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Relational reasoning: an educational experiment promoting digital diagrammatic thinking

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Abstract: This paper reports on an educational experiment promoting relational reasoning as a form of argumentation with graduate students of ICT in learning. Relational reasoning includes working with mind maps, concept maps, use case diagrams, decision trees, flow diagrams, dialogue maps, situational maps and more. More broadly we can say that relational reasoning consists firstly of using nodes and arcs to represent and overview interrelated meanings as visual networks and secondly allowing the interaction with these networks to generate new dynamic perspectives on the content. The educational experiment consisted of four dedicated lessons introducing different diagramming techniques to students of ICT in learning and supporting them in using these techniques as part of their reasoning and analysis in relation to their semester project. A core example tool was ArcForm that is a general-purpose relational reasoning notation and has been explored as a notational foundation for e-learning systems (Allsopp 2013, 2015).

Keywords: Relational reasoning, design/teaching intervention, ArcForm

1. Introduction

This paper explores an educational experiment with graduate students of ICT in learning. We aimed to promote relational reasoning, a form of digital diagrammatic thinking using network graph representations comprising nodes and arcs. The program was based on a belief that learning relational reasoning can help students to better analyse complex situation, interpret data and improve the clarity of their arguments and analysis.

Suthers (2001) distinguishes between; 1) *artefacts*, which are the individual representations, 2) *notations*, which are the rules and conventions for a specific type of representation and 3) *tools*, which are the interactive environments that help us to draw and explore a representation. We will refer to the use of both notations and tools as *techniques*. Relational reasoning notations can be further characterised by whether they are cross-domain or domain specific. Cross-domain notations include mind maps (Buzan 1974), concept maps (Novak & Cañas, 2008), dialogue maps (Conklin, 2006) and argument maps (Beardsley 1950). Domain specific notations in for example software design include Universal Modelling Language (UML) (Jacobson, Booch & Rumbaugh, 1998) notations like use case diagrams and class diagrams. Many tools have been developed for relational reasoning notations. These include XMind, MindJet, and iMindMap (for mind maps), CMap (for concept mapping), Compendium (for dialogue mapping), Argumentative, Truthmapping.com and Rationale (for argument mapping), and StarUML and UModel by Altova (for UML). While the above mentioned cross-domain notations and their associated tools can be used to explore a breadth of subject matters they are still purpose-specific in that they support a specific process; mind maps support brainstorming or note taking, dialogue maps support facilitation of synchronous discussions and so on. There are also general-purpose graph drawing/layout tools such as Gephi (Bastian, Heymann & Jacomy, 2009) and yEd (Bremer 2007). These can be used for any of the above notations, and for ad hoc notations created for special situations. A technique that we focus on in this paper, ArcForm, can be considered both a cross-domain and a multipurpose notation (Allsopp, 2013).

Aalborg University's internal fond for educational innovations endorsed a program titled "Relational Reasoning" to introduce graduate students of ICT in learning to the above techniques. Our approach was to create a course comprising several lessons where the students are trained in notations and their tools. This paper explores the introduction of relational reasoning techniques in a toolbox course format to university students. In order to do that we have conducted a design intervention promoting relational reasoning

techniques and explored an envisioned learning trajectory related to motivation for learning the techniques. We use observation from the intervention to further develop this learning trajectory.

1.1 Envisioned learning trajectory

Our hope was that learning the above mentioned techniques could help students to better analyse complex situation in their projects, interpret their data and improve the clarity of their arguments thus supporting their semester projects. Our research approach is based on design-based research as it has been described in educational research (DBR collective 2003, Ejersbo et al 2008). In the following section we will articulate our theoretical foundation that has informed our intervention and its envisioned learning trajectory.

