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Critical Thinking, Peer-Writing, and the Importance of Feedback

Åsa Cajander, Mats Daniels, and Anne-Kathrin Peters
Uppsala University
Uppsala, Sweden

Roger McDermott
Robert Gordon University
Aberdeen, Scotland, UK

Abstract—Critical thinking is one of the key competencies listed by OECD (Organisation for Economic Co-operation and Development) [1], a central European Community organization, and is also mentioned as a learning outcome for higher education by international organizations, such as ABET, ACM, and IEEE, as well as in numerous national and university legislations regarding higher education degrees. The ability to communicate, not least in writing, is another important competence our students are supposed to gain during their education. There is thus high agreement regarding the importance of these competencies, but it is not clear how to achieve this.

Keywords— *critical thinking; peer-writing; feedback; collaboration; writing; competencies*

I. INTRODUCTION

Critical thinking is one of the key competencies listed by OECD (Organisation for Economic Co-operation and Development) [1], a central European Community organization, and is also mentioned as a learning outcome for higher education by international organizations, such as ABET, ACM, and IEEE, as well as in numerous national and university legislations regarding higher education degrees. The ability to communicate, not least in writing, is another important competence our students are supposed to gain during their education. There is thus high agreement regarding the importance of these competencies, but it is not clear how to achieve this.

It is not uncommon to view competencies, such as critical thinking and communication, as something that develops as a side effect while learning the knowledge associated with a subject, e.g. computer science. Our view is that it is vital to consciously set up learning environments where these competencies are addressed in terms of knowledge, attitude, and skill. Theoretical knowledge is normally in focus at academia and is often what the students are assessed on. This is in part a consequence of a lack of experience with assessing skills and to an even higher degree attitudes. Many would argue that attitudes are not something that should be assessed, but we see it as something integral in a competence and thus being a part of assessment [2, 3]. We argue that sound assessment methods are vital for creating a learning environment where the students take learning competencies, such as critical thinking and communication, seriously.

We will use the critical thinking competence as an example in conveying ideas for how peer-writing and feedback can be used to set up a learning environment where this competence is enhanced and assessed. The way we view the critical thinking

competence and the educational setting, i.e. the IT and Society course [4], are first presented to give a background for our ideas and results. With this background in mind we will present and analyze an example of a three stage writing assignment, in which peer-writing and feedback are central components. Critical thinking is an essential part of the development of the communication and writing competencies and we will address these competencies in relation to development of critical thinking ability. We will conclude with some general remarks regarding the creation of educational settings suitable for addressing the development and assessment of competencies in general.

II. DEVELOPING CRITICAL THINKING

We will give a rather simplified definition of critical thinking as a general concept followed by a pretty straightforward model of a staircase model for development stages regarding critical thinking and a more indepth description of metacognitive aspects of critical thinking. The purpose is to provide an understanding of the critical thinking competence to serve as a background for the presentation and analysis of the assignment we will present as well as for the more general conclusions regarding the creation of learning environments suitable for development of professional competencies and especially critical thinking.

A. Definition

Critical thinking is a concept that means more than just thinking critically about something. It is a general concept that can be applied in any discipline and profession involving use of accepted means of gather and use information to come up with solutions that are reflected upon from several viewpoints. A trademark of critical thinking is the aspect of reflecting about other options and potential weaknesses in the solution, perhaps especially those stemming from taking things for granted. We will also use the development of critical thinking competence as a component in developing communication and writing competencies. Professional competencies are typically interrelated in that development of one leads to the development of others and that the development of one is dependent on having other competencies.

We will in this paper view it as a competence and use a model depicted in figure 1 where a competence is composed of three integrated parts, i.e. knowledge, attitude, and skill [2].

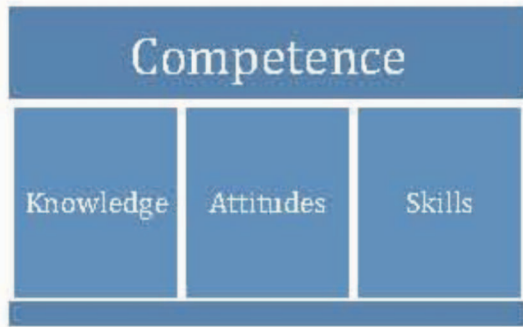


Fig. 1. Components of a competence

This is similar to how Glaser propose what a critical thinking ability involves [5]:

- An attitude of being disposed to consider in a thoughtful way the problems and subjects that come within the range of one's experiences
- Knowledge of the methods of logical inquiry and reasoning
- Some skill in applying those methods.

