DEVELOPING ASSESSMENT RUBRICS IN PROJECT BASED COURSES: FOUR CASE STUDIES

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ABSTRACT

A common approach to assessing outcomes in project based courses is to use formal scoring guides or rubrics. However, there are major challenges in using such rubrics. These challenges are related to the variety of outcomes of project based courses and the desire to use rubrics for both formative and summative assessment. In addition, there are difficulties related to building a common understanding of the rubric criteria among both students and instructors. As part of a visiting researcher appointment at Chalmers University of Technology in Gothenburg Sweden the author worked closely with several course leaders (examiners) to create rubrics in baccalaureate and masters level project based courses. Rubrics developed as part of the American Association of Colleges and Universities (AAC&U) Valid Assessment of Learning in Undergraduate Education (VALUE) project were adapted to address the criteria related to specific course learning outcomes. These collaborations resulted in the case studies that are described in this paper.

KEYWORDS

project based courses, rubrics, pedagogy, engineering education,

Project based courses have a number of unique elements that add to the complexity of assessing student learning outcomes. These elements include issues related to assessing both the quality of the process of project conceptualization, design, and implementation as well and the quality of the resulting product. The process includes problem solving as well as critical, analytical and creative thinking. And, it often includes interdisciplinary teamwork and working with external clients. The product may include oral and written descriptions of the result of the project development and implementation process as well as an actual physical prototype or finished product or system. In this regard, the process and product assessment involves many if not most of the CDIO syllabus topics.

A common approach to assessing outcomes in project based courses is to use formal scoring guides or rubrics. However, there are major challenges in using such rubrics. These challenges are related to the variety of outcomes of project based courses and the desire to use rubrics for both formative and summative assessment. In addition, there are difficulties related to building a common understanding of the rubric criteria among both students and instructors.

As part of a visiting researcher appointment at Chalmers University of Technology in Gothenburg Sweden the author worked closely with several course leaders (examiners) in four project based courses in the areas of Product Development (MPP126); Applied Mechanics (TME130); Industrial Design Engineering – Product semiotics (MPP071); Production Systems Project – Pre-study (IAR058) to create rubrics for the formative and summative assessment of learning outcomes in baccalaureate and masters level project based courses. Rubrics developed as part of the American Association of Colleges and Universities (AAC&U) Valid Assessment of Learning in Undergraduate Education (VALUE) project [1] were adapted to address the criteria related to specific course learning outcomes. These collaborations resulted in the case studies of how to address the challenges of using rubrics in project based courses that are described in this paper.

BACKGROUND

Chalmers University was one of the founding institutions of the Conceive-Design-Implement-Operate (CDIO) Initiative. Over the last 10 years faculty members in a variety of departments have used the CDIO Standards to provide a structural template and the CDIO Syllabus to provide a content-related template for the development of courses [2]. In addition, the concepts related to constructive alignment are embodied in the CDIO book [3] and have been widely applied to guide the development and implementation of courses at Chalmers, especially in the Product and Production Development Department.

The national model for evaluation of higher education in Sweden places major emphasis on the quality of degree projects as an indicator of the quality of the entire educational program. Degree projects (final year projects, independent work) occur last in the education program. They are intended to serve as learning experiences that integrate disciplinary knowledge gained during the program with the professional skills needed to make use of that knowledge.

The degree project is highly valued in the Swedish education system [4]. Indications of quality embodied in degree project reports influence university funding. In addition, the assessment of degree projects is used to guide program pedagogical improvements not only in relation to subject matter knowledge but also professional skills such as project planning and management, teamwork, and oral and written communication.

CONSTRUCTIVE ALIGNMENT

The primary focus of constructive alignment is the description of intended student learning in the form of clear and precise outcome statements. The purpose of specifying student learning outcomes is to provide direction to teachers for teaching and students for learning and to provide the focus of both formative and summative learning assessment. This is consistent with the constructivist approach in that it makes explicit that the primary points of reference of the educational process are students and their learning. All of the courses described in this paper were developed using the Constructive Alignment framework and the CDIO Syllabus and, therefore, have comprehensive and well-articulated student learning outcomes related to their aims.

