LEARNING ASSESSMENT – A PALETTE OF METHODS IN A MASTER'S PROGRAM

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ABSTRACT

There are several different examination methods to assess students' achievements. These assessment methods should be matched with the course learning objectives, support deep understanding of concepts and active learning as well as different learning styles among the students. The objective of this paper is to share and reflect on the experiences of different assessment methods applied in a master's program in Ergonomics and HTO (Humans, Technology and Organization) at KTH in Sweden. The paper is based on the authors' observations and experiences as main teachers in the master's program and student evaluations. The pro-gram consists of five courses representing different areas within Ergonomics followed by a project course and the Degree Project. The students have multidisciplinary backgrounds and difference in work experience, which calls for special attention regarding what means to use to support the students' deep understanding and active learning. To support the students' cross-disciplinary collaboration and individual learning processes different assessment methods have been developed. In the first five courses, there is a written exam to assess theoretical knowledge as well as reflective and application knowledge. This is supplemented by an array of other assessment methods to stimulate the development of a multidisciplinary view. These include seminars, laboratory exercises, as well as individual and group assignments. In the group assignments, the groups are mixed with students from different educational backgrounds to demonstrate the need to encompass several perspectives to understand different phenomena. For all courses, the learning outcome is also assessed by oral presentations. This palette of assessment methods are used through-out each course in the master's program. However, sometimes challenging to develop assessment methods to fit students with different backgrounds, the variety of methods allows for students to demonstrate their knowledge and understanding through different means and in different contexts.

KEYWORDS

Examination, ergonomics, HTO, assessment methods, CDIO Standard: 11

INTRODUCTION

There are several different examination methods to assess students' achievements. These assessment methods should be matched with the course learning objectives, support deep understanding of concepts and active learning as well as support different learning styles among the students (CDIO, 2016). Earlier studies have described different study approaches and their outcomes on students' learning (Ramsden, 2003). In a surface approach, the students memorize facts and details without much reflection about the implications of their meaning (Marton & Säljö, 1976), while in a deep approach to studying, the students reflect on the meaning of theories and how they can be applied to real-life situations. Ramsden (2003) put forward that deep teaching/learning approaches are related to higher quality outcomes as well as higher students' satisfaction. As the examination form in itself affects the way the students study and learn (Biggs, 2003), it is important to develop examination forms which constitute deep learning processes (Hult, 1998).

The objective of this paper is to share and reflect on the experiences of different assessment methods applied in a master's program in Ergonomics and HTO (Humans, Technology and Organization) at the Royal Institute of Technology (KTH) in Sweden. Ergonomics is a multi-disciplinary field and defined by Corlett and Clark (1995) as: "The study of human abilities and characteristics which affect the design of equipment, systems and jobs. It is an interdisciplinary activity based on engineering, psychology, anatomy, physiology and organizational studies."

The paper is based on the authors' observations and experiences as main teachers in the master's program since 2007, student evaluations and reflection on the students' results.

LEARNING ASSESSMENT

As assessment methods strongly influence the students' learning, the assessment forms must be related to the course objectives. This highlights the importance of formulating good learning objectives as well as to develop methods to assess to what extent the students reach these objectives (Lindberg-Sand, 2008). According to the CDIO approach, learning assessment should not take place only at the end of the course, but different methods for assessment should be used for the students to demonstrate their learning throughout the course, and some assessment methods can also be used as teaching methods (Crawley et al, 2014). Toohey (1999) has divided examination into a number of methods to assess different aspects, see Table 1.

Table 1. Description of Use of Assessment Methods (Toohey, 1999)

Assessment method	Assessed aspects
Objective tests	Broad fact-based knowledge of the syllabus
Essay examination	Higher level of thinking
Open-book exams	Problem solving and interpretation of knowledge
Case study or problem-centred exams and assignments	Performance close to professional practice
Practical/professional tasks	Knowledge application and skills
Production of works of art	Knowledge application and skills
Oral presentations and seminars	Ability to organize information and develop arguments
Reflective tasks	Reflection on practice, growth in understanding, reasoning and development of professional attitudes

These assessment methods should be based on the qualifications needed for the students in the future. Looking at the required qualifications in their profession, engineering students will need to understand how models and theories may be applied in different contexts. As they then will have access to literature, open-book examinations are more realistic and will probably encourage the students to study with a deeper approach for the examination (Toohey, 1999). Furthermore, a deep approach may be encouraged through four principal factors (Biggs, 1989):

- An appropriate motivational context
- A high degree of learner activity
- Interaction with others, both peers and teachers
- A well-structured knowledge base

In a CDIO approach, Crawley et al. (2014) highlight the importance of sound learning assessments for student and program success. This includes assessing the students' achievements from multiple and diverse sources; integrating teaching and assessment, so that improved assessment also improves teaching; and assessing the students in different teaching-learning contexts. In the CDIO standard 11 (CDIO, 2016), it is further stated that the assessment methods should address both disciplinary knowledge as well as personal, interpersonal, and system building skills. A variety of methods also allows for different learning styles and results in increased reliability and validity regarding the assessment process.

