EXPERIENCES OF AND IMPROVEMENT OF WRITING SKILLS IN A LECTURE BASED COURSE IN POLYMERIC MATERIALS

Maria Knutson Wedel

Rodney Rychwalski

Mikael Rigdahl

Johan Malmqvist

Gert Persson

Birger Karlsson

Chalmers University of Technology
Göteborg, Sweden

ABSTRACT

This paper aims to describe the development work done regarding the project Topic to Study (TTS) which intends to enforce written communication skills while simultaneously improving student working knowledge. TTS is a part of an ordinary lecture based master level polymer course assessed by a written exam; points earned from TTS are added to exam points and typically constitute 10% of total. It is a learning experience where, early in the course, participants are offered a range of topics to choose from. These are slightly more specialized than the course content and the students are expected to find the relevant information by the use of scientific literature and write a very short academic report. The improvement was made on the basis of faculty experience, course evaluations 2001-2008, programme goals, best practice from within the CDIO initiative as well as pedagogical research. Firstly, new *outcomes* for the project were stated. Secondly, *assessment criteria* were formulated and handed out to students to be brought to bear on the report. The criteria contain aspects of the technical content as well as aspects of academic writing and oral presentation. Thirdly, *actions regarding teaching approach* necessary for faculty to take on were identified concerning clarity and transparency in assessment and feed-back, specifically in order to strengthen the outcomes regarding critical thinking and judgement. Finally, the experiences from the development were written in a more generic manner and gathered in a *guide*, to be used by any faculty member, within the master programme or outside, wanting to perform a writing project in a traditional lecture based "knowledge transfer" course.

KEYWORDS

CDIO, development, written communication skills, write to learn, best practice

BACKGROUND

The reasons for students to perform a writing project in an engineering course are manifold. Basically there are two main aspects. Firstly, the students can be *writing to learn*, using the process of writing to achieve a deeper working knowledge. The result is often positive even if it is claimed that the actual cognitive process is complex; even though since long studied,

more knowledge is probably needed to fully understand the these processes [1]. Secondly, it can be claimed that the students are **learning to write**, learning the skill of writing in the disciplinary context. The CDIO-concept stresses the importance of integration, as pointed out in CDIO standard seven; Integrated learning. This means that communication skills are to be trained in the engineering context, which is clearly stated to be of pedagogical benefit [2,3]. The possible benefits are more; Brew [4], for instance, claims the importance of bringing the students into the research paradigm. She suggests a new model of relationship between teaching and research which replaces the concept of scientific discipline by academic communities of practice where teaching is student-focused, concentrating on conceptual change within a learning milieu intertwined with the research milieu. The students can be regarded as apprentices.

Even though there are many benefits with writing projects there are some issues to regard. As with all learning experiences it is important to be aware of the intended learning outcomes, design an appropriate support to facilitate learning and make sure that assessment is constructively aligned [5]. It is not uncommon that students experience writing tasks in engineering education set up without support or formative feedback or with intentions and assessment unclearly described. It is clear that support to faculty on integrating generic engineering skills, like communication skills, have the potential to improve learning further. According to the number nine and ten of the twelve CDIO standards, possibilities for faculty to develop their competencies is something that is important in a CDIO-inspired environment [2]. As a part of the continuous competence development, faculty could also actively share their experiences and practices with each other.

This paper aims to describe the development work done regarding a writing project performed within an advanced level polymer course. More specifically the remainder of the paper is structured as follows:

- The TTS project, prior to development, is described in more detail
- The process of change is described starting with a chapter on analysis regarding teaching, learning, course evaluations 2001-2008 as well as TTS outcomes in relation to the CDIO-based programme goals. This is followed by a presentation of the new changes to improve the learning.
- A short evaluation is made of the first year of implementation of the reformed project
- A more generic teaching aid package developed on the basis of this specific project is presented

THE PROJECT "TOPIC TO STUDY" (TTS)

The project TTS is performed in a course aimed at polymer education: *Engineering polymers (MPM080)* at Chalmers University of Technology. The course was previously given within a 1½ year international master's programme. Since 2007 and the change to the 3+2 (BSc + MSc) Bologna system, it is set within the master's programme Advanced engineering materials (MPAEM). This programme is international but also forms the last two years of the 5 year Swedish "civilingenjör"-degree. The "Civilingenjör" (MScEng) programme of mechanical engineering, which hosts the MPAEM, has undergone a complete process of change during 2000-08 into a CDIO-based programme, and the MPAEM programme started in the spirit of CDIO as described elsewhere [6]. However, the students are enrolled with their BSc degree from mechanical or chemical engineering, engineering physics, technical design, materials science, metallurgical or polymer engineering and have thus varying background in terms of CDIO-competencies.