In addition to specifying outcomes the course examiners (lead instructors responsible for the course) have developed sets of standard course materials that describe the teaching and learning activities. The examiners have also created supplementary materials in the form of detailed course memos, reference and background materials, guides for project team formation and management, handbooks on report writing, step by step task manuals, etc.

As part of the course descriptions the examiners layout the assessment schedule and methods along with assessment criteria. In many cases there are extensive guides and/or criteria for assessing various course elements such as products related to different progress check points or gates as well as formal exams and quizzes.

Discussions with the course examiners identified the need for more clearly and explicitly defined assessment criteria. The author introduced the rubrics develop under the auspices of the

Association of American Colleges and Universities (AAC&U), VALUE: Valid Assessment of Learning in Undergraduate Education project [1]. The VALUE rubrics address the following areas:

Intellectual and Practical Skills
- Inquiry and analysis
- Critical thinking
- Creative thinking
- Written communication
- Oral communication
- Reading
- Quantitative literacy
- Information literacy
- Teamwork
- Problem solving

Personal and Social Responsibility
- Civic knowledge and engagement—local and global
- Intercultural knowledge and competence
- Ethical reasoning
- Foundations and skills for lifelong learning

Integrative and Applied Learning
- Integrative and applied learning

Each VALUE rubric includes a definition of the particular learning outcomes area, the framing language to provide the context for assessment, a glossary explaining the assessment criteria, and the generic rubric form. The rubric itself consists of the assessment criteria, a rating scale, and brief narrative description related to each point on the scale intended to guide the evaluation of assessment evidence. These provided a starting point for developing course specific assessment measures.

CASE STUDIES

The three following case studies are organized using the Constructive Alignment concepts; learning outcomes, teaching and learning activities, and learning assessment. They illustrate how the VALUE rubrics were adapted to meet the needs identified by the lead instructor (examiners).

MMP126 Product Development Project and TME130 Project in Applied Mechanics

These two courses are considered together since the lead instructors both decided that they wanted to focus on teamwork outcomes and will both use the resulting rubric.

Learning Outcomes

As stated in the course description, *the aim of MMP126 is to make the students experience a real product development project by letting them carry out an industrially assigned product development task in a cross-functional project team with students with different educational backgrounds.* It is expected that after completing MMP126 students will have gained a variety of technical knowledge and skills as well as professional abilities.

Similarly, TME130 is intended to provide students with both theoretical and applied knowledge and skills including teamwork and communication. In this course students are given *an opportunity to apply knowledge in mathematical modelling using computational and experimental techniques. The learning environment is organized in such a way that an emphasis is put on practising communication skills and developing experience working in teams*. The Project in Applied Mechanics course focuses specifically on the development of models for crack detection using ANSYS Workbench to model fluid mechanics, solid mechanics and structural dynamics aspects of wind turbine blades. The students are expected to integrate and apply all of the technical knowledge and skills as well as professional abilities that they have previously learned.

Students come from different specializations within applied mechanics so that different outcomes as expected of them. However, all of the students are expected to show insight and the ability to work in teams and collaborate in groups with different compositions and to be able to give written and oral presentations of their technical investigation.

Teaching and Learning Activities

The Product Development Project (MMP126) course's main elements are the project itself and a series of lectures with literature assignments on product development related topics. The projects are specified by an industrial company and contain tasks such as analysis of customers/market needs, specification of requirements, concept generation, analysis of technical and economic feasibility, detail design, and prototype building.

Students are organized into cross-disciplinary teams with 6-8 students with different disciplinary backgrounds (mechanical engineering, automotive engineering, automation, industrial design engineering, industrial economics and organization, and quality and operations management). Each team has both an academic and an industrial supervisor. All projects follow the same master process that includes control gates where predefined deliverables are presented and approved at design reviews conducted by the academic and industrial supervisors and other student teams. At the final gate a written project report, a project seminar and an exhibition of models and prototypes occur.

