Detective work: Supporting engineering students' learning when reading scientific texts

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ABSTRACT

Keywords – active learning, reading, research based teaching.

When students begin their master studies, one skill that needs to be enhanced, is their ability to read, understand and explain scientific texts within their chosen field of study. The lecturers have the challenge of speeding up this process because it is the foundation of most learning at master level. The aim of this study was to develop a method to make scientific reading a problem solving and explaining activity to fit the learning styles of the typical engineering students. In our method, detective work, questions concerning a specific scientific article are formulated by the lecturer beforehand. We suggest that the questions are characterized by not require an overview of the text beforehand, and either relating to student's prior knowledge or being explanatory. In the session where the questions are answered, we suggest using teamwork and competition to motivate students. In the spring 2015, biomedical engineering master students completed a detective work sessions about big data in health. The results showed that students engaged actively in the detective work sessions. Student feedback suggested that student leaning was a mixture of deep leaning and surface learning, and consequently they had to engage in further learning activities after the session. Exam results showed that 80% of students received maximum points for the written exam question related to big data in health, the percentage of students receiving maximum points in the rest of the exam questions ranged from 20% to 90% with an average of 56%.

I INTRODUCTION

When studying to achieve a master's degree, it becomes imperative for students to be able to read, understand and explain scientific texts within their chosen field of study. Understanding the scientific methods, as well as their possible applications and limitations is a fundamental academic skill, which may support students' critical reflection whether they will later pursue a career in industry or in academia. However, we experience that our engineering students read scientific articles, as if they were text books and focus on recall rather than understanding and reflection. In addition, they tend to only read scientific articles when it is absolutely necessary and demanded from the lecturer. Consequently, we have developed a method with the aim to support engineering students in understanding scientific articles. We developed our method taking into account the reading practice of experts, well-known strategies for learning from text, and student's preferences for problem solving activities. We refer to our method as Detective work, and we explain the background in the following paragraph, and the actual method in section II and III.

Scientific texts and how they are read

Developing methods for improving student's abilities to read scientific text require a basic understanding of what a scientific text is, how it is written and how experts read scientific texts compared to novices.

Geisler gives a thorough introduction into these aspects (Geisler 2013). She explains that the scientific article has often been viewed as an autonomous text i.e. a text written with a specific intention, which is expected to be understood similarly by all readers. However, research has shown that scientific articles are rhetorical constructs where the writer wants you to follow his or her line of argument. When reading, faculty members will tend to resist the line of argument, engage in finding contextual details, assess claims and pay attention to methodological details that they from experience know will affect the result. In contrast students will tend to try to follow the line of argument and end up agreeing with the authors (Geisler 2013). One aim of our method was to help students use a reading strategies of experts rather than novices.

Students learning strategies when reading scientific texts

Supporting students in comprehension rather than recall is important because we want to support learning strategies associated with deep leaning rather than surface learning (Marton, Säljö 1976). A comprehensive review of learning techniques, not specifically related to higher education, have shown that different strategies exists such as elaborative interrogation, self-explanation, summarization, keyword mnemonic and practise testing. Overall findings suggest that students who possess abilities such as elaborative interrogation and self-explanation generally perform better than students with other simple learning strategies such as summarization and keyword mnemonic, but they also show that students with strategies that relate theory to practise performs better than all the simple methods (Dunlosky et al. 2013). Findings are consistent with Aalborg University's PBL strategy where the principle of relating theory to practice is a corner stone. In our experience, the motivation for reading a scientific article (whether it is in a course or is related to projects work) is that the knowledge you gain from one text can be incorporated with the students a priori knowledge, so that they understand the overall problem or solution in a new way or even better than they did, before they read the text. However, a new study shows that student's arguments are only rarely based on more than one text (Linderholm et al. 2014), and from our current practice we recognize students' problems of forming an argument based on more than one text. In particular, this is a problem for new master students that moves from primarily reading textbooks to primarily reading scientific articles because they have to learn to navigate within a set of scientific perspectives from different authors that might be aligned or contradicting, rather than being presented with a textbook and presume that it is presenting the truth. Consequently, we had to keep in mind that even though our aim was to teach students to read and understand one academic text better, we also wanted them to be able to put the text into the context of what they knew beforehand, and what they had been reading before, **-** they had to understand and relate.

Learning preferences of engineering students

Engineering students often have a learning preference for active learning rather than reflective learning (Felder, Silverman 1988), and it is well-known from our teaching practise that reading scientific texts or listening to lecturers about research does not come natural to most of our students. Consequently, we aimed at developing a method to make scientific reading a problem solving activity to fit the learning style of most of the engineering students. In the following section, we explain how we applied the above mentioned principles to design the detective work method.