DESCRIPTION OF THE MASTER'S PROGRAM

The education presented in this paper is a master's program in Ergonomics and HTO taught at the Royal Institute of Technology (KTH), Sweden. Three main teachers collaborating since 2007 manage the program. Their competences and research areas cover complementary multidisciplinary areas such as mechanical engineering, physiological ergonomics, cognitive science, Ergonomics/Human Factors in general, work organization, group dynamics, and industrial management and engineering.

The students that are admitted to the program may have a background in technical science, health science as well as behavioural science. About 25-30 students are admitted every two years. The aim is to have one third of the students with each background to create good cross-disciplinary working groups. Approx. half of the students come directly from undergraduate studies, and the other half have worked for several years The professional group of students

include consultants, self-employed people, teachers, representatives for Swedish authorities within occupational health and safety, etc. The master's program can be followed as fulltime study in one year or as halftime study in two years. The students meet for two to three full days every four weeks and study on their own or with other students between the meetings.

The program consists of five six-credit courses representing different areas within Ergonomics: 1) Human, Technology, Organization (HTO); 2) Physical Ergonomics; 3) Cognitive Ergonomics; 4) Organization, Change Management and Work Environment Legislation (here named Organization); and 5) Research Methods and Study Design (here named Method). These courses are followed by a project course and the Degree Project of 15 credits each. The overall learning objectives for each course are presented in Table 2 below.

The overall purpose of the master's program is to provide a system's view on the interaction between human, technology, and organization at work in order to enhance human wellbeing, design of technology and organisation to increase overall system performance. The students are to attain this holistic view during the program, which is described in the syllabus as:

The students will have knowledge about:

a) how to analyse work and work activities as well as how to design workplaces which promote safety, health and wellbeing for the individual and operations performance (e.g. productivity, absence of disturbances, and quality),
b) how to manage projects and change processes, especially how to integrate Ergonomics and HTO in development processes,
c) regulations and professional roles, such as consultants, experts and facilitators, and
d) the interests of different stakeholders in working life, the importance of cross-disciplinary collaboration as well as how Ergonomics specialists and practitioners may collaborate.

Table 2. Overall Learning Objectives for Each Course

Course/credits	**The students should after fulfilled course be able to:**
HTO 6 credits	• Understand and apply various HTO perspectives on operations, • Analyze the activities and jobs from different HTO perspectives, • From different perspectives propose measures to improve the interaction Human-Technology-Organization in a way that promotes human health and wellbeing, as well as the efficiency of the system as a whole.
Method 6 credits	• Understand the differences and relationships between different scientific perspectives and methods, and develop a well thought out approach to these, • Apply knowledge of how to plan an investigation and to collect, process, analyze and interpret data in different types of studies, • Master some common methods of research and investigation in Ergonomics / HTO, • Critically review research papers and studies in Ergonomics / HTO.
Cognitive ergonomics 6 credits	• Understand and practically apply knowledge of human cognitive conditions in the interaction human-machine interface, • Analyze and suggest improvements to the human-machine interface, • Understand and evaluate how the allocation of functions between human and machine affects the interaction between human-machine and system performance, • Visualize and apply cognitive aspects of an HTO analysis.

Organisation 6 credits	• Define and discuss basic concepts that deal with the construction, distribution and coordination of work, • Explain the design of the work and production system and its relationship with job satisfaction and productivity, • Suggest and motivate changes in an existing work organization with the support of the basic concepts and principles within the area, • Develop a concept for successful improvement.
Physical ergonomics 6 credits	• Understand and be able to apply knowledge of human physical capabilities, limitations and needs in working situations. • Understand the overall picture regarding the interaction between people and work, and how this affects the quality and efficiency of the system, • Understand the origins and prevention of musculoskeletal disorders, • Explain the meaning of work organization from a physiological point of view, • Perform physiological and ergonomic measurements and calculations, • Give proposals for the design of workplaces and equipment.
Project work 15 credits	• Demonstrate the ability to search for and acquire the necessary knowledge within a chosen project area, • Demonstrate the ability to professional written and verbal communication by reporting results in oral and written form, • Demonstrate the ability to critically review and discuss other project works, • Independently and in collaboration with others be able to apply the acquired knowledge and plan a project task relevant to the course.
Degree Project 15 credits	• Be able to apply relevant knowledge and skills acquired in the main field to a given problem, • Within given frames, even with limited information, independently be able to analyze and discuss complex issues and handle larger problems on the advanced level in the main field, • Demonstrate the ability to reflect upon and critically review their own and others' scientific results, • Be able to document and present their work with strict requirements on structure, format and language, • Demonstrate the ability to identify the need of further knowledge and take responsibility for own knowledge development.