The lectures cover product development topics that are elaborated in the course-related readings. A reflection report about the relevance of the contents of the lectures and the course literature is composed by each team and appended to the final project report.

In describing the rationale of the Project in Applied Mechanics (TME130) in the course description it is stated that, *a critical step in the development of a new wind turbine power plant is to design the wind turbine blades. This requires considerable knowledge in aerodynamics, structural dynamics and solid mechanics. To the knowledge of the examiners no specification of a complete wind turbine blade exists in open literature*. Therefore, the task is to use information that is provided in the course references to create a 3D representation of a wind turbine blade and to calculate pressure distributions using computational fluid dynamics. Student teams must then use these pressure distributions, together with mechanical analysis of the stiffening structures to create a material model that can establish the structural response of the blade to a static wind load. Finally, teams make assessments using their model to estimate how large blade defects have to be in order for them to be detected.

Learning Assessment

While the content and types of projects in these two courses differ, major learning outcomes of both courses concern the functioning of individuals and teams in the project development and implementation process. Specific direction is given for the structure and content of project reports as well as the criteria related to the quality of the projects themselves. For example, the MMP126 Product Development Project *course memo* lists the criteria related to the *product solution* as technical contents and understanding, creativity and level of innovation, market and user understanding, economy and resource efficiency, and fulfillment of specification. Students are provided with a report synopsis that explains what should be included in each section. The instructors refer to it as a guide for the structure of the report as well as a guide for checking to make sure that the report components meet the criteria that will be used to assess it.

Although students receive a lot of information about what is expected, the Product Development Project examiner identified an important learning outcome that needed further explication: *Interact with members in a team to fulfill common goals by contributing with own competence and skills and making use of other team member's competence and skills*. A Product Development Project team member peer and self-evaluation form has in the past been used for the evaluation of group member participation. The form included the following categories, contribution to the technical contents of the project, contribution to the creative dimension of the project, contribution to the project documentation, and responsibility taken for *driving* the project. Student used a five point scale to evaluation both their own and other team members' contribution: 1= minimal, 2 = minor, 3 = satisfactory, 4 = substantial, 5 = very substantial.

Similarly, the lead instructor of Project in Applied Mechanics (TME130) identified the following outcome as needing an improved assessment approach: *show insight and ability to work in teams* and *collaborate in groups with different compositions.* In this course**,** the criteria related to the teamwork were technical contribution, commitment, team interaction, and responsibility, and students were required to anonymously rate themselves and their team members in the four categories on a scale of 1-10 (low to high).

There was a feeling on the part of both examiners that the process and criteria for the peer review and instructor assessment of teamwork functioning needed improvement. This realization came from both student feedback and reflection on the part of the examiners and other instructors, based on their efforts to assess teamwork over the last several semesters. These very general approaches to assessing individual and team performance were found to be inadequate since they did not define the criteria or provide guidance in carrying out the evaluations. In particular, their very general nature made it difficult for students to complete the peer and self-evaluation and for the instructors to explain their assessment results, especially to those students who were not pleased with their assessments (e.g., those who felt that they deserved a better grade than the rest of the project team).

The AAC&U Teamwork VALUE rubric criteria and their descriptions were modified in consultation with students who had done well in the Product Development Project course during the previous term and then pilot-tested with students enrolled in the fall 2012 term. The original criteria for the AAC&U VALUE Teamwork rubric are [5]:

- Contributes to Team Meetings
- Facilitates the Contributions of Team Members
- Individual Contributions Outside of Team Meetings
- Fosters Constructive Team Climate
- Responds to Conflict

The most extensive change was made in the criterion, Fosters Constructive Team Climate, which was divided into two criteria as follows: Shows confidence in other team member's abilities and Shows courtesy and respect (see Appendix A).