II GENERAL METHOD: DETECTIVE WORK TO SUPPORT COMPREHENSION OF SCIENTIFIC ARTICLES

In detective work, questions concerning a specific scientific text are formulated by the lecturer. The questions are characterized by not requiring an overview of the text beforehand because they should support a non-sequential reading activity, and not having understanding as a prerequisite. This is where the term "detective work" originated i.e. the students are asked to collect separate pieces of evidence by answering the questions, and after having collected all the evidence, they may see the full picture. In the following we explain how our detective works are designed to take into account the reading practice of experts, well-known strategies for learning from text, and student's preferences for problem solving activities.

Reading practice of experts

In our detective work, we specifically tell the students not to read the text before the lecture because we want to prevent that they read sequentially, and understand the content of the article as a given truth. We use questions to support a non-sequential reading activity and to direct the students to methodological details.

Application of known learning strategies

The questions are characterized by either relating to student's prior knowledge or being explanatory. Questions that relate to prior knowledge support students in comprehending one scientific text in the context of other scientific texts. Explanatory questions are aimed at supporting students in self-explaining while reading. In addition, discussing the answers with the students in a small group, with the rest of the class and with the lecturer further support the approach of "learning by explaining".

Problem solving

When reading a text, the aim is that students add the new reading to their existing knowledge. In its core, this is not problem solving even though the extra knowledge might help them in solving problems later on in the course or as a part of project work. However, the different activities in the detective work incorporate elements of problem solving, team work and competition to motivate students to work actively with the scientific article. The activities of detective work is:

1. Written and oral introduction to the assignment
2. Groups of 2-3 students are formed
3. Each group choose one question from a common detective work question sheet – groups cannot choose the same question
4. Groups answer questions and send a few slides to the lecturer to document the answer
5. Each group choose a new question from the question sheet. Point 3-5 are repeated until all questions are answered, or time runs out
6. The groups present their answers to the whole class, receive feedback from the lecturer, and get access to the whole set of slides afterwards.

The written introduction, which is instructive and detailed in explanation style, and includes the whole set of detective work questions, supports the idea of having a task that the students have to solve together, and that the students, who work fastest will get the opportunity of choosing questions first. In the following section, we explain a specific design of detective work for a course in "Methods and Models for Clinical Information Systems"

III SPECIFIC METHOD: DETECTIVE WORK USED IN A MEDICAL INFORMATICS COURSE

We have developed a detective work session for the course, Method and Models Clinical information systems, which is placed as an elective course in the second semester of Aalborg University's master programme in Biomedical Engineering and Informatics. The detective work sessions were designed and used initially in the spring semester 2014, and based on these experiences two detective work sessions, one about big data and one about NoSql databases have been updated, carried out and evaluated in the spring semester 2015. This section take its point of departure in the detective work session about big data, because this session is mostly balanced towards students comprehending the content of one scientific article, whereas the NoSQL session is placed at a subsequent time in the course, and consequently, focuses more on relating the scientific article to knowledge achieved by the students earlier in the course. Whereas both is within the aim of the detective work, the first is more illustrative for people outside the field of clinical information systems research because it does not presume very much a priori knowledge.

Type of questions

The detective work example is based on a scientific article where big data for health care applications is introduced (Jensen et al. 2012), and we have included the whole detective work description in the appendix. The set of questions include nine questions. Three of these questions (3,4,5) are concerned with explaining figures in the scientific article. When students explain figures to each other, they start comprehending some of the basic ideas of the article. Other questions (1,7,8,9) follow up on this direction by letting the students explain different aspects of the paper, and answer "what" and "how" questions. In addition, two of these questions (1, 3) that focus on explanations, are also relating the scientific article to students' a priori knowledge, and one question (5) asks about a professional opinion. These add-ons to some of the questions are designed to support reflection on the relation to the rest of the course. The last two questions (2,6) are asking "why", and they are directing the students towards considering some of the methodological challenges of big data in health.

Simplicity as a guiding principle

Many of the questions have page numbers or figure numbers attached because we did not want the students to focus on "locating the right place", and we could not presume that they had an overview of the text because they were instructed not to read it beforehand. Often, when lecturers design questions they are defined as quiz or exam questions, meant to evaluate the intended learning outcomes. In contrast, these detective work questions are designed to be simple, and most answers can be found by the students directly in the text. We aimed to design a process that allowed the students to learn from the text, and that required simplicity and close-to-the-text questions.

