-nonlinear" insertion we were interested in how the functionality was perceived, nevertheless after a few sessions with participants it was clear that the concept wasn't being discovered and therefore we had to adapt our evaluation process. This appeared to be reasonably helpful as none of the participants were able to discover the functionality on their own.

7.4.8.1. A node in between

As part of our protocol, we did include a specific task of "placing a new node into the middle of the story" which we asked our participants to perform. An apparent ambiguity of formulation manifested when participants misunderstood the concept of "middle of the story" for spatial centre of the plane - trying to either move the whole story into the middle of the plane

or trying to write a new node in between of other nodes.

> "I would either just move this one down and create a new one or... move this one down and then just build on this guy (writing into the first node) (32:03)" - Participant #12

The task of "adding a node in between" wasn't easy to fulfill even after more explaining, clarifying and giving hints. It has to be objectively said, it was tricky to find a way to communicate the task without giving unnecessary clues for the participants. These ways, hints ranged from phrases such as "middle within the temporal presentation", "within the

Figure 110: Participant #9 moving whole story into the middle of the plane

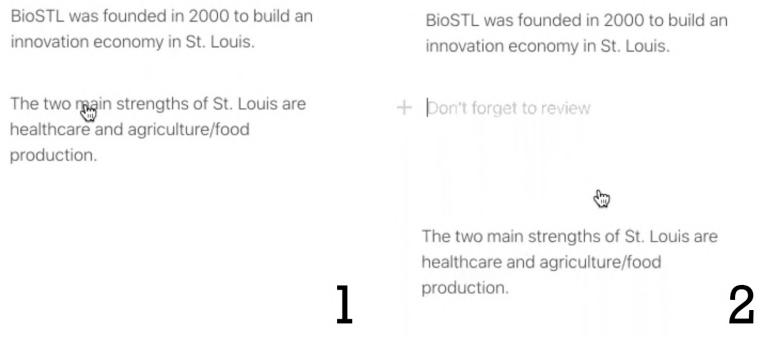


Figure 111: Participant #12 writing new node in between of other two nodes

order", "middle of the order", "try to change the number in the counter" to "while you are editing you are also reading (Participant #11, 39:23)". Similarly as in the case of tracking the discovery times for panning, we collected times for the discovery of "pre-nonlinear insertion"", that is, the ability to add a node in the middle of the order of existing nodes. The same way, this table serves only informative purposes and in no way it tracks the time of an action as we did not conduct a usability test. For example, in the case of participant #11 the total discovery time includes divergence in which the participant was showing debating a way on how to achieve it and showing me a different tool meanwhile.

DT	Total DT	RT	Context	Participant
00:04	06:48	32:42	After first hint	#11
00:06	01:02	20:29	After first clarification	#7
00:07	00:54	40:05	After first clarification	#9
00:51	02:05	31:54	After first clarification	#12
04:52	04:52	39:43	Couldn't find	#10
05:58	05:58	28:27	Couldn't find	#6
08:29	08:29	26:38	Couldn't find	#8
XX:XX	XX:XX	59:50	Couldn't find	#5

The table consists of discovery time (DT), which stands for the time between the last intervention, i.e. initially describing the problem / task, hint or clarification and the actual discovery of the functionality. The total discovery time (Total DT) stands for the time of discovery since the formulation of the problem, task. Recording time (RT) is the time of the recording when the event started. As we can see, nobody managed to discover the functionality on their own, neither they did manage to discover it after being explained the problem they had to resolve - the problem being putting a new node in the middle of the existing ones. The context of the discovery is explained in the table in the 4th column. We can see the distinction between clarifying the task / problem and giving a particular hint which we already did refer to. In the last cases participants weren't able to encounter the functionality on their own and needed to be guided step by step or shown explicitly. It has to be said that in the cases such as with participant #6 this performance could have been impacted by using a different language in which we conducted the evaluation interview and in the case of participant #5 by the already long duration of the session.

7.4.8.2. Ordering of nodes

What has also been noted during evaluating this particular functionality was **the necessity of the ordering of nodes within the whole story** which would allow switching and reorganizing the order of nodes without having to delete them and having to add new.