The new rubric will be field-tested in both courses, MMP126 Product Development Project and TME130 Project in Applied Mechanics, during the spring 2013 term to guide further refinement in anticipation of full implementation during the 2013-2014 academic year.

MPP071 – Project Industrial Design Engineering – Product semiotics

Learning Outcomes

As described in the Project Industrial Design Engineering – Product semiotics (MPP071) course description, *the aim of this course is to give basic knowledge about product semiotic theory, and through practical training and a design project develop the ability to analyze and design products with focus on communicative criteria of the product*. After completion of this course, students should be able to:

- describe product semiotic theory and have a good command of its terminology a well as acquire a semiotic way of looking at things
- analyse, formulate and articulate the message of a produce
- apply product semiotic theory in practical design work and from a defined life style, context, specific expressions, etc.
- design a product with a desired message in a conscious way

Teaching and Learning Activities

Since this is an introductory course it includes literature studies (i.e., readings), lectures and seminars, exercises, and an individual design project. The lectures and seminars and related readings discuss areas such as products as a sign, the product semantic functions, methodology and terminology for analyzing a product's semantic functions, gestalt laws and basic form aesthetic aspects, life styles, image board, expression board, etc. The design project involves the development of an image board, an expression board, idea sketching, conceptual sketching, 3D-modelling in Studio Tools, a presentation in Power Point, and a written analysis.

Learning Assessment

This course is intended to help beginning (baccalaureate) students in Industrial Design Engineering to *develop the ability to analyze and design products with focus on communicative criteria of the product*. It is very important for the lead instructor to be able to provide constructive and clear feedback as the students go through the product development process. In particular, students must be helped to understand and to begin to internalize the criteria need to be able to *design a product with a desired message in a conscious way*. Semiotic analysis is the study of signs and symbols and how they interact to create meaning. This involves being able to *analyse, formulate and articulate the message of a produce* and then to *apply product semiotic theory in practical design work*.

Opportunities for feedback occur at each step in the process as students develop an image board and an expression board, engage in idea sketching and conceptual sketching, use 3D-modelling tools, and then make a presentation in Power Point. The final product is a written analysis of their project using *the methodology and terminology for analyzing a product's semantic functions, gestalt laws and basic form, aesthetic aspects, life styles, etc.* Because of this process' very creative and, therefore personal/subjective nature it is sometimes difficult for the instructor to clearly and sensitively articulate the strengths and weaknesses of the student's work at each of these steps. This is especially true with beginning students who need encouragement to be creative and take risks while at the same time sometimes needing a reality check when their own self-assessment is overly positive or their work has gone off the track.

As described by Wikström [6]:

> Design semiotics has been used in order to analyze the meaning of design artifacts and the way in which products construct meaning. Semiotics is the study of sign processes – or semiosis. Semiosis, a term coined by Peirce, was defined by Charles Morris as a sign process, i.e. a process in which something is a sign to some organism (Morris 946:366 in Nöth 1990). Morris derived three dyadic relations of semiosis which he considered to be the basis of three dimensions of semiosis and semiotics. *Syntactics* is the study of the relation between a given sign vehicle and other sign vehicles, *semantics* study the relations between sign vehicles and their designate while *pragmatics* study the relation between sign vehicles and their interpreters (Nöth 1990).

These concepts are used to assess the students' products in MPP071. In addition, there are two AAC&U rubrics that have relevant criteria to the students' approach to addressing the design challenge. The first is the Inquiry and Analysis VALUE rubric where inquiry is defined *as a systematic process of exploring issues, objects or works through the collection and analysis of evidence that results in informed conclusions or judgments* [5]. In particular the criteria related to the design process provides a continuum of generic performance levels that are related to the steps of the semiotics course methodology (see Appendix B).