One of the characteristics of university teaching is that those being taught are usually adults. According to Illeris (2012), adult learning can best be understood by the way it is different from childhood learning; while childhood education often takes place with a high degree of trust to the adult's responsible for the child's learning, adult learning is on the contrary characterized by a higher degree of autonomy and aligned with the needs experienced by the learner (Illeris 2012, 574). Illeris (2012) suggests that adult learning can be described by three concerns or characteristics; 1) meaning as necessary; adults learn what they want to learn and what they think is meaningful for them to learn, 2) responsibility as sparse; adults only take the responsibility of their learning that they are interested in taking, and 3) resources as important; in their learning, adults draw on the resources available for them (Illeris 2012, 575). Seemingly, the circumstances for learning in university settings are quite good, since the adults are enrolled in a program they have chosen themselves, however, a number of factors make it difficult to exploit these seemingly fertile surroundings. Illeris writes (2012) that we cannot necessarily assume that the students' choice of enrolling in an university program is completely free, and that it is highly likely that the students are faced with learning content (for example an obligatory module) which they have not specifically chosen (Ibid., 578). Other circumstances in our intervention also potentially challenged the students' level of motivation; the course was conducted at a time in the semester were the students had already begun their semester projects. Would students be interested in learning new techniques at a time when pressured by deadlines? How could we organize the program in a way that would support their needs?

Our envisioned learning trajectory was that students would be motivated by the cross-domain power of the techniques and the immediate application of the techniques to their own work. The emphasis was therefore to argue for the broad cross-domain applicability of the techniques using examples from different domains to illustrate aspects of the notations. We also assumed that it would be motivating for the students if we organized the program in a way that would allow them to experiment with the tools by applying them on their own projects. Hands-on exercises were therefore an essential element of every lesson. We investigate this envisioned learning trajectory by drawing on video observations of students' work and discussions, observational notes and qualitative student evaluations. Our analysis and discussion especially concentrates on the level and cause of motivation experienced by the students attending the program.

2. The Program

The program, Relational Reasoning, was conducted as a part of a pedagogical initiative at Aalborg University seeking to incorporate ICT in Problem Based Learning (PBL). We held the program as a voluntary and extracurricular course comprising four lessons of two hours that provided training for graduate students in ICT and Learning at Aalborg University. Each lesson introduced the students to one or more related notations and relevant digital tools for working with the notation. These lessons covered respectively maps for situational analysis, mind maps and concept maps, dialogue and argument maps, and ArcForm. Each lesson comprised introduction lectures, exercises where the students got the opportunity to gain hands on experience with the notation and time for the students to experiment with applying the tools on their own PBL projects. Students started with hand drawn maps, but in cases where these notations were supported by digital tools, the students also received instruction in, and time to use, these. Each lesson had three facilitators (including the lecturers) supporting between six and 12 students who formed groups of two to four. This gave the students ample access to the supervisors during the exercises and project work. Each lesson ended with a class discussion evaluating the notation and tools, and the lesson as a whole. In the following we will describe each of the lessons, paying special attention to the last lesson where ArcForm was introduced to the students.

Situational Analysis. In the first lesson we introduced Adele Clark's (2005) Situational Analysis (SA) and specifically focused on the various kinds of maps in Situational Analysis and their potential in respect to processing and visualizing qualitative data. Clark describes SA as a theoretical/methodological approach that provides the researcher with a number of principles to follow in order to visualize and organize empirical data on its own terms. We introduced the three types of maps in SA, namely situational maps, relational maps and social world/arena maps (Clarke 2005). All maps were introduced with examples from the one facilitators Masters thesis, but relational maps are those considered most obviously a relational reasoning tool, because it includes arcs between the identified actors. We did not use digital tools specifically designed for relational maps, but encouraged the students to use general-purpose graph drawing tools.

Mind mapping and concept mapping. In this lesson we introduced Tony Busan's ideas behind mind mapping, as well as historical precursors to mind maps. We showed and explored a number of mind map examples where some were hand drawn and some were drawn using a digital tool. We asked students to hand draw a mind map relevant to their project and discussed differences between mind maps and concept maps. We described various different mind mapping tools (xMind, MindJet and iMindMap), a concept mapping tool (CMap) and a tool that is not strictly speaking for mind maps or concept maps, but resembles both (TheBrain). The features of xMind were described in greater detail and all of the student groups used this to create maps relevant to their project.