B. Development Steps

We want to stress the importance of both the attitude and the skill parts in this (and in any other) competence and believe that it is essential that the students practice their skills and that they become aware of how their attitudes influence their abilities. One way to make the development of a critical thinking ability concrete is to compile a list of steps involved in the process. Wolcott presents a staircase with four steps from a foundation representing steps towards what she refers to as "better thinking" [6]. The foundation and the steps are:

- **Knowing (foundation)** - repeat or paraphrase from textbooks, reason to single "correct" solutions.
- **Identifying** - identify problem and acknowledge reasons for enduring uncertainty and absence of single "correct" solutions, identifying relevant information and uncertainties embedded in the information.
- **Exploring** - interpret information: recognize and control for own biases, articulate assumptions and reasoning associated with alternative points of view, and qualitatively interpret evidence from a variety of points of view. Organize information in meaningful ways that encompass problem complexities.
- **Prioritizing** - After thorough analysis, develop and use reasonable guidelines for prioritizing factors to consider and choosing among solution options. Efficiently implement conclusions, involving others as needed.
- **Envisioning** - Acknowledge, explain, and monitor limitations of endorsed solution. Integrate skills into

ongoing process for generating and using information to guide strategic innovation.

She then describe characteristics of persons on the different steps based on stages 3 - 7 in the reflective judgment model proposed by King and Kitchner [7] as follows:

- **Confused fact-finder** - someone at the knowing (foundation) step view solving a problem as finding a single correct answer. Typical behaviors are to quote inappropriately and provide illogical/contradictory arguments based on textbooks, professors, or other sources. He/she is often seen as not "getting it."
- **Biased jumper** - someone at the identifying step try solving a problem by compiling evidence and information to support a chosen solution. Typical behaviors are to jump to conclusions, not recognizing own biases, accusing others of being biased, stacking up evidence while ignoring contradictory evidence, arguing for own position and against other positions, and equating unsupported personal opinion with other forms of evidence. He/she acknowledges multiple viewpoints but cannot adequately take another viewpoint.
- **Perpetual analyzer** - someone at the exploring step view the goal of solving a problem as to establish a detached, balanced view of evidence and information from different points of view. Typical behaviors are being unable to establish priorities, failing to reach or adequately defend a solution, exhibiting strong analysis skills, but appears to be "wishy-washy", writing papers that are too long and seem to ramble, and suffering from "analysis paralysis".
- **Pragmatic performer** - someone at the prioritizing step view the goal of solving a problem as coming to a well-founded conclusion based on objective comparisons of viable alternatives. Typical behaviors are to objectively considering alternatives before concluding, focusing on pragmatic solutions, incorporating others in the decision process and/or implementation, stopping analysis when reasonable solution/decision is reached, and giving insufficient attention to limitations, changing conditions, and strategic issues. He/she sometimes comes across as a "biased jumper", but reveals more complex thinking when prompted.
- **Strategic re-visioner**: someone at the envisioning step view the goal of solving a problem as to construct knowledge, to move towards better conclusions or greater confidence in conclusions as the problem is addressed over time. Typical behaviors are to seek continuous improvement/lifelong learning, being more likely than others to think "out of the box", anticipating change, and working toward constructing knowledge over time.

C. Metacognitive Aspects

As mentioned above, reflection is a central aspect of critical thinking, and it is therefore important to consider aspects of

metacognition [8] when discussing the application of critical thinking to learning activities. In this respect, metacognitive reflection can be seen as some kind of supervisory activity on the cognitive processes. As stated by Ku and Ho [9], “a critical thinker is one who is in charge of his thinking processes, while metacognitive strategies enable such control to take place”. There is clearly an overlap between the cognitive and metacognitive aspects of critical thinking. For example, questioning as a strategy could be regarded as either a metacognitive or cognitive activity depending on context and purpose. If one is reading a book, the activity of asking questions about the text could be employed simply to obtain knowledge about the book’s content. This would be a cognitive strategy. Alternatively, the learner may be asking questions of themselves in order to try to monitor whether they understand the subject matter. This is a metacognitive strategy. Therefore, discussion of critical thinking in terms of metacognitive aspects includes reasoning about both cognitive and metacognitive strategies as the two aspects are so closely intertwined and dependent upon each other. In general, however, one can draw the loose distinction that cognitive activities help to acquire, retain and transfer knowledge that is directed to accomplishing some particular task, while metacognitive activities allow one to regulate and govern the execution of that task in order to ensure a satisfactory level of performance while reaching that goal.