Since this is a foundational course, one of its primary purposes is to orient beginning students to the expectations and perspectives of the discipline and to develop the requisite knowledge, skills and values needed for their lifelong professional development. Therefore, the Foundations and Skills for Lifelong Learning VALUE rubric [5] is also relevant. The following define the most accomplished MPP071 *capstone* performance related to the rubric criteria. Students could be coached all during their studies to help them develop these capabilities:

- Curiosity – Explores a topic in depth, yielding a rich awareness and/or little-known information indicating intense interest in the subject.
- Initiative – Completes required work, generates and pursues opportunities to expand knowledge, skills, and abilities.
- Independence – Educational interests and pursuits exist and flourish outside classroom requirements. Knowledge and/or experiences are pursued independently.
- Transfer – Makes explicit references to previous learning and applies in an innovative (new and creative) way that knowledge and those skills to demonstrate comprehension and performance in novel situations.
- Reflection – Reviews prior learning (past experiences inside and outside of the classroom) in depth to reveal significantly changed perspectives about educational and life experiences, which provide foundation for expanded knowledge, growth, and maturity over time.

This last criterion, *reflection*, is the focus of the final self-analysis product and is the most difficult to teach and to give feedback on. However, this criterion may be used to stimulate a discussion with students on the development of their ability to reflect (see Appendix C).

These alternatives are being explored by the lead instructors as feedback is provided to individual students to determine the most appropriate direction for future development.

IAR058 Production Project – Pre-study

IAR058 is a compulsory course in the Production Engineering masters in science (MSc) degree program. It is intended to provide students with an opportunity to integrate the knowledge and skills gained through the other compulsory courses taken during the first year of the program. The course includes close industry cooperation in order to help students learn how to use knowledge in the context of industrial reality. And, it is a pre-study for the masters thesis production project to be completed as the capstone of the program during the second year.

Learning Outcomes

Students, through active collaboration in a project group, receive training in transferring well-founded scientific theory into practice. Through this case study effort, the lead instructor identified several learning outcomes that clarified, elaborated on or augmented the initial outcomes above. These primarily concerned the ability to write and follow a structured project plan, using the Project Model LIPS [7] as a guide. These outcomes included: defining a problem; identifying strategies; proposing solutions/hypotheses; critically evaluating a project plan (their own and others via project documentation and opposition); explaining and defending their group's project plan in a simple and clear way (using clear language and graphics); and writing a self-reflection about the group dynamics and how they view their future role as a professional engineer (including thoughts about sustainability and ethics). These statements of student learning outcomes guided the development of teaching and learning activities as well as assessment methods.

Teaching and Learning Activities

The Production Project – Pre-study course (IAR058) provides practical training in project methodology, literature research, project management, technical project report writing, and presentation and opponent techniques among other topics such as sustainability and science and engineering ethics. The course is organized around the project groups. After forming groups, students select project themes from a number of alternatives. To guide the students through their projects and to help them achieve the learning objectives, each group meets with a university supervisor once a week. These meetings typically include assistance on finding relevant background theories, adding experience on project planning, technical support on applied software packages, and support with writing the final planning report. The supervisor also helps the group set up a meeting structure and facilitates internal communication within the group. In addition, the project groups conduct several company visits and have at least one industrial contact who provides necessary input information and industrial experience. The Project Model LIPS [7] is used to help student teams organize their work.

The course also includes a series of lectures intended to give the students general knowledge about project planning, literature search and proper academic citation, and presentation techniques. A literature seminar is based on *The Reflective Practitioner* [8] and is intended to inspire the students to apply the ideas in the book to their project work. Each group is provided with a virtual project room for continuous communication and documentation. This virtual project room is used by the supervisors to follow and assess the teams' progress, in terms of their achievement of the course learning outcomes, and to provide formative feedback on the teams' work.

The new learning outcomes noted above were developed in response to student feedback that the LIPS model was perceived as being rigid and prescriptive and that the need to present many interim reports was overwhelming. As a result, the structure of the course will be loosened and students will be given more time between written reports and will be given more guidance.