Dialogue maps and argument maps. We introduced dialogue maps, as Conklin (2006) does, as an approach to wicked problems (Rittel & Webber, 1973) and social complexity. However we quickly gave the students a taste of dialogue mapping in practice by conducting a mini workshop using the Compendium dialogue mapping tool. The facilitator asked the initial question "What should we vote today?" which was understood by all the students as referring to that day's (December 3, 2015) Danish national election about adopting EU rules on cross-border policing. The facilitator added students' replies as ideas, questions, pros and cons icons pointing to the original question or any other icon already added. Figure 1 shows the resulting dialogue map including the input form one student that suggested that our initial question "What should we vote?" should be considered a question in response to answering yes to a more basic question: "Should we vote?"
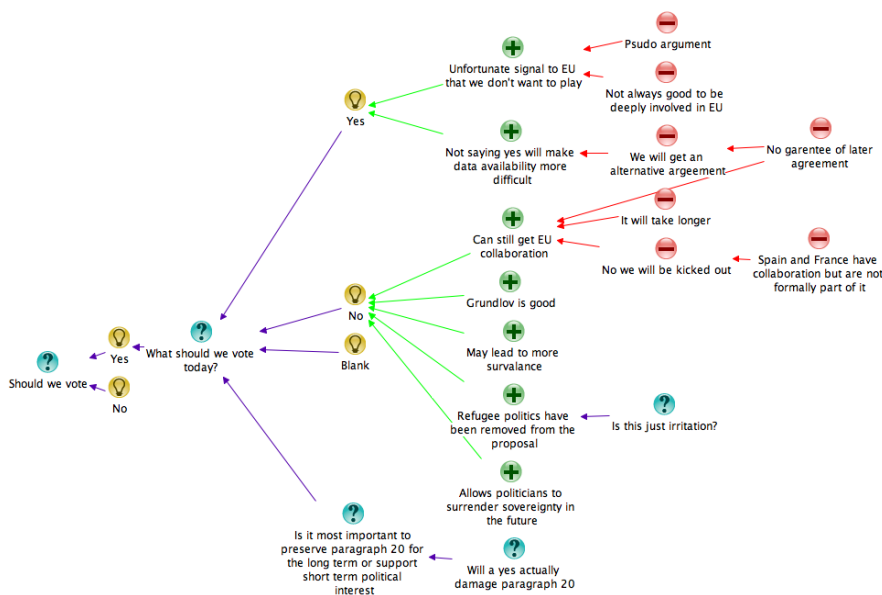

Figure 1. A dialogue map created collaboratively in class using Compendium.

After using and discussing the students experience in the dialogue mapping workshop we briefly introduced argument mapping (Beardsley 1950) and provided example maps created using the interactive tool at Truthmapping.com. Here we worked backwards from a conclusion to sub conclusions in a tree structure all the way to the constituent assumptions. After this student groups choose between creating a dialogue map or an argument map relevant for their own project.

In the final lesson we wanted to show relational reasoning from a more general-purpose perspective where specific notations are created on an ad hoc basis to show specific types of relationships. This is not easy to teach and requires students to be inventive. We thought we could pull them in the right direction by introducing them to a new notation which combines an extension of general principles of graph based representation with an approach to labelling arcs and nodes allowing diverse natural language sentences to be read from the network.