> "It makes sense to me that I arrive at the 2nd node and now if I add that plus I write the 3rd node because I have displayed only two, respectively it can be something... but it is somehow a bit... There is that disadvantage that during that the person does not see the other things, so the part of it is hiding for a moment, but still it comes to me that it doesn't give me that option to reorganize these things. That after I am like what? That I should delete that thing and come to the 3rd node and make it again? (40:55)" - Participant #9

> "It would be nice to have a... I think if you were to change... to be able to change the ordering it would be on this little thing (pointing to the counter), could be an okey spot. And then you could be like 'Oh...',... ahm. You could hover on each item in this list... it would have like a mapping.. It would be a list of all these things (pointing to nodes), it would be an inventory and then you could reorder it which is a simple reorder field and if you do run each of these it shows which it corresponds to (27:28)" - Participant #11

7.4.8.3. Conclusions

What have we learned when evaluating "pre-nonlinear insertion" has been the necessity of the showcase of the feature. The feature is very

simple and straighforward if being shown, yet difficult to understand when explained. Also we believe that the feature itself is not sufficient to organize the order of the nodes within the story. It is nice to have and could lead a way to creating nonlinear branches, but the need of **nodes reorganization in a whole story requires different affordances, but does not exlude coexistence with what we call "pre-nonlinear insertion"**. A different question for the future endeavour would be how to differentiate multilinear (nonlinear) branches from each other.

7.5. Summary

Before we jump into conclusions on which changes or improvements should we commit to in the next iteration of the development of our tool we look upon answers on the question concerning the features that participants were missing. The responses serve advisory and orientational purpose for us to better understand the demand of our users and potential early adopters in addition to already evaluated concepts and themes we identified during our interviews.

Participants	Feature
#2, #3, #5, #8, #10, #11	Formatting / Styling
#2, #10	Image resizing
#2, #12	Arrow keys for show / hide
#3, #11	Audio nodes
#6, #9	Connections
#9, #10	Templates
#1	Collaborative
#2	Selection of multiple nodes
#4	Accessibility (Bigger font)
#4	Sharing
#5	Video nodes
#5	Guides
#5	Reset / Restart
#5	Accessibility (Easy-eyes colour)
#7	Searching
#9	Drawing
#9	Linking of stories
#10	Zoom
#11	Pasting a picture
#11	Autoplay
#11	LaTeX support
#11	Speech bubbles

7.5.1. Fixes

The most common response happened to be the feature of formatting or customization which did stand for either typography or the ability to change colours of the font. Both of which we developed to allow more visual degrees of expression. We also recognized the essential need of resizing an image and relatively simple functionality of allowing arrow keys to serve the purpose of traversing through the story (revealing and hiding nodes the similar way as scrolling does) - that creates a viable alternative also for those who use touchpad. It was essential for us also to find a way to make the interaction of scrolling more sensitive and therefore prevent the rapid revelation / hiding of several nodes at once which can cause disorientation. Another feature we confidently committed to was the affordance of adding connections to the content which was not only mentioned as a demanded feature, but was actually searched for. Last but not least what we reflected on after the evaluation was the communication within the landing page. Our intention was to communicate the tool in greater clarity, design the story in more spatially coherent way and provide a more visible call to action and communication of benefits when using the tool.

7.4.2. In Progress

In this subsection we intend to just brielfly name those features (or whole directions) which for the reasons of time limitations we couldn't implement, but we consider significant in the development pathway of the tool.

7.4.2.1. Design Improvements

Sharing

When it comes to smaller design improvements, we recognize the importance of sharing which overall cultivates the process of growth and increases the likeliness of viral spread of the tool and its practice. A panel being shown in the end of the story could serve to redirect the reader to other stories, to create their own story or to eventually share the story they just read.

Guidance

For new users the hidden features and affordances of the interface could be overwhelming and we do recognize the need to offer a sort of a guide that would point out on these hidden features either in the first time encounter of the user with the interface or progressively depending on the interactions that would user do.

Transitions

An interesting way to resolve the fast, rapid movements to a node that is in the area further away from the currently focused one would be to change the time for the transition from fixed to dependent on the distance. In other words, the velocity of such transition would be the same, but the time in which we arrive from one node to another would depend on their distance. Similar way Google Earth transitions from one place on the map to the other where places further away from each other cause the transition to be longer.

Counter / Slider

We've been already pondering the potential of the counter to turn into much more than just the counter of the nodes. While being asked for the ability to reset and return the story to the beginning, slider could fulfill much more than just that. It could also allow user to selectively set the tool to be focused on particular node and therefore in chosen place of the story or slide of the presentation to use familiar terms. There is a potential add more tools to the slider as it already attracts the main editing menu. Different modes could allow to traverse through not only temporal dimension of the story, but for example semantic dimension - allowing modification in how much detailed we want our story to appear.