As the new learning outcomes are integrated into the course, the lead instructor will develop a set of lesson plans with activities that first introduce the outcomes to students and then provide them with a number of opportunities to become familiar with the rubrics and their criteria and scoring descriptions as discussed in the next section.

Learning Assessment

Three of the AAC&U VALUE rubrics will provide the foundation for the assessment of the new learning outcomes in this course, namely, *problem solving*, *critical thinking*, and *written communication* [5]. Since IAR058 involves a pre-study and does not go all the way to implementation, the first four criteria of the *problem solving* rubric parallel the LIPS Project Model and will be used for assessment purposes: define the problem, identify strategies, propose solutions/hypotheses, and evaluate potential solutions. The *critical thinking* rubric criteria will be used to help students focus on the following criteria: explanation of issues, evidence, electing and using information to investigate a point of view or conclusion, influence of context and assumptions, student's position (perspective, thesis/hypothesis), and conclusions and related outcomes (implications and consequences). And, the *written communication* rubric will be used to guide the development of reports and will focus on: the context of and purpose for writing including considerations of audience, purpose, and the circumstances surrounding the writing task; content development; genre and disciplinary conventions; formal and informal rules inherent in the expectations for writing in particular forms and/or academic fields; sources and evidence; and control of syntax and mechanics. In addition, a previously developed *reflection* rubric based on *The Reflective Practitioner* [8] will be adapted to the VALUE rubric format:

- Your personal perspective has been developed as a result of your study.
- You articulate a personal vision as a future professional engineer including a relevant discussion of professional values and ethics.
- You relate to the knowledge categories for work life and the framework of reflection-in-action theory.
- You argue for the importance of using a holistic view and sustainability thinking when analyzing unfamiliar and emerging problems in industry.
- You discuss also your future professional career in the light of team work and theories for group dynamics.

An example of a draft Reflective Practitioner rubric is shown in Appendix D.

As a part of the pre-planning for the next offering of the course in fall 2013, current students will be engaged to provide comments and suggestions on the wording of the rubrics as well as the new and revised lesson plans related to them.

Summary and Conclusions

Constructive Alignment has been established as the pedagogical framework in the Product and Production Development Department (PPU) at Chalmers University of Technology. The aim of the pedagogical research and development projects described in this paper was to enhance the formative and summative assessment methods used in project based courses through the adaptation of the AAC&U VALUE rubrics.

Key elements in this project's success were, first, the voluntary involvement of the course examiners (lead instructors) for each of the target courses. This resulted in their extraordinary commitment to and engagement in the project. Second, this project was part of the ongoing review by course faculty of assessment information collected. In this sense, it was not an exceptional activity and, therefore, was welcomed as a valued-added element by the course faculty. Third, the AAC&U VALUE rubrics have credibility as a result of the processed used to create them and the fact that they are not prescriptive. That is, the experts who generated the rubrics made it explicit that the rubrics were to be adapted to local conditions and cultures. In this way they provide a point of reference for the review of current assessment methods and models for new methods. Fourth, student input was sought in the identification of target areas and in the refinement of the rubrics thus enhancing the use of the rubrics by student for self-assessment. Fifth, this project is part of a larger ongoing, faculty led Constructive Alignment pedagogical development process that is focused on the assessment element, which will help to embed it in PPU and Chalmers University culture more generally.

Over the next year newly developed rubrics will be field tested and refined. It is hoped that this will result in an improved educational experience for students and enhance the department's already outstanding pedagogical reputation.

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APPENDICES

Appendix A. Change made in the AAC&U Teamwork rubric criterion, Fosters Constructive Team Climate. (Contact Lars Almefelt lars.almefelt@chalmers.se for a copy of the full rubric.)