IV EVALUATION OF DETECTIVE WORK USED IN MEDICAL INFORMATICS

When doing the detective work, we observed that students became engaged in discussing the article in small groups, and they were able to complete the detective work questions. Only one question was not answered due to lack of time. However, explaining close-to-text questions seemed easier than explaining questions that related to prior knowledge and "why" questions. The slides produced by the students (1-2 per question) had a lot of text on them, and were more directed towards remembering the content of the scientific article, than presenting the content for others. At the presentation, feedback was given by the lecturer to correct mistakes, supplement with details, and direct the students toward the answer of the question that was not answered.

At the time where we evaluated the course "Method and Models Clinical information systems", student feedback suggested, that the students were concerned with the fact that they had gained knowledge concerning the set of questions that they worked with during the detective work session in small groups, but the knowledge concerning the questions that the other students worked with and presented, they learned much more superficial. In addition, they did not know how to prepare for their exam because they did not know the depth of knowledge, which they were expected to have learned i.e. they experienced a mix of surface and deep learning. Consequently, some students would prefer the classic approach where the whole text presented by a lecturer to support them in sense-making. In addition, some students expressed insecurity about the session where the answers to the questions was presented. They did not like to present material, which they were not one hundred percent sure of was correct. Exam results showed that 80% of students received maximum points for the written exam question related to big data in health, which was the topic of the detective work. The percentage of students receiving maximum points in the rest of the exam questions ranged from 20% to 90% with an average of 56%.

V DISCUSSION

When we used the detective work method in our medical informatics course, the students worked actively in small groups with a scientific article, and the detective work questions helped them extract core points from that article, and to present the points to the class. Student feedback was mixed, but exam scores were satisfactory.

Some students seemed to prefer the method that they were used to with lectures followed by quiz/group work. In classic lectures, a well-planned line of argument is presented by the lecturer, which sometimes make the content look easier than it actually is, and tends not to take into account too many contradictions. After lectures, students may feel that they have obtained a nice overview, and know the depth of knowledge, that they are expected to live up to at the exam. However, the students are put into a passive position in this process, and are most likely not to be engaged in explaining the content, or in reflecting critically on the line of argument of the lecture. In this study, we were actually pleased that the students experienced mixture of surface and deep learning. Now, we just need the students to perceive these experiences into something positive. In the future, we will make sure that students are instructed on how to reach a consistent deep learning level, by doing additional work after class e.g. an e-learning follow-up approach with a wiki-page where each question can be answered by the students to support the formation of a learning community. Building a learning community by using online tools, has earlier been suggested as a blended learning approach (Bell 2014). This approach would also solve the timing issue, because no more than one lecture can be spent on big data in health, and many of the other presented topics. We do not plan on making modifications based on the students' reported insecurity related to presenting new material. Striving for perfection in presentation will take up too much time compared to the learning outcome. We further believe that an imperfect presentation is a good additional skill to learn. For example, knowledge sharing activities may benefit from staff that can work with a text efficiently, and present what they have learned without overspending the allocated time resources.

We have suggested the detective work as a method to support students when reading scientific papers, both to help them comprehend the content of the scientific article, but also to illustrate a method that can be used when reading other scientific articles. Learning about and getting experience with the science of a profession have been the focus of previous studies, and they range from classic lecture based approaches where students are taught to read and write science (Marušic, Marušic 2003), to e-learning approaches that seek to harmonize how science can be taught (Kulier et al. 2008). However, these are dedicated courses, whereas higher educations have the goal of research based teaching as a part of all education and courses. To make research based teaching more than a vision, we have to enhance the science literacy among students. Science literacy is one of the focus areas of the detective work method, and it has also been subject to earlier research (Levine 2001). Whereas Levine's approach differs from ours in that students home work are centred around getting an overview of the text and answering one dedicated question, both methods have elements of group work and contextual reflection, and succeed in making students work actively with a given text. One limitation of our study is that we have not been able to measure whether we improved the general science literacy through our method, because we did not evaluate whether the detective work made the students read other scientific articles within the field of medical informatics differently. However, the instructive nature of the detective work might be counter-effective in the respect of re-using the approach when reading other texts with because questions are dedicated to this one study. More general questions or tasks where the students have to formulate questions as well as answers might help improve the general science literacy among students, but may be too complex to be feasible.