Pasting a picture

Living in the age of dragging and dropping, copying and pasting, it is only natural for the user to expect the pasting functionality to works. A simple Ctrl+V could allow adding of the picture which was copied directly to the plane. Allowing to read also dropping events when the user is dragging a file into the Semioskop interface could allow for richer interaction between local and web environments.

7.4.2.2. Pivotal Interventions

In this short paragraph, we would like to briefly mention those features which present a broader pivotal and implementational shift in the way the tool is conceived now.

LaTeX Support

Certainly implementing a support for LaTeX could be a very rewarding feature as there hardly is a bigger need for spatial writing than in the area of mathematics and STEM subjects. Yet when approaching the typesetting technology of LaTeX we found how tricky it is to implement. The render of the formula can take up to a few seconds and the editing or a way to edit it would present a more significant design challenge.

There is also question of the format. Should the formula be rendered as a picture? Or should it be rendered on each reload of the website? Another concern is how it would affect the identity of the tool. Could the tool for self-expression, sensemaking and mind mapping turn into a niche mathematical applet for a narrow group of people with technical focus?

Selection of multiple nodes

A notoriously known functionality in all vector graphics software allow us to select multiple objects on our screen. The similar way multiple nodes could be selected, moved around and formatted at once in Semioskop. The question is within the interaction of selection. We already mapped the interaction of holding a mouse and moving it around to the action of panning. There is probably no other way than to introduce a new mode which would allow to select. Which mode should be the default one? Would the Semioskop still preserve its minimalistic appeal and the badge of a tool for writing or would it start slowly changing into a sort of complex, professional designing or presentational software?

Collaborativity

To allow collaborative activity has been discussed and pondered on many times during this work. The level in which the collaborativity needs to be implemented would however present a new range of issues and problems which for the time being we did not want to go into. It would require the change in the way in which we modify our data model, a redis server for realtime messaging of the changes within the story and overall an intervention in the architecture in which we preserve and modify our data. It would also open new questions on the design's side of the tool like the need of users to organize permissions of who is able and unable to collaborate within the story, possible new panels for visual indications of which users are active within the story or collaborative space and the issues of territoriality which would need to be resolved. However, minimally speaking, there is a potential in following the pathway of Wikipedia, constructing a more open interface in which all stories can be edited by anyone and they do not have to updated necessarily in real time. Within such project the concept of legitimate peripheral participation could be put into the use allowing for example readers to participate on the creation of their own meaning within existing stories.

7.4.2.3. Open Features

Two aspects of the tool do remain completely open as we did try to reflect on them or implement their precursors and those are interlinking of stories and the aspect of nonlinearity. By "pre-nonlinear insertion" we materialized a vision in which writer could insert a new branch of content at the specific place of the story. Such branches could create another visual layer within the space of the story, being traversed through for example aforementioned slider which could have a mode for nonlinear branches. Within the topic of linking between the stories, one has to realize the ambiguous nature of the link. A link can be completely transclusionary, allowing existence of one origin, but display on multiple places. However link can exist also in a form of metadata within a copy, a sort of "transmissable origin gene" that remains within the groups of nodes as they are copied and changed and modified across variety of stories. And even if part of the story has not been copied or referenced to directly, it can still hold a similarity to another part. Should one be allowed to link such similarities? Should there be an AI in a form of feedback loop which would reinforce those linkages between content which are related?

Despite all proposed future improvements and changes, what is clear is that there still is a need for competence. More viable use cases could create an understanding of the vision and active environment of engaged writers and readers which activities could crystalize the pathway for the tool forward.

8. Conclusion

8.1. Achievement

When we started to write our work, our goal was to make the comprehension of knowledge and information more efficient by intervening in the format, way in which we write. We did explore and research the topics of writing from variety of perspectives and laid down an interdisciplinary description of the human activity and practice of reading / writing within the contexts of nonlinearity and storytelling. We utilized the methodology of research through design that allowed us not only to have an open mind towards new and novel radical approaches of seeing this problem, but also to actually describe it and therefore open new ways of its understanding.