The concept of metacognition is generally characterised as having two aspects: an epistemic component which is directed towards knowledge of oneself and the cognitive processes that go on when engaging in learning, and a regulatory component which deals with the application of strategies to control activities. Flavell further divides the knowledge component into three categories: knowledge of person variables, task variables and strategy variables. There is evidence that knowledge of person variables, such as what factors affect one’s thinking, task variables, such as how context of a problem affects the cognitive skill required to solve it, and strategy variables, such as knowing the reason why one would use a particular skill, help students to improve their self-regulatory function (e.g., [10-13]). All these concepts are highly interrelated with (metacognitive) regulatory activity using (metacognitive) knowledge to improve cognitive performance. However, it appears that a simple awareness of the need to apply a metacognitive regulation is not enough for good performance; one must also be able to make critical judgements about which strategies to use at different contexts [14].

There have been a number of attempts to identify the formal relationship between metacognition and critical thinking, several of which focus on the observation that metacognitive strategies promote regulatory and supervisory competences (e.g. [15-17]). For critical thinking, such strategies can be classified into three types: planning, monitoring and evaluating [15, 18]. Planning-type activities include those that direct thinking towards a particular goal, selection of appropriate methods of solution, and the allocation of available resources [19, 14]. Monitoring activities are attempts by learners to acquire and maintain an ongoing critical awareness of how well they understand their performance on a

task [14]. This awareness of the level of one’s comprehension is sometimes described as “metacomprehension”[20]. This includes checking the state of a task in order to validate one’s own level of comprehension and allocating attention to important ideas [21-22]. Evaluative strategies are those that involve the examination and correction of one’s own cognitive processes [23] such as assessing the legitimacy of goals, reasoning processes, and conclusions [14] as well as making revisions when necessary.

There is clearly a development cycle here. A deeper understanding of a subject emerges from engagement in these strategic activities which direct learners to engage with the learning material through a process of generating inferences, asking questions, evaluating answers, and so arrive at an explanation. After engaging in this process of solution, the learner reflects on the success of such activities [24-26]. It has been found that students’ use of these types of learning strategies improves as their knowledge of the range and domain of applicability of such strategies broadens and deepens [27]. Knowing about the nature of different strategies and under what circumstances a particular strategy should be employed increases performance. This may be because metacognitive knowledge gives learners a more useful set of mental representations with which to understand the situation and a better vocabulary to describe the key elements of the problem [28].

III. EDUCATIONAL SETTING – THE IT IN SOCIETY COURSE

The educational setting for our study is the IT in Society course with students mainly from the fourth or fifth year at the IT program at Uppsala university. The course attracts students from other programs and some international exchange students normally attend the course. The course also includes an international collaboration with an American university, Rose-Hulman Institute of Technology, that offers a similar course to their students. The course is based on Open-Ended Group Project concept [29-32], learning to handle wicked problems [33], as well as student contributing learning [34]. The project in the course has a real customer, and all students work together in one project related to health care.

The students work in teams in the project and they chose a focus area related to socio-technical aspects of software engineering [35] as the course aims to provide students with substantial knowledge and ability concerning the interplay between technology, users and organisations based on relevant areas in human-computer-interaction, psychology and system construction, as well as experiences in real systems developing projects. The learning goals of the course are also related to development of professional competencies, and in the beginning of the course the students write an individual learning contract that describes their personal learning goals for the course. In order to pass the course the students should be able to present a professional solution both orally and in written form, as well as to evaluate, criticize and validate solutions to IT-related problems from perspectives such as ethics, sustainable development, work environment, economy and usefulness. Critical thinking is thus vital for the students to pass this course. The semester long project results in a project report that is handed over to the customer. As a part of the

scaffolding in the course we have worked with the assignment described below.

IV. THE ASSIGNMENT

This assignment is given half way into the semester. The students have had time to dig well into researching their respective focus areas and we often see that some of them have almost lost sight of the overall goal with the project. The time is thus ripe for attempting to let the students to place their work in relation to their project partners into a coherent context, and not least influence others as well as being influenced by them.

A. Description

This assignment is split into four parts distributed over roughly three weeks. The four parts are presented below:

Step 1: “Write 1-3 pages for the report based on what you have done so far in the project. The text should be accompanied by clear descriptions of where in the report structure it fits and motivations of why it fit there”. This part is thus a fairly standard assignment.

Step 2: “Write a peer-review on this contribution. The peer review should be at least one page. Note that your review should be sent to your peer, as well as to the faculty”. Each student is in this step assign a text handed in by another student in step 1 and we provide a rubric designed to help them give critical feedback in a constructive manner. The rubrics include an open ended part and a criteria grid. In the open ended part the students are supposed to write a review that contains both positive and negative critique related to the following areas: organization of the text, citations, grammar and style, content and overall impression. In the criteria grid the same areas reappear and the students are asked to value the areas as either weak, satisfactory, or strong.