2.1 Introducing ArcForm

ArcForm has been described in Allsopp (2013 and 2015). Allsopp (2013) includes a chapter describing observations of individuals using the notation, but no published research describes it being introduced to a class. In the lesson students received a formal description of ArcForm as a nonlinear, visual form of simple English to support improved collaborative thinking. They were immediately shown an example of an ArcForm map as shown in Figure 1 and heard as a number of sentences were read from the map. Figure 1 is a modification of a map shown in Allsopp (2015) updated to reflect changes in the way that object descriptions are shown.
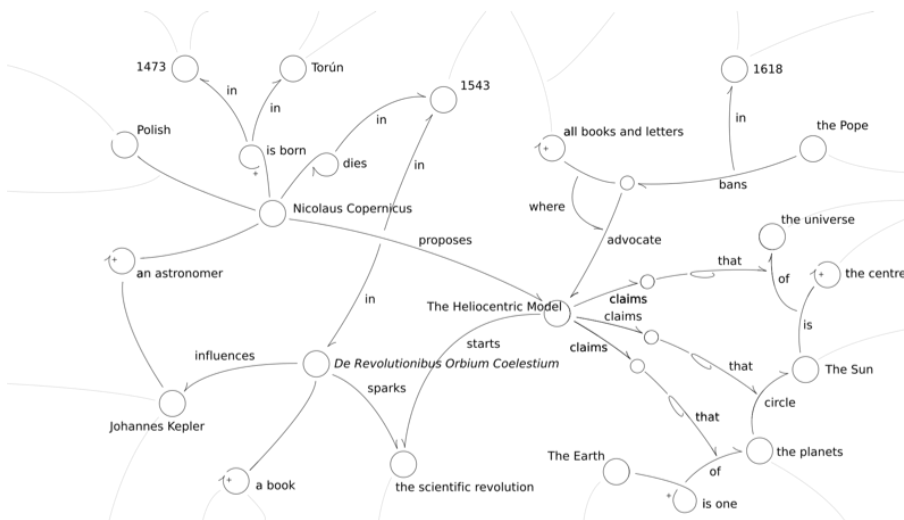

Figure 2. An ArcForm map presented in class.

The students received an introduction to the different types of tokens used in ArcForm maps: the node, the label, the join arc, the semi arc and the arc rolled up to resemble a node or semi arc. They were shown how arcs could recursively point from or to other arcs and how grammatically normal sentences are explicitly captured in the structure as described at http://arcform.org. The students were shown how objects are represented by nodes and can have labels (possibly more than one label) with proper nouns, object descriptions or properties. Simple sentences were shown with join arcs or semi arcs and labelled respectively with transitive verbs and intransitive verbs. Arcs labelled with prepositions, adverbs, or subordinating conjunctions were shown pointing from simple sentence arcs to create more complex sentences. The students were also shown how complex object descriptions could also be represented as arcs connecting nodes or other arcs.

The students were introduced to the concept of unitokenality (Allsopp 2013), where every meaning can be represented by a single token without duplication. In ArcForm we point arcs from or to that single token whenever we want to use that meaning in other meanings. ArcForm is not currently supported by a user friendly digital tool, but we showed how equating a token in one map with a token in another map will make it possible to merge maps. And because ArcForm expressions can be stored in a simple data scheme we will be able to integrate massive amounts of information into a single dynamically drawn network of meaning crossing subject boundaries. We explained how filtering and laying out that network will support the dynamic and ad hoc creation of new perspectives on existing knowledge.

One of the facilitators described a research project (Tamborg, Misfeldt and Fougt, 2015) where a teacher training program was evaluated. The researchers identified many diverging expectations between different actors and the different *logics* (Nielsen 2012) that influenced their thinking. At first these relationships were mapped using relational maps as described above, before they were mapped in an ArcForm map. The students were asked to compare the two maps. Finally the students were given step by step instructions in translating English sentences to ArcForm, before they were asked to capture aspects of their own work in ArcForm.