8.1.1. Strong concepts

In this process we were free to critically explore new, different ideas and identify following strong concepts which we later developed and some of them (first 4) tested:

- Infinite Canvas / Spatial Writing
- Simultaneous Dragging & Editing
- Progressive Disclosure
- Non-linear Insertion
- Connections
- Dependent Node

With infinite canvas / spatial writing we intended to break ourselves from the constraining space of sheet paper format and progressive disclosure allowed us to maintain a sense of orientation (if used correctly) similarly as connections. We also opened up a pivotal possibility for the introduction of non-linear text in everyday practice of writing through concepts of non-linear insertion and dependent node. Moreover, we

demonstrated that our design model can be realized through the prototype we created which served as a proof of concept for spatial and non-linear writing.

8.1.2. Post-evaluation Insights

Within the process of evaluation we gathered following crucial insights:

- Common Use of Touchpad
- Presentational Space > Participative Space
- Node Placement & Spatial Orientation
- Familiarity with Mind Maps & Storytelling
- Necessity of Connections
- Non-linear Insertion
- Connections
- Nodes Ordering

Namingly the fact that we initially forgot to optimize our prototype for the use of touchpad and focused only on the mouse as a common peripheral device. This has been solved by decreasing the sensitivity of scrolling interaction and by introducing also other ways (such as arrow keys) to traverse through the story. Many participants wasn't aware of the dragging possibility and they assumed that they were seeing a presentation at first, rather than being within a participatory space. Even though we did not yield on this insight, it is important to note as it can provide us important assumption into our next design iteration. From our observations and data from our participants' sessions, we could induce that node placement affect their spatial orientation. Mainly, nodes which are consecutive, yet are far away cause the whole screen and its contents to change during the transition, breaking the sense of continuity. Other instance of such continuity break was the appearance of node in the opposite direction to the one in which the nodes have been appearing till then. Comparing the answers on the questions regarding the activity of storytelling and familiarity with mind maps and the engagement of participants we could infer to assume that good familiarity with both of the concepts did allow participants to be engaged more during the process of our prototype evaluation, mainly their quicker discovery of some of the features and the way in which they were able to identify and already utilize the tool. We confirmed the need of connections as visual cues for perceiving the structure of text and hinted the need of, besides having a possibility to insert node

non-linearly, to also ordering the nodes within the story as a whole. By introducing a new way of thinking about the digital medium we described and depicted possible ways to implement and pivot nonlinearity as a concept within it. In this way we illustrated a potential for a new perspective about the practice of writing within the essentially infinite multidimensional screen real estate of the cyberspace.

8.2. Open Aspects

There are a couple of open aspects within our work which we shouldn't ignore, one of them being the aspect of a real use case. This has been something which due to the time constraints we weren't been able to address as we would like to. Despite the fact that we provided a few examples depicting our proposed vision, the use of the tool and its identity has stayed very much in the process of its defining. This could also be an advantage as we did let participants in the process of evaluation define it on its own. The variety and ambiguity of its use we attribute to the fact that one can't yet see the use of a new medium without actually experiencing the creation within it at first. Another aspect that we would like to emphasize our concern about is the nonlinearity itself. Even though, we provided a stepping stone in order to break the visually orthogonal organization of the text and content, the progression in which the story is revealed still resembles many signs of being linear. We do argue however that the conditions in which non-linear or multilinear narratives emerge are at first linear. In other words if there is no perceived linearity to break, one cannot speak about non-linearity. In this way our intention was to provide an environment in which such break could occur and find a pathway to it. When seeing the challenge of non-linearity from the perspective of actual interaction, it has been shown in the user experience evaluation that the "non-linear insertion" as we designed and implemented it was for a significant part of people conceptually inacessible or unexpected at least. A different relation that has been observed was the one between ambiguity and non-linearity. The introduction to non-linear or multilinear relations between nodes requires what we call a certain level of "guided generative ambiguity" as the process of mapping such non-linear or dependent relations between nodes manually could be tedious. However, complete randomness is not desired neither. Here we would also like to mention the unrealized, yet shimmering idea of colour tokens or colour currency which could lock and unlock nodes in the process of exploration. Even though it could increase a level of complexity in the process of writing, in the end it could serve a greater purpose in allowing existence of fully non-linear stories in which branches and pathways are only possible to explore after others are.