Step 3: “Write a reflection on the feedback on your contribution. This should be between one and three pages”. For this part we ask them to write a reflection that is at least at the dialogic reflection level in Table 1. The students were familiar with these levels of reflection from an earlier assignment in the course, where the students were asked to reflect on collaborating across the Atlantic Ocean.

Level of Reflection	Indicator
1. Descriptive Writing	The student simply describes experience without significant attempts at analysis. Although essentially non-reflective, it can nevertheless serve as a foundation for later, more complex activity.
2. Descriptive Reflection	The student attempts to provide reasons for their learning experiences based upon quasi-reflective personal judgements.
3. Dialogic Reflection	The student enters into a personal discourse to explore possible reasons for observed

	outcomes.
4. Critical Reflection	In this context, critical reflection was taken to be demonstrated by the elaboration of reasons for personal learning decisions and experiences which takes into account a mature understanding of the psychological and pedagogical factors affecting the learning process.

Table 1: The different levels of reflection as presented in the assignment to the students (adopted from Hatton and Smith Framework for Reflective Writing [36])

Step 4: In the final step the faculty gives individual feedback on the student's contribution in a mail. Often this feedback is based on all steps in the assignment, but it is focused on the third step where the students reflect. This is a step where we can give quite individualized coaching to students.

B. Learning Goals

The perhaps most obvious learning goal of the assignment for the students is the improvement of their writing competence. This is also an important learning goal as seen from the faculty point of view, but improving both collaboration competence and critical thinking competence are learning goals in this assignment. These learning goals are intertwined in this assignment. The first step mainly focus on the writing competence even if collaboration is a small part of it in that they need to think about their joint product (the report). a The ability to give constructive feedback in step two is essential for fruitful collaboration, but the effort to compose this feedback also provide the students with valuable insights regarding their own writing competence as well as practicing critical thinking. The reflection in step three is mainly aimed at the critical thinking competence, but also contributes to their writing and collaboration skills.

C. Analysis

We have looked at the assignments that the students handed in (see steps 1, 2 and 3 above) in order to detect how well the assignment scaffolded the three learning goals, i.e. the improvement of the students collaboration, critical thinking, and writing competencies. Other sources for our analysis were the final project report and the final written reflection and the accompanying individual meeting.

Writing competence: Looking at the texts handed in during the first step revealed that the students in general wrote understandable text and had a fairly good grip on where in the report the text would fit. All students perceived that they received valuable feedback in the second step and expressed gratitude to the student giving the feedback. Their reflections showed insights into where they should improve with regard to writing and also that they felt more comfortable with providing text for the report. The following quotes from the third step convey our general feeling about how the students reacted to the assignment.

The way the reviewer provided the feedback was very easy to identify the points in which I should work upon, and as I mentioned in the beginning, his comments includes critical thoughts that I make great use of.

This quote clearly shows a metacognitive capability as well as a perception of having improved as a writer.

It shows where my writing skills are lacking, but also spurs me to do a better job.

This student shows insight into where he/she should put efforts in to improve the writing competence.

As I want to improve my writing, and not only produce something that is okay, I really like this type of feedback which makes suggestions for improvements and not only pointing out errors.

Again a quote showing a clear appreciation of the feedback from a peer and also an understanding of what in the writing competence that should be improved.

An indication of an improved writing competence among the students is that most of what the students wrote in the first step also ended up in the report in an improved version.

Collaboration competence: Collaboration is a fundamental part of this course and we have over the years introduced a number of ways to provide scaffolding for the students without compromising too much on the open-ended group project concept. Reflection in general [37-39], making a learning contract [3], and constructive controversy [40-41] are the main methods used to provide this scaffolding. We have also looked into the issue of valuing peers [3] and this has been a guiding light for the assignment presented here. Both step two and three are designed to help the students collaborate in that they aid the students in finding a common “style” for the report and also open their eyes to the value of their peers. The following quote express an attitude that most students also conveyed in their final reflections:

In the future, I would like to do more peer reviewing. I see it very necessary for us as a group, and for each individual to improve even if their focus attribute does not include writing. I am not simply learning for this course, but for life.