VI CONCLUSIONS

In this study, we designed a method to support students when reading scientific papers that build on the principles of:

1. Non-sequential reading to use the reading practise of experts
2. Learning by explaining and contextualizing
3. Enhance motivation by using elements of problem solving, team work and competition

We applied the principles in a detective work session about big data in health, and evaluated it by observing the students work, listen to students feedback, and through the written exam. The students' feedback was mixed, but engagement in coursework and exam results suggested that the detective work supported students in reading a scientific article, and comprehending its content. Reflections on whether students use the detective work as a guide to how other scientific articles can be read and comprehended, have not been evaluated as part of this study.

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VIII REFERENCES

Bell, A., (2014), *Teaching insights - 9 flipped classes*. Available: http://www.itl.usyd.edu.au/programs/teaching_insights/pdf/insight9_flipped_classrooms.pdf.

Dunlosky, J., Rawson, K.A., Marsh, E.J., Nathan, M.J. and Willingham, D.T., (2013) *Improving students' learning with effective learning techniques promising directions from cognitive and educational psychology.* Psychological Science in the Public Interest, 14(1), pp. 4-58.

Felder, R.M. and Silverman, L.K., (1988) *Learning and teaching styles in engineering education.* Engineering education, 78(7), pp. 674-681.

GEISLER, C., 2013. *Academic literacy and the nature of expertise: Reading, writing, and knowing in academic philosophy.* Routledge.

Jensen, P.B., Jensen, L.J. and Brunak, S., (2012) *Mining electronic health records: towards better research applications and clinical care.* Nature Reviews Genetics, 13(6), pp. 395-405.

Kulier, R., Hadley, J., Weinbrenner, S., Meyerrose, B., Decsi, T., Horvath, A.R., Nagy, E., Emparanza, J.I., Coppus, S.F., Arvanitis, T.N., Burls, A., Cabello, J.B., Kaczor, M., Zanrei, G., Pierer, K., Stawiarz, K., Kunz, R., Mol, B.W. and Khan, K.S., (2008) *Harmonising evidence-based medicine teaching: a study of the outcomes of e-learning in five European countries.* BMC medical education, 8, pp. 27-6920-8-27.

Levine, E., (2001) *Reading your way to scientific literacy.* Journal of College Science Teaching, 31(2), pp. 122.

Linderholm, T., Therriault, D.J. and Kwon, H., (2014) *Multiple science text processing: Building comprehension skills for college student readers.* Reading Psychology, 35(4), pp. 332-356.

Marton, F. and Säljö, R., (1976) *On Qualitative Differences in Learning: I—Outcome and process*.* British journal of educational psychology, 46(1), pp. 4-11.

Marušic, A. and Marušic, M., (2003) *Teaching students how to read and write science: a mandatory course on scientific research and communication in medicine.* Academic Medicine, 78(12), pp. 1235-1239.

IX APPENDIX: DETECTIVE WORK RELATED TO BIG DATA FOR HEALTH CARE APPLICATIONS

Mining electronic health records: towards better research applications and clinical care. Peter B. Jensen, Lars J. Jensen and Søren Brunak.

In your groups, choose one of the questions marked with (I) and answer it. Document your answer as one or two power point slides and send it to kirse@hst.aau.dk, name the presentation with the number of the question (3-5). All groups should answer different questions.
When you are done choose a question of type (II), document it in a similar manner, name it (1,2,6-9) and send it.
When all questions are answered, a power point presentation will be assembled -- hopefully covering all the important aspects of today's text ;-)
Finally, the groups will present the slides they have created in the following order:

1. What are the potentials of data mining in health care? (General answer and at least one clinical example of your own making) (II)
2. Why does use of administrative data introduce biases? And why are administrative data sources utilized for research purposes anyway?(II)
3. Explain figure 1 in your own words. How is the figure simplified compared to the actual heterogeneity of Electronic health record content? (I)
4. What characterises clinical text? Clinical text is a challenge in a mining perspective. NLP and standardised terminology might be a solution, explain how (include an explanation of BOX 1). (I)
5. Explain figure 2. In your professional opinion, which way of analysing EHR-data holds the greatest promise? (I)
6. Why should you be aware of transitive relationships when exploring correlations?(II)
7. What is a cohort study? And how can mining approaches assist these studies?(II)
8. What are the potentials and challenges of linking EHR data and genetic data?(II)
9. Name and explain the limiting factors. See p. 402-403 (II)

X BIOGRAPHICAL INFORMATION

Kirstine Rosenbeck Gøeg just received her PhD-degree, and she is now employed as a scientific assistant at the Department of Health science and Technology, Aalborg University, Denmark. Her main area of research is terminologies and information models in clinical information systems. Among other teaching related tasks, she introduces students to the methodologies applied in medical research and clinical information system research.

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