Other open aspects would include some of the desired functionalities such as formatting of the text, introduction of social media content, audiovisual content, LaTeX and search. Last, but not least, we would like to point out the potential that still lies in the searching for the niche. Even though we managed to describe the sociotechnical transition of writing in various contexts which can greatly help in the process of market evaluation, we haven't had reached the specificity in which we wanted to describe the niches that could benefit from our application. This is certainly related also to the lack of published use cases. Within the leverage of the potential that the tool has we speculate the possible benefits which other technologies such as artificial intelligence could bring once a user feedback loop is clearly distinctive and reinforced. In particular we ponder the idea in which the canvas or the plane wouldn't have to exist only within the context of a specific web application such as the one we designed, but could be extrapolated to the whole application of a web browser. Creating a new protocol or possibly utilizing open graph meta tags, one could access different websites in the form of simple, small and compact cards. These cards could be then loaded on the plane, each representing different link, connecting various platforms, news sites, quotes from social media and preserving the context of browsing within one plane, within one window.

8.3. Lessons Learned

Apart from being a rewarding learning experience this was an exercise of the Zimmerman methodology of research through design which thanks to the practical experience with it we are not only able to have a material understanding of, but also we are able to localize it within the scope of other methodologies which we briefly mentioned and described in the chapter on methodology. Within this exercise we were able to follow a method for our research through design process and reflect on it through the specific Zimmerman's criteria:

8.3.1. Process

We choose the methodology research through design because of the lack of the clear definition of the problem that we intended to resolve. Within this process we intended to acquire better understanding of the reasons why, even when we have the technology, devices, screens, we still write in an orthogonal and linear format. We were gathering understanding in the process of research through design in which we were sketching, collecting, designing and building ideas, features and a prototype with an objective of resolving this unclear problem and with a target of providing a contribution to its description and understanding. The closer look on the process which we followed was

described in the scheme in chapter on methodology and this we tried to follow, entering the iterative process of design, building and reflecting with a description of the context of the problem we try to resolve, its localization within the broader scope of practices and technological transitions and with a certain set of beliefs, assumptions which define our vision. In the end of the process we subjected our prototype to the evaluation in which we tried to gather more knowledge on how users perceive our artefact, how they interact with it, what kind of experience they have with it, but most of all where do they situate it in their own regular practices.

8.3.2. Invention

When addressing the invention within the process of the method we followed, we state that we tried to include great variety of perspectives from multiple disciplines ranging from cognitive sciences, human-computer interaction, activity theory, psychology to literary science, transition design and interaction design. We hoped to provide very unique, new perspective on the problem, yet with extensive mapping to existing scientific and field knowledge.

8.3.3. Relevance

Assessing relevance, we define our objective as changing the form in which we write with the goal of making communication more efficient.To narrow down our problem we focus on making the communication of extensive or complex topics more efficient. For this we try to bring into the practice of writing concepts of nonlinearity and spatiality. The vision is to enhance human capability of knowledge awareness through extending both the perception of current discoursive and information space and through improving the ability to communicate and participate in a human discourse.

8.3.4. Extensibility

The artefact we created we properly described through its design as well as implementation process. This creates an opportunity for the design to be replicated. Moreover, we discussed ideas that have not been a part of the final design, yet once in the future could be and we suggested and assumed what the best possible route of continuity for this artefact could be. The ability to extend what we are creating was also a primary goal in the development and implementation phase in which we tried to follow the most common and promising technologies when it comes to medium to long term technological progress, choosing the environment of world wide web, frameworks of React and Next.js and the language of Javascript. The way in which we implemented our

code followed conventions and practices in order to provide as much stable and easily extensible tool as possible.

8.3.5. Relationships between Design & Technology

This is also reflected in the way we viewed the relationship between the design and technology. In this particular case, having our background primarily as a software engineering, one could probably sense a technological influence on some of the design choices we made. Nevertheless, we believe that there are trade-offs between technology and design which make sense and it's not always reasonable to follow a design vision if it complicates its technological development and materialization. In this way we believe in certain technological pathways which allows us to prototype fast, even though, we might need to deny some of the more courageous ideas. This way a prototype can be developed in a form of a pivot which can then, if being successful, can influence the technology itself.

8.3.6. Personal Reflection

Last, but not least we would like to reflect on how the work affected us personally and how we assess our work. Personally it has been mostly a struggle to accept imperfection, to accept temporary states of the progress of the work as legitimate working (boundary) objects which could be collaborated upon. In this moment, we could understand better which steps and methods are necessary for an efficient research writing, without losing ourselves with every topic in the new process of exploration and writing. We could also state that there are chapters or sections which we haven't evaluated properly in terms of their scope and that took some of our time unnecessarily. There are also parts which could be explained upon in broader way. Nevertheless, there have been plenty of new theoretical knowledge we managed to acquire through this process and most of all the material knowledge of the design practice which we exercised that stays.