ASSESSMENT IN THE MASTER'S PROGRAM

Assessment – Overview

The philosophy of the structure and teaching in the master's program described above is that the different courses are linked together through a theme from the HTO course and by the different courses "hooking" into each other regarding distinctions, interactions, perspectives, etc. This is partly reflected in the assessment methods to help the students' acquiring and applying a systems thinking and how different subsystems in the HTO-system affect the whole and vice versa.

The students' multidisciplinary backgrounds and difference in work experience call for special attention regarding what means to use to support the students' deep understanding and active learning. This difference constitutes a dynamic learning environment with high potential for collaboration and knowledge sharing across academic disciplines. The need to apply several perspectives for problem solving is also acknowledged as the program proceeds over the wide span of Ergonomics, covering human physical and cognitive aspects, human-machine interaction and organizational issues as well as the systems view of HTO. To support the

students' cross-disciplinary collaboration and individual learning processes a variety of assessment methods have been developed. In all first six-credit courses, there is a written exam to assess theoretical and applied knowledge. This exam is written in class with or without access to course literature, or at home during a limited time. Especially for home examination the students have expressed that the written exam constitutes an important learning process. The written exam is in all cases complemented by an array of other assessment methods to stimulate the development of a multidisciplinary view. These include seminars, laboratory work, as well as individual and group assignments. In the group assignments, the groups are mixed with students from the three main educational backgrounds to demonstrate the need to encompass several perspectives to understand different phenomena and to foster a multidisciplinary and systemic approach which is a cornerstone in the masters' program. For all courses, including the project course and the degree project, the learning outcome is also assessed by oral presentation. In some cases, this also includes opposition of another group's work. The project course and the degree project are also assessed through a project report.

The students have appreciated the variation in assessment methods although they expressed different personal preferences. The combination of case study analyses, reflective group assignments, seminars, laboratory exercises and final written exams in different forms has been appreciated as part of a good learning process.

Example of Assessment – the Course Organization

In the course Organization, the students' achievements are assessed through four different means: Literature assignment, discussion of recorded lectures and interviews, poster design, and written home exam. These are described below.

Literature Assignment

The assignment is based on two scientific journal articles for which the students individually reflect on ten questions. The assignment is presented in a written reflection of about 1200 words prior to a seminar, in which a selection of the questions are discussed. Grade pass/fail.

Film Discussion

The film discussion is based on five film sequences on theoretical models and an interview of an experienced change manager. The film sequences have been recorded and uploaded on a digital course platform. The students are given five questions to reflect on the film sequences, write down in bullet form (1-2 pages) and be prepared to discuss in a seminar during a course meeting. One example of a question to reflect on could be: How can you take into account motivation theories during change processes and in organizational design? Grade: pass/fail.

Poster Design

In this assignment the students work in groups of three to four students. The groups are assigned by the teachers and consisting of students with different backgrounds. The task is to design a poster on any topic which is related to the course content. It can be based on own experiences or some phenomenon that the students want to study in depth. The students are here expected to search literature outside the course literature. The poster could be designed in different ways, but the size should be at least three A3-pages. The poster is uploaded on the digital course platform and printed. The poster is also orally presented (during approx. 10 minutes) at a vernissage during a course meeting. Grade: pass/fail.

Written Home Exam

The written home exam consists of three questions of overall and reflective character. The answers are written in a digital template with predetermined maximum space of two pages for each question. An example of a question could be to discuss some organizational philosophies that have influenced the design of current production systems, in what way these philosophies have influenced the design and how the student relate to these philosophies. Criteria for assessing the exam are the student's relation to and balance between a) relevant theory and facts, b) understanding and application of theory, and c) own reflection. The exam is distributed nine days before the deadline, including two weekends to facilitate for half-time students. The written home exam is graded A-F, which is also the final grade for the course.

Example of Assessment – the Course Cognitive Ergonomics

In the course Cognitive Ergonomics, the students are examined by five assignments assessed by different methods: The assignments which are further described below consists of 1) Cognitive laboratory exercises, 2) Design of human-machine interface, 3) Hierarchical and cognitive task analysis, 4) Literature assignment, and 5) Written open book exam.

Cognitive laboratory exercises

In this assignment the students perform a number of exercises based on a software program regarding information processing in the human brain. The exercise includes e.g. 'Visual search test' and reflections on how the results from the exercises could be applied in human-machine interaction design. The assignment is conducted in groups of three students assigned by the teacher and embraces individual outcomes as well as reflections of how to interpret the outcome in group. The assignment is uploaded on the digital course platform and assessed by the teacher as well as discussed in class to make sure the students have understood how to apply the theoretical knowledge in design assignments. Grade: pass/fail.