Shows confidence in other team members' abilities	Motivates teammates by expressing confidence about the importance of the task and the team's ability to accomplish it. Facilitates team spirit by actively inspiring and encouraging other team members. Further strengthens a good atmosphere in the group by, e.g. initiating social team events.	Motivates teammates by expressing confidence about the importance of the task and the team's ability to accomplish it. Facilitates team spirit by actively inspiring and encouraging other team members.	Motivates teammates by expressing confidence about the importance of the task and the team's ability to accomplish it.	Accepts other team members' competences and abilities to accomplish the assigned task.
Shows courtesy and respectfulness	Shows up to meetings on time. Always treats team members respectfully by being polite and constructive in communication and uses positive vocal or written tone, facial expressions, and/or body language. Speaks well of the team and characterizes the team in a positive light externally.	Shows up to meetings on time. Always treats team members respectfully by being polite and constructive in communication and uses positive vocal or written tone, facial expressions, and/or body language.	Shows up to meetings on time. Always treats team members respectfully by being polite and constructive in communication.	Shows up to meetings on time.

Appendix B. AAC&U Inquiry and Analysis rubric criterion, Design Process. (Contact Li Wikström li@chalmers.se for more information about the use of rubrics in the ***Product semiotics*** course.)

Design Process	All elements of the methodology or theoretical framework are skillfully developed. Appropriate methodology or theoretical frameworks may be synthesized from across disciplines or from relevant subdisciplines.	Critical elements of the methodology or theoretical framework are appropriately developed, however, more subtle elements are ignored or unaccounted for.	Critical elements of the methodology or theoretical framework are missing, incorrectly developed, or unfocused.	Inquiry design demonstrates a misunderstanding of the methodology or theoretical framework.

Appendix C. AAC&U Foundations and Skills for Lifelong Learning rubric, Reflection. (Contact Li Wikström li@chalmers.se for more information about the use of rubrics in the ***Product semiotics*** course.)

Reflection	Reviews prior learning (past experiences inside and outside of the classroom) in depth to reveal significantly changed perspectives about educational and life experiences, which provide foundation for expanded knowledge, growth, and maturity over time.	Reviews prior learning (past experiences inside and outside of the classroom) in depth, revealing fully clarified meanings or indicating broader perspectives about educational or life events.	Reviews prior learning (past experiences inside and outside of the classroom) with some depth, revealing slightly clarified meanings or indicating a somewhat broader perspectives about educational or life events.	Reviews prior learning (past experiences inside and outside of the classroom) at a surface level, without revealing clarified meaning or indicating a broader perspective about educational or life events.

Appendix D. Reflective Practitioner Rubric (Contact Bertil Gustafsson bertil.gustafsson@chalmers.se for more information about the use of this rubric.)

	Good Work	Passed	Needs Improvement
Personal perspective and vision	There is evidence of sound judgment in the construction and organization of your reflection delivery.	Some use has been made of learned theories, but the overall structure is in need of revision to identify your personal perspective and the value/structure of learning materials.	You are not aware of that production engineering work stems from values and visions about what things should be like, knowledge of what is possible, and ideas of how to get there.
Reflection-in-action	You argue for a responsible design-oriented engineering founded on greater reflexivity; you substantiate your personal vision as a future professional engineer with the knowledge categories for work life and the framework of reflection-in-action theory.	You could better develop your personal opinion about why unfamiliar and emerging problems in industry need Reflective Production Engineer.	Your theory account is not much more than from a "cut and paste" writing procedure.
Holistic view and sustainability thinking	There is evidence of judgment in the construction and organization of your reflection delivery.	You could better develop your personal opinion about why unfamiliar and emerging problems in industry need Reflective Production Engineer.	You need to recognize the importance of using a holistic view and sustainability thinking when analyzing unfamiliar and emerging problems in industry.
Team work and group dynamics	You discuss your future professional career in the light of team work and theories for group dynamics	You could better integrate teamwork and theories of group dynamics into your view of yourself as a professional engineer.	You need to acknowledge the importance of teamwork and group dynamics as a professional engineer.

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