9. Annex

9.1. Initial Activity Plan

No.	Date	Month	Category	Activity
1	2021-02-15	February	Artifact Design	Design and implementation of a minimal interface that allows to write text fragments, play them (present) and move the canvas. Completing last parts of the state of the art research.
2	2021-02-22	February	Content Creation	Identification of topics for writing. Creation of the first graphs for the *Tools for Thought* community and their engagement. Identification of metrics.
3	2021-03-01	March	Artifact Design	Addressal of issues encountered in the previous engagement. Implementation of "Write your own" hook. Creation of generative positioning artifact. Design of collaborative / participative user flow.
4	2021-03-08	March	Content Creation	Content creation based on the previous engagement. Possible engagement with #scicomm community. Potential topics: personal story, others' stories, cheatsheets, research in visual essays, chinese characters composition.
5	2021-03-15	March	Artifact Design	Copy & paste a.k.a prune-and-graft functionality. Design and implementation of recommendation / autocomplete interface - for both writing and reading. Design and implementation of hyperlink artifact (pages being create upon browsing).
6	2021-03-22	March	Data Acquisition	Analysis of the data from interactions obtained till now. Formulation of insights and strategy.
7	2021-03-29	March	Artifact Design	Introduction of media - design and implementation of media upload interface. Implementation of collaborative / participative user flow. Design and implementation of *.html export.
8	2021-04-05	April	Data Acquisition	Analysis of the data from interactions obtained till now. Formulation of insights and possible strategy.
9	2021-04-12	April	Artifact Design	Response on user's experience. Iterative changes. Possible integration of explored features.
10	2021-04-19	April	Artifact Integration	Integration of explored artifacts' and features. Possible proposal for usability testing.
11	2021-04-26	April	Usability Testing	Conduct of user survey with the intention of specifying possible themes for improvement of the tool.
12	2021-05-02	May	Transition Framework	Proposal for transitional roadmap for the artifact(s) and their possible implementation with particular areas of practice - practical research
13	2021-05-09	May	Transition Framework	Proposal for transitional roadmap for the artifact(s) and their possible implementation with particular areas of practice - communication
14	2021-05-16	May	Dissertation Writing	Summarization of results. Writing of practical part of the thesis.

9.2. Sheet for pattern / theme identification

ID	Age	Profession / Field	Mind Maps (Do you use mind maps?)	Have you ever found yourself repeating the same story over and over?	What kind of story it was?	Can you find yourself explaining a professional topic in a form of a story?
#1	26	Student (Design & Multimedia)	- not really	- doesn't remember such occurence		- not really
#2	36	Professor (Design & Multimedia)	- concepts, sketches (paper) - or big projects (software) + organization - difficult to navigate	- hmm, yes - lack of enthusiasm	- startup presentations	- yes, startup presentations, on conferences
#3	28	Researcher / Teaching Assistant (Design & Multimedia)	- in the form of artboards	- yes, with variation it gets better	- personal	- completely, better format to engage with audience
#4	24	Psychologist	- yes, htp test, mapping traumas, questions (of patients)	- somewhat, yes	- personal	
#5	27	Forest Engineer	- yes, resumes, explanations - context is essential	- yes, more or less	- professional (forest use) - personal	- yes - why is important to take care over water
#6	24	Student (Community Management)	- nope	- yes, more or less - retell to myself to remember better	- personal stories	- nope
#7	27	Medical Researcher	- brainstorming (for myself) - bullet points - social / political topics - reverse search is tedious	- yes	- personal	- TEDx Talk
#8	23	Student (Design & Multimedia)	- in the class, online, collaboratively	- exhausting - prefers to write it	- in class probably	
#9	27	Consultant / Embedded Development	- draws circuits, creates documentations, uses UML - understood that mind map is a tool for communication + shows relations - loss of universality - everyone interprets the map in their own way	- yes	- as a way to communicate concepts	- sure, for commucation with clients - I want to make it simple and understandable
#10	29	Architect	- never used mind maps	- yes and it's alright for me	- to family, friends - they forget things - if I feel good	- I can, but I am not a good speaker
#11	21	Research Program Manager (Bc. in Cognitive Sciences)	- first school assignments - design activity + freeform, associations - too abstract, layout is difficult	- no? yes? yes.	- meeting a hiker in Colorado	- pitch for a project
#12	34	Business Development	- using for collecting thoughts, personally, on paper (however, paper is not as accessible) + seeing the outcome (having overview) - doesn't know	- yes, on social gathering, or an anecdote, stories which impact us - it is annoying in business context, but in such personal contact is needed (5-6 times per week)	- startup that I want to bring to St. Louis - 75% of the story is the same, - 25% is personalized	- yes, startup that I want to bring to St. Louis