3. Findings

The authors used three approaches to evaluating the program's usefulness for the students. 1) We collected students' own comments on the notations. We were three facilitators in each lesson and therefore able to take notes as students voiced their thoughts. Unsolicited comments were of particular interest, but the facilitators repeatedly asked the students to share their thoughts on different aspects of the techniques. The students were asked questions like: How they could use the techniques in their own project? If, and how did they think they would add value? And what, if anything did they find challenging? Perhaps due to the small class size the students were very active in giving feedback. 2) We also observed as the students used the notations to map aspects of their PBL project that they were working on. This involved the facilitators moving between groups of students, answering questions when necessary, but otherwise taking notes on technique specific issues being discussed. 3) Finally, when the students submitted their semester project reports, we registered their use of the techniques in the projects. Although this approach added a quantitative aspect to our data collection, it has not played a central part in assessing the program. Some reports included one or more diagrams from the program, but the number of students participating was not considered sufficient to support confident claims about their perceived value. Furthermore the program took place near the end of the project period, and possibly too late for the students to take full advantage of the techniques.

Our findings from student's comments and our observations of students using the notations are diverse, but grouped according to whether they pertain to the special purpose notations or whether they pertain to ArcForm. The finding from the former can be summarized briefly. The participating students considered the lessons relevant. They articulated how they saw the individual techniques being useful. Their explanations reflected what had been explained in the introduction, but were sufficiently rephrased to suggest some independent understanding. They could use the techniques to explore their own projects. This was seen in every lesson as groups of students quickly began to map issues. There were many discussions about how to express ideas in the notations or use the relevant software, but there were equally many discussions suggesting that the actual ideas in their project were being considered deeply or even getting revised in the mapping process.

Overall the students showed a high level of engagement in terms of engaging actively in classroom discussions and frequently asking questions to the teachers. Closing comments were all predominantly positive. Here students emphasized generic benefits like "being able to visualize thoughts", "getting an overview of something complex" and "saving time". Also the digital aspect "getting hands on experience with digital tools" was emphasized.

3.1 Learning ArcForm

Unlike the special purpose notations, ArcForm was not immediately understood by the students. This was inferred from the students asking a higher number of clarification questions during the earlier part of the presentation. There were questions relating to the versatility of the arcs. Arcs in ArcForm are not unspecified

as in mind maps or in relational maps, nor are they restricted to a single type as in dialogue maps and argument maps. It is unclear if these questions were also precipitated by ArcForm's more complex structure with arcs pointing from or to other arcs. There were also questions relating to the nodes. Nodes in ArcForm are more restricted in their meanings than ideas in mind maps, but much less than nodes in dialogue maps that always represent whole sentences and nodes in relational maps that represent actors. There were questions relating to the dual nature of ArcForm as a diagramming form vs. an information integration scheme. The data integration aspect of ArcForm is not seen in the other notations and several students seemed unsure of what this involved.

Despite some confusion about how to use ArcForm, most students expressed appreciation for its potential use as a diagramming tool. This was particularly evident when they compared how a complex situation was presented both in ArcForm and as a relational map. There were several comments suggesting an appreciation for being able to use "ordinary language" in a visual map.

Understanding an ArcForm map and seeing how the notation could be useful, is important, but we also wanted to see if students could express (statements) in ArcForm. Here students experienced two types of difficulties. Initially there were many students who got stuck expressing simple sentences in ArcForm. The most common mistake here was to draw an arc from a node, when it should have been drawn from another arc. This challenge with drawing ArcForm was identified by Allsopp (2013), who recommended explicitly stating that the meaning of an arc is not identified by its label, but by the concatenation of its label with the labels of its source and destination. Thus instead of a specific arc labelled "owns" representing a concept like ownership, it represents for example 'Nike owns Converse'. With the later interpretation it is easier to see this arc as the source of a new arc labelled "from" and representing 'Nike owns Converse from 2003'. After this way of thinking about arcs was clarified, most groups of student groups were able to correctly draw quite long sentences involving several arcs pointing from or to other arcs.

Another type of difficulty came later when students attempted to capture complicated object descriptions like "the first owner of Converse" not as a single label, but as arcs and nodes. Although the students were helped and the rules for doing this were repeated, the students were only in a few situations able to apply the rules to new descriptions. The students seemed frustrated one student expressed that he felt "there is smoke coming out of my ears". Only one student was able to add complex object descriptions to their ArcForm sentences.