The TTS project is part of a traditional lecture based course concluded by a written exam; points earned from TTS are added to exam points and typically constitute 10% of the total

amount of point needed to pass the exam. The module has been running since 2000 and is a learning experience, where early in the course; participants are offered a range of topics to choose from. These are slightly more specialized than the course content and the students are expected to find the relevant information by the use of scientific literature. The topics could be defined as:

- modern topics/trends in polymers research and/or industry e.g. "Polylactic acid - a polymer from renewable resources" or "Polymers containing nanotubes - a new generation of composites"
- fast lane advanced polymers e.g. "High-modulus polyethylene - a poor man´s Ferrari?"
- actual theories and characterizations e.g. "Free volume/PALS - what is the importance for polymers?"

The assignment is performed in groups of 3-4 students and the teachers supply coaching and feedback when asked for. The assessment is written and oral; the resultant literature survey is presented by means of a very short written report (700-1000 words) and a short oral presentation of only 5 min to the class at a mini-conference organized at the end of the course. The intention of having the report very brief is to give the students an opportunity to train on finding the essential knowledge, the most important out of a larger supply of information, and create short written and oral presentations common in an industrial engineering context. The limitations to the learning experience are set as follows:

- TTS is a polymer science and engineering exercise and not any other one. e.g., it is not a mechanics of materials exercise
- TTS can have various forms: e.g. compilation of existing knowledge
- TTS can include ethical/societal/environmental issues
- TTS shall report and briefly discuss
- TTS is not meant to be in-depth mini-publication
- TTS is not a report with innovative ambitions towards new business

The purpose of TTS from the beginning was to provide a learning experience that would give the students a possibility to view the core engineering subject from a new perspective. The students shall be able to go more into depth into the polymer discipline and deal with a selected research or engineering specific topic extending the course material though broadly connected. The project will provide motivation, variation in forms of teaching and professionally relevant outcomes of the teaching & learning process. For many of the students the project is a final, 'crown' activity in polymers education. As a result students will understand that the course is a 'scientifically living platform' a field where world-wide research takes place at cutting-edges. Particularly important intended learning outcomes identified from the beginning was individual research thinking, introduction to scientific papers and more reading, building up on scientific platforms, witnessing that scientific progress is achieved with 'tools' discussed in course as well as presentation and listening, critique and feedback.

EVALUATION OF THE TTS PROJECT

Over the years faculty experience has been that the TTS project works out, the students do their writing at the expected level of proficiency and there are no complaints. However, as all learning activities often have a potential for development, it was supposed that a thorough examination concerning alignment of learning outcomes, assessment and activity would improve the project.

From the students' point of view the learning experience was found to be satisfactory but the course evaluations showed that students over the years grade TTS to be slightly less rewarding compared to the course on the whole and not fully reaching the intended learning outcome "to bring the students further into the world of polymers", see table 1. It has to be noted though, that the questionnaire item on TTS is not strictly asking for evaluation of the activity. In addition, TTS was subjected to remarkably few comments. While students often had various comments on the course, they did not comment on TTS (the only comment ever made was that more time (>7 min) should be allocated for presentation of TTS. It is still not clear why this project work raised so few comments. It is a demanding experience in terms of time spent and the scientific literature is different from the usual text books.

Table 1
Results from course evaluations 2001-2009 regarding TTS and the course on the whole

Year	Question: *Has TTS brought you further into the world of polymers? (% of all replies)*			Question: *Would you recommend the course to other students? (% of all replies)*		
	Yes	Hesitant	No	Yes	Hesitant	No
2001-2002	46	46	8	63	31	6
2002-2003	62	34	4	76	24	--
2003-2004	43	43	14	43	43	14
2004-2005	57	21	22	62	38	--
2005-2006	55	45	--	100	--	--
2006-2007	78	5	17	83	13	4
2007-2008	73	20	6	80	6	13
Afterwards						
2008-2009	70	20	10	90	10	---

From the point of view of programme curriculum and goals, the TTS experience addresses several of the important generic skills pointed out in the CDIO syllabus. During the design and implementation of the MPAEM curriculum 2006, specific emphasis was placed on considering CDIO-based programme goals, formulating course learning outcomes and ensuring integration of personal and interpersonal skills [6]. The resultant programme goals are shown in appendix A. As part of the continuous curriculum development it was also seen as important to investigate whether it was possible to improve the TTS project.