Use (How would you use this tool?)	Features	Discovered Keywods	Interaction with touchpad	Connections	Text Orientation	Placeholder
- showing trips, slideshows	- collaborative	It makes feel concepts you are reading	- changed for a mouse	- yes, to find a way back - structure comforts		
- freeform way of organizing	- styling - image resizing - arrows for < > - multiple selection	Feeling of Freedom Brainstorming in a free way To express more	- haven't had a problem			
- art boards / mood boards (infinite canvas) + progression	- customization - audio insert - font size change	Scattered Mind	- tricky, but handled			- cute
- patient writing their story (therapy)	- bigger font - sharing (whatsapp, instagram)	Big Picture, Seeing Overview	- fear of missing something = scroll to fast - feels like she is doing something wrong	- lines give structure, comfort	- slightly confusing	
- to make discourse = to express opinion about the idea - to read a novel (organization of characters) - to write (therapy) = to describe what is happening in my head	- colors - videos - guide lines (guides) - go to beginning - eyes-easy color - customization	Explain Yourself Better	- if I don't have my external mouse, I wouldn't know what to do	- implied existence		
- personal stories	- connections		- it was difficult - was constantly revealing / hiding more than wanted - accustomed to scroll = down	- could help organize, yes	- expressed sensation of being lost	- que mono
- data presentation - preserves context	- ctrl + f	Data Presentation	- was using, but handled well - with a bit of challenge when dragging - clicks to select and only then expects to drag	- didn't mention - but wants to search back - wants branching	- where to look? - it is confusing	
- for writers, comedians - moving things you write can ignite new thoughts	- customization, formatting	"Motion in Text"	- got comfortable with the mouse	- didn't actually use in mind maps		
- manuals, recipes, guides, tutorials	- connections, templates, drawing - linking of stories	Guide through the concept	- used mouse all the time	- was immediately searching for them - gives context		
- reading, storyteling, making notes - writing what I feel like, drawing, sketching - this is what is in my mind	- zoom in / out infinitely - change colours - resize image - more professional layouts / templates	This is what is in my mind	- was very fast with the touchpad, then moved to mouse, even though she didn't like that	- showing you where to read		- loved it!
- lecture notes, writing a fictional story	- formatting - pasting a picture - fixed width (?) - autoplay - LaTeX support - speech bubbles, dialogue - audio: field narration / ambient	Photostory / Filling the gaps	- haven't had a problem	- settle background lines instead of strong connections - to direct one's eye, to show direction - to show which text is new	- wanted a flash, so he can see which node was revealed as a last - took him a moment	
- collect your thoughts, memorization tool	- down arrow for playing	Memory building technique	- in moments too fast / in moments too slow, experienced some difficulty	- missing connections, yes - they could assist in spatial orientation - could lead to flashcards		

Storytelling	Indicator	Metanarrative	Writing while playing	Mind map - showing all at once	Ordering	Action call	Zoom	Story Linking
		- didn't realize that landing page was an example of what you can actually create						
- more about expression, skills, not about a tool	- it is already at 2 when I start							
- puts a pressure								
			- confused 'middle' for spatial organization					
- didn't know what to write								
- didn't know what to write but found out								
			- thought that spatial organization determines the order					
			- thought that spatial organization determines the order	- doesn't like that can't see everything	- wanted to order all of the nodes at once	- weak		- linking
			- thought that spatial organization determines the order	- doesn't identify showing all at once as a problem	- not very practical to order stuff when when having too many nodes		- I wish to zoom!	
			- thought that spatial organization determines the order - however recognized the benefit of putting emphasis on / returning to parts that he already wrote		- how do I change order - wanted to order all of the nodes at once			- seeing two pages/ stories at once
- started to write his business pitch immediately			- discovered fairly easily					

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