Although there was some difficulty using ArcForm, this was not considered insurmountable by the students. One student offered that the difficulty level of learning ArcForm was equivalent to the difficulty of understanding Actor Network Theory. Another student asked how much more there was to the language and was told of the minor details that were left out. To this he answered: "If this is all the grammar we need to learn, it should be doable. It requires a bit of practice, but there are no long descriptions of each element and that helps."

4. Discussion

An obvious question to reflect on is: how valued was the program? On the one hand the students responded overwhelming positive to all of the lessons, but it was an extra curricular program and we assume that those that attended were already interested to some degree. Because we have evidence that some students experienced that the techniques are helpful we therefore plan to continue the program as another DBR iteration. In this new iteration we will adjust the timing of the program so as to better inform their choices in their PBL projects. It is also interesting to consider that learning new techniques is probably best done well in advance of impending deadlines.

Regardless of the timing, our emphasis on hands on use of the notations in class was highly appreciated and will be continued in a future iteration. A change to content rather the timing of the program would however result from a potentially revised envisioned learning trajectory. In the following section we discuss how some findings specifically relating to ArcForm can inform such a revision.

4.1 Revising the envisioned learning trajectory and improving ArcForm introductions

The findings suggest that the students consider ArcForm to be a challenging notation to learn as exemplified in the "smoke coming out his ears" comment. Yet, the students' engagement in learning ArcForm is characterized by persistence, effort and the willingness to overcome the challenges they are confronted by. As mentioned earlier, our envisioned learning trajectory was informed by literature suggesting that adults learn what they want to learn and what is meaningful for them to learn. We believed that the cross-domain applicability of a notation would be motivating for the students. However, as a student's comment below illustrates, it was not the demonstration of cross-domain applicability that he experienced as motivating, but rather the insight he experienced in a single use case representing a single domain:

> "(...)it's pure magic in reducing complexity as in the examples with the logics. The three contradictory logics which were at stake could occur in many collaborations. There are these conflicts of interest, which you can point to and say; well, this is where the dog is buried, so to speak. And when you master it I think it is easy to translate something that is complex. It enables you to look at it from the outside and then go inside and pull something relevant out."

In the comment the student mentions an example with three logics. In the lesson in which we taught ArcForm we introduced a use case that demonstrated how we had used the notation in our own research. We demonstrated how we applied ArcForm in order to explore and illuminate the multiple expectations arising for a group of teachers in a teacher training program. The use case showed the students how ArcForm worked as a way for us to visualize a network consisting of many actors and complex relations in a way that increased overview and transparency. In overcoming the difficulties associated with learning ArcForm, the student points to the value of a single use case that we jointly explored in the lesson. The student refers to the use case with excitement and as the crucial eye-opener that for him demonstrated that ArcForm is a notation that potentially can help to unravel complex situations.

Our initial envisioned learning trajectory was that the students would be motivated by the cross-domain power of the techniques and the immediate application of the techniques to their own work. Though our empirical evidence is scarce, this student's statement challenges the structure of our initial envisioned learning trajectory that the cross-domain applicability of a notation would be the main factor that motivates students to learn it. This student's statement tells us that it was using ArcForm to explore a specific domain that encouraged him to learn the notation. In a university pedagogical contexts this suggests that perhaps it is more relevant to illustrate *how* tools are useful and not *that* they are useful. The excerpt demonstrates that the student's engagement and motivation for learning ArcForm, in spite of the experienced difficulties, was closely connected to the fact that he experienced it as meaningful. The revision of the learning trajectory, however, should not neglect the direct use case related to the students' semester projects as a motivation for taking on the responsibility of learning ArcForm. We are suggesting a shift of focus from the direct instrumental reasons in terms of the broad usefulness related to learning ArcForm towards spending more time exploring a specific use case. This balance relates to the three aspects of motivation in adult learning, namely that meaning is necessary, that responsibility is sparse, and that resources are important (Illeris 2012). It does so by highlighting that in this case, experienced meaning is not the same as usefulness and that we need to provide rich use cases as resources for the students experienced meaning in order to build motivation.