Evaluation of the TTS in context of the above programme goals showed that specifically five were addressed to some extent by the TTS namely, 2.4, 2.5, 2.8, 3.1 and 3.3:

1. create, analyse and critically evaluate different technical solutions
2. critically and systematically integrate knowledge and predict and evaluate material behaviour and events, also with limited or incomplete information
3. communicate, in a dialogue, their conclusions and the rationale underpinning these, to both specialists and non-specialists, nationally and internationally, based on fundamental concepts, results from material characterisations or theoretical predictions
4. formulate judgement concerning selections of materials or development of new materials that include reflecting on scientific, social and ethical responsibilities and to demonstrate awareness of ethical aspects on research and development work
5. draw conclusions showing insight into the possibilities and limitations of materials science, its role in society and the responsibility of humans for its use, applying social, environmental and ethical considerations

The first two goals concern the technical aspects of TTS; it might involve analysis of technical solutions or techniques used in materials science or predict or evaluate materials behaviour in a specific setting. The third concerns the actual communication part, technical writing and oral dialogue, with an audience of peers from an international community. The fourth and fifth goals are both not purely technical but intertwined with societal and sustainable aspects e.g. judgements, societal or ethical considerations

DEVELOPMENT OF THE TTS PROJECT

After evaluation different aspects of the TTS experience was improved; outcomes, teaching approach and transparency in assessment criteria. Based on the evaluation in context of the programme goals above, the following further limitations or requirements were formulated for the TTS:

- TTS report and presentation is an exercise to integrate the knowledge in the topic field
- TTS report should be based on published scientific results, may include ethical aspects, and students should comment on the importance of such research for the society
- TTS report and presentation should be constructed from fundamental concepts, results from material characterisation, theoretical predictions and the like
- If and when material judgement is involved then, generally, a reflection/awareness of scientific, social and ethical responsibilities is important. Particularly, such judgement would seem compulsory for novel materials in TTS. However, due to the shortness of the projects as well as likely inexperience in this matter, the team could include this discussion, but this is not a strict requirement.

Even though the programme goals mentioned above are met to a larger extent after the reform, it has to be noted that the outcomes for the experience are yet to be explicitly outlined as "the student should be able to..".

In addition to clarify which learning outcomes that are addressed and the accompanying requirements of the project, considerate attention was placed on analysis of how the experience could become more appreciated and to a higher degree help to reach intended learning outcomes. In a previous CDIO-project students were interviewed regarding their learning approach and the results compared to pedagogic literature on surface and deep approaches to learning. The resultant "list of 10 requests from students" conveys a compact list of good ideas whereof "Make sure students know exactly what is expected of them. Produce explicit criteria for assessment" is one [7]. Foundation for Critical Thinking has developed guidelines for engineers to critically evaluate their own writing [8], and pedagogic research point in a direction that supports the idea of transparency in assessment would facilitate learning [9]. For TTS, clearer criteria for the students to follow were thus one of actions chosen. **Assessment criteria** were brought to bear on the TTS written report and oral presentation, where both activities were necessarily evaluated per team and not per individual student. The criteria contain both aspects of the technical content as well as aspects of technical writing. The following list was handed out to the students:

- is the material 'on track', clearly organized/structured and within limits? (number of words)
- is there an attempt made to integrate the knowledge in the topic field?
- is the work dealing with the topic using polymer science and engineering methods/platform?
- is the coverage of the topic field comprehensive and complete?

- has the group shown (some) knowledge of relevant literature and judged well in choosing the references? (titles of references must be given)
- do students comment on the importance of such research for the society?
- are conclusions included, and what is their quality in the report and presentation?
- are the authors rights to figures observed in the report?
- what was the graphical impact of the report and presentation?

In addition to the new outcomes and the criteria handed out to the students, several **actions regarding teaching approach** were taken in order to facilitate reaching the intended learning outcomes by the students. The basis for the actions taken was mainly experience from the previous eight years, where explicitly it was found important that the task should be set early in the course, as it was found to be of importance for students to finish the project in due time before the exam. In addition students need to know what they should expect, not expect, and experience partnership. The changes were again related to clarity and transparency regarding assessment and feed-back and specifically actions taken in order to strengthen the intended outcomes regarding critical thinking and judgement. The actions were gathered in a Guide, to be used in a more generic teaching aid package as described below.

DEVELOPMENT OF A MORE GENERIC TEACHING-AID

As a result of the work with TTS it was possible to develop an adaptable teaching-aid package, to be used by any faculty member, within the master programme or outside, wanting to include a writing assignment in a traditional lecture based "knowledge transfer" course.

As a way of improvement suggestions are proposed regarding (i) a change of course time plan, (ii) guidelines for teachers (*Guide)*, (iii) criteria for students (*Criteria)* and (iv) implementation/realization (*Outcomes)*. The main suggestions are as follows:

(i) to set the activity **early** in the course

(ii) Be inspired by the proposed teaching approach **Guide in table 2**. Students need to know what they should expect, not expect, and experience partnership feeling among themselves and with lecturer. The guide contains advice to set clear expectations about the student´s writing and presentation, explicit guide on what you can or hope to provide for the supervisee as well as what is not provided. In addition some suggestions are given on how to improve partnership.