A clear statement of someone at the envisioning step in Wolcott’s staircase [6]. This quote also shows that the students have experienced peer reviewing as a way to collaborate as useful, both for this project, and for future group work. As the students have experienced peer reviewing as useful, they have also experienced that it is important to argue and explain an opinion and to listen to group members who have valuable feedback. We believe that this has fostered an atmosphere of trust and strengthened teamwork. This may have facilitated that the students changed the focus of their project work to motivation as a factor for using, or not using, the system they investigated. This was an interesting shift that the students collectively negotiated late in the project. One student, who initially had difficulties with coming through with his ideas, commented in the final meeting on how he learned to adjust how he expressed his ideas by being more attentive to what the others said and how he should contextualize his ideas closer to

the worldview of the others. He claimed that this writing assignment had a substantial positive impact on how he functioned in the group, which also match the observations by the faculty. In summary, this indicates that the assignment fostered collaboration and supported development of the students collaboration competence.

Critical thinking competence: It has been clear to the faculty over the years that the students improve their critical thinking competence during the semester by observing how they reason about the project in general and about reasons for how it developed, as well as showing a greater understanding for how other things than technology influence their analysis and having a more developed approach to open-ended problems. We have also noted that the level at which the students succeed to write subsequent reflections improve over the semester. That said, it has been frustrating to note that many students fail to recognize this improvement or only vaguely realize that they have become better at dealing with open-ended problems largely due to an improved critical thinking competence. It has therefore been satisfying to note that this assignment supported most, perhaps all, students in their critical thinking competence development and that they realized that it had improved. The following quote is an example of a student likely to be at the prioritizing, or even the envisioning, step on the “better thinking” staircase above presented [6]:

You can learn as much from reviewing a poorly written text as well as a well-written one. It is important to always read the reviews you get, use the critique and reflect over why the reasons for the reviewers observations.

The quote also clearly shows that the student has metacognitive abilities when pointing out insights into different ways to learn.

The restructuring of their work and their report towards a focus on the role of motivation for their results is, apart from being an indication of a high level of communication competence in the group, a sign of students at the upper end of the “better thinking” staircase.

D. Summary

We argue that this assignment fits well with our ambition to create an educational setting which promotes development of critical thinking, as well as the writing and collaboration competencies. One crucial aspect is that the students actually became aware of this development. That this is important can be illustrated by an episode from a lecture on competencies, where one student this year suddenly realized that the ability to think creatively was not something one was born with, but that it actually was possible to learn how to improve this competence. The view of what one can learn and what somehow is part of the personality one has has major impact on how students react to a course like the IT in society. Being aware of the personal epistemologies in a student group is thus helpful in setting up a suitable learning environment [42-43]. It is also helpful for individual students to be aware of their beliefs.

V. CONCLUSIONS

Our results are about an assignment set in a specific educational setting. The assignment, or a similar one, can however be used in other educational settings. Important aspects to consider are, in our experience, to clearly present the pedagogical ideas with the assignment and to make an effort to identify where on the staircase to “better thinking” [6] the students are.

Presenting the pedagogical ideas is based on us assuming that your students are unused to assignments like this and that it is vital to boost their motivation for taking the assignment seriously. This includes discussing competencies in general, e.g. what they consist of and how they can be improved. The personal epistemology of the students might be such that they are sceptic to the idea of being able to improve competencies like critical thinking.

Identifying where the students are on the “better thinking” staircase [6] is important in deciding on how to support the students in the assignment. Aiming at taking the students from the step where the majority of the cohort is to the next step is where the assignment will be most useful. Making the assignment at a level that is too high compared to the general level of the cohort will result in frustration and not much learning due to students becoming too confused. Similarly, setting the assignment at a too low level with regard to the level of the cohort will perhaps make the students happy but not much learning will happen. The reason for this is similar to arguments for finding the Zone of Proximal Development that was introduced by Vygotsky [44] and represent knowledge and skills that a person is ready to learn at the moment. Being able to target leaning at this level has a major impact on the students’ motivation.

We have over the years developed scaffolding for the IT in Society course suitable for students being at the exploring step on Wolcott’s staircase [6]. We try to identify students at either the prioritizing or envisioning step during individual meetings and observations in order to provide these students with appropriate challenges, including to function as role models when it comes to critical thinking. It is furthermore our ambition to identify students at levels below the exploring step in order to provide them with more concrete tasks and transfer to a course better suited for their current competence.

We have presented an assignment suitable for the development of several competencies identified as being crucial for the engineers of today. The results were encouraging and indicate that the general idea behind the assignment is sound and can be transferred to other educational settings. The usefulness of this type of assignment is likely to depend on being able to target the assignment at where the students are on the steps to “better thinking”. We strongly suggest that a degree program should have a clear plan for how to support their students to progress towards having well developed competencies such as critical thinking ability, by integrating assignments like the one presented in this paper in courses at different levels in the program.

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