The revision of the learning trajectory that we develop here is of course first and foremost relevant to ArcForm, since this is the notation under examination. However, the balance between broad usefulness and understanding a specific use case is a general concern that can be used in the revision of the relational reasoning workshops in the future.

5. Conclusion

Our results indicate that some time must be spent focusing on a specific domain rather than fleetingly showing many examples from different domains. Exploring the opportunities that arise out of one use case can provide the necessary motivation to learn the more difficult notations. This revises our envisioned learning trajectory to connect student motivation in learning relational reasoning techniques to experienced meaning with concrete (domain specific) examples. It remains to be seen in future iterations if and how students benefit

from learning the various techniques. Will they use them in their semester projects and can they help them to better analyse complex situations, interpret data and improve the clarity of their arguments?

References

Allsopp, B. B. (2013). *Introducing Arc Form: Designing a satisfactory highly non-linear alternative to texts for general-purpose idea development.* PhD dissertation. Kbh: Aarhus Universitet, Institut for Uddannelse og Pædagogik.

Allsopp, B.B. (2015). ArcForm as a Notational Foundation for e-Learning Systems. *Proceedings of the 14th European Conference on e-Learning*: *University of Hertfordshire Hatfield, UK*. red. / Amanda Jefferies; Marija Cubric. Vol. 1 1. udg. Reading : Academic Conferences Limited, 2015. s. 9-17 (Proceedings of the European Conference on e-Learning).

Bastian M., Heymann S., Jacomy M. (2009). Gephi: an open source software for exploring and manipulating networks. *Proceedings from The International AAAI Conference on Weblogs and Social Media.*

Beardsley, Monroe C. (1950). *Practical logic.* New York: Prentice-Hall.

Bremer, Lars (June 25, 2007). Nimm's leicht. *c't Magazin* (in German), no. 14/2007, pp. 89–90

Buzan, T. (1974). *Use your head*. London: BBC Books.

Clarke, A. E. (2005). *Situational analysis: Grounded theory after the postmodern turn*. Thousand Oaks, Calif: Sage Publications.

Ejersbo, L. R., Engelhardt, R., Frølunde, L., Hanghøj, T., Magnussen, R., & Misfeldt, M. (2008). Balancing product design and theoretical insights. In A. E. Kelly Lesh, Richard A., Baek, John Y., (Ed.), *Handbook of design research methods in education : innovations in science, technology, engineering, and mathematics learning and teaching.* New York; London: Routledge.

Illeris, K. (2012). *49 tekster om læring.* Frederiksberg: Samfundslitteratur.

Jacobson, I., Booch, G., & Rumbaugh, J. (1998). *The unified software development process.* Reading, Mass: Addison-Wesley.

Conklin, E. J. (2006). *Dialogue mapping: Building shared understanding of wicked problems.* Chichester, England: Wiley.

Nielsen, L. T. (2012): *Teamsamarbejdets Dynamiske Stabilitet. En Kulturhistorisk Analyse Af Læreres Læring i Team.* Ph.d.-afhandling, Aarhus: Aarhus Universitet

Novak, J.D, Cañas, J. (2008). The Theory Underlying Concept Maps and How to Construct Them. *Technical Report IHMC CmapTools* 2006-01 Rev 2008-01.

Suthers, Dan. (2001). Towards a Systematic Study of Representational Guidance for Collaborative Learning Discourse. *Journal of Universal Computer Science*, 7 (3), 254-277.

Rittel, H. W. J., & Webber, M. M. (1973). *Dilemmas in a general theory of planning.* Berkeley: Institute of Urban and Regional Development, University of California.

Tamborg, A.L, Misfeldt, M., Fougt, S. S. (2015). Local Supervisors and Action Learning. Paper presented at Emerging Researchers Conference, Budapest, Hungary.

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