Design of human-machine interface

The students are now prepared to implement theoretical and practical knowledge by analyzing an existing product and suggest specific improvements according to design principles. Also this assignment is done in groups of 3 students assigned by the teacher to stimulate discussion between the different backgrounds among the students. A document embracing 1000-1500 words are handed in by each group on the course platform and each group present their suggestions for other groups in seminars to discuss different design solutions. The students are given oral and written feedback. Grade: pass/fail.

Hierarchical and cognitive task analysis

This assignment includes a deep reflection regarding obtained knowledge and skills in analyzing human performance from different perspectives and suggestions regarding a redesigned product. This assessment is based on a written document (1800-2200 words) that is uploaded on the course platform and oral presentation in seminars. Grade: pass/fail.

Literature assignment

To further stimulate the students to deepen their knowledge in a specific aspect, a literature search on scientific papers in the domain is made in groups. A written analysis of two articles per group (around 1000 words) is made. The articles are presented orally and discussed in seminar groups and assessed in terms of written as well as oral presentation. Grade: pass/fail.

Written open book exam

The course ends with an open-book exam which requires that students have some depth in their theoretical knowledge and also have the ability to reflect and apply the knowledge on a deeper level. An example of a question could be: Below follows a description of accident "X". Analyze what happened on the following perspectives: a) describe the sources of error from a cognitive ergonomic perspective, b) describe the undesirable effects associated with the automation that you can derive from this example, c) describe briefly the accident based on the interaction Humans-Technology-Organization. Criteria for assessing the exam are the student's relation to and balance between a) relevant theory, concepts and models b) understanding and application of theory, concepts and models and c) critical reflection and personal reflections. The exam is graded A-F, which is also the final grade for the course.

ANALYSIS AND DISCUSSION

A master's education with a system perspective where human interaction with technology and work organizational context is studied require an extensive breadth of objective knowledge while at the same time requiring a depth of analysis, reflection and application. This requires an assessment arsenal, or palette, covering the different types of knowledge objectives described earlier for each course.

The three main teachers that are responsible for the overall planning and developing the master's program have thus put great effort in developing appropriate and varied assessment methods within and across the courses in the program. Students also have different learning styles and preferences, partly depending on their undergraduate discipline but also due to personal preferences, which further accentuates the importance of a broad approach in assessment methods. Defining the assessment methods according to Toohey (1999) shows that a variety of assessment methods are used in each course, see Table 3.

Table 3. Assessment Methods in the Courses with Toohey's (1999) Terminology

Course	Objective tests	Essay	Open-book exam.	Case & Problem -based	Pract. & Prof.	Seminars oral pres.	Oral exam	Refl. tasks
HTO				x		x		x
Res.method..	x			x		x		
Cog.Erg.			x	x		x		
Org.				x		x		
Phys.Ergon.	x			x		x		
Project course				x		x		
Degree Project				x	x	x		

Overall in the master's program, there is a strong emphasis on problem-based assessment, which encourages the development of understanding and application of knowledge. In all

courses there are also seminars and oral presentations. All these assessment methods facilitate deep learning (Toohey, 1999). In the master's program the students are involved to a high degree in their learning process, both in individual elaboration of the course content and in interaction with other students in different group tasks, and there is a great deal of group work when the students interact with each other. This in combination with problem-based tasks and distinct knowledge bases in each of the different courses highlight the complexity of real world phenomena and trigger the students to a deep learning approach (Biggs, 1989).

A challenge in developing assessment methods has been the different levels of pre-understanding that the students have in the courses, from having very limited knowledge about a certain area to sometimes being specialists in an area with thorough knowledge and work experience. The challenge is then to identify a suitable mix of assessment methods that constitute learning for all students and obtain the learning objectives regarding different learning aspect within each course according to Table 2. Therefore it is even more important to use different kinds of assessment methods, which address different depths in knowledge, understanding and application. Further, as the students are expected to relate the content of each course to a systems perspective, more than domain-specific knowledge is required. This means that even if students have more extensive knowledge in one field they gain knowledge of how it contributes to various applications of a holistic approach and those who have little pre-understanding still get sufficient knowledge and understanding to be able to apply it in different contexts.

CONCLUSION

This paper has described and reflected on the variety of assessment methods used in a master's program to fulfil learning outcomes and encourage deep learning. These include for example written exams, oral presentations, seminars, and problem based tasks, in which the students learn on an individual base as well as in group work. This palette of assessment methods are used throughout each course in the master's program and recurrently reflected upon in relation to the development of the courses and the students' learning processes. However, sometimes challenging to find assessment methods to fit students with different backgrounds, the variety of methods allows for students to demonstrate their knowledge and understanding through different means and in different contexts.

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BIOGRAPHICAL INFORMATION

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