(iii) **Assessment criteria** are helpful to be brought to bear on the written report and oral presentation where both activities will be evaluated per team and not per individual student. We suggest to hand out the assessment criteria, also incorporating students' ability of critical thinking, to the students,.

(iv) The intended learning **outcomes** should include generic skills, derived from programme goals.

EVALUATION AFTER RUNNING THE REFORMED TTS 2008-2009

Faculty experience was positive, especially it was noticed that the general level of proficiency was greatly increased regarding both oral and written presentations. This was also noted by other faculty members in a parallel course.

Table 2
Proposed guide for faculty to use in implementation of writing assignments

GUIDE

Students need to know what they should expect, not expect, and experience partnership:

1. Set clear expectations about the student´s writing and presentation:

- number of pages/words
- when written work is expected
- date for oral presentation
- clarify that every member of project team will be presenting
- set date when feedback on written report and presentation will be ready
- clarify whether students should keep back-up copies
- inform if you plan to keep supervisory record (from the course of *TTS*, from presentation, from written report, from perhaps questions and discussions)

2. Be as explicit as you can what you hope to provide for the supervisee:

- methodological help
- structuring the report
- advice on the literature search
- theoretical ideas
- help with computing
- visits (if fieldwork is involved)
- hand-on help with equipment
- practical tips

3. Be as explicit as you can what you cannot or will not provide:

- *e.g.,* email supervision
- *e.g.*, language correction, stylistics and spelling

4. Elements of partnership:

- encourage training of judgement: *e.g.*, read each other's work
- ask for their critical opinion: *e.g.,* on the references they used
- reflect to students that likely they will face the need to 'sieve off' some omnipresent and ubiquitous 'noise knowledge' and this will help sharpening and making the report and oral presentation attractively terse
- more partnership, e.g., ask for a couple of suggestions towards next year topics

The course evaluation, see table 1, was somewhat disappointing, not showing any difference, but the overall evaluation of the course seemed to have slightly increased. The statistics of the course evaluation is uncertain though, since the ratio of students answering this year was much lower than usual owing to a change from paper to a computerized system. A positive sign was that 100% of the respondents graded the Assessment criteria as very useful. An

improvement for next year will be to formulate the intended learning outcomes more explicitly and in an active manner.

ACKNOWLEDGEMENTS

CONCLUDING REMARKS

This paper describes the development work done regarding a writing project performed within an advanced level polymer course. Specifically

- It was found useful to express the limitations or requisites of the assignment and analyse from the aspect of programme goals in order to include appropriate generic skills in the intended learning outcomes. The evaluation after implementation seems to be positive.
- Assessment criteria were formulated and made transparent, handed out to students to be brought to bear on the report. The criteria contain aspects of the technical content as well as aspects of writing.
- Actions regarding teaching approach were identified. Explicitly it was found important that the task should be set early in the course, students need to know what they should expect, not expect, and experience partnership.
- A guide was proposed, gathering the experiences in a manner useful to faculty members

REFERENCES

[1]   Klein P.D., "Reopening Inquiry into Cognitive Processes in Writing-To-Learn", Educational Psychology Review, Vol. 11, No. 3, 1999, pp. 203-270

[2]   Crawley E., Malmqvist J., Brodeur D. and Östlund S. Rethinking Engineering Education - the CDIO Approach, Springer-Verlag, New York, 2007

[3]   Barrie S.C., "A conceptual framework for the teaching and learning of generic graduate attributes", Studies in Higher Education Vol. 32, No. 4, 2007, pp. 439–458

[4]   Brew A., "Teaching and Research: New relationships and their implications for inquiry-based teaching and learning in higher education", Higher Education Research & Development, Vol. 22, No, 1, 2003, pp. 3-18

[5]   Biggs J., Teaching for Quality Learning at University, 2nd ed. The Society for Research into Higher Education and Open University Press, Berkshire, England, 2003

[6]   Knutson Wedel M., Malmqvist J. and Goodhew P., "CDIO Applied in the Context of Materials Science" In proceedings of 3rd Annual CDIO Conference, MIT, Cambridge, Massachusetts June 11-14 2007 (on CD or www.cdio.org)

[7]   Edström K., Törnevik J., Engström M. and Wiklund I., "Student Involvement in Principled Change: Understanding the Student Experience", Proceedings of the 11th International Symposium Improving Student Learning, OCSLD, Oxford, England 2003 www.cdio.org

[8]   Paul R., Niewoehner R. and Elder L., The Thinkers Guide to Engineering Reasoning, Foundation for critical thinking, 2006

[9]   Rust C., Price M. and O'Donovan B., "Improving Students' Learning by Developing their Understanding of Assessment Criteria and Processes", Assessment & Evaluation in Higher Education, Vol. 28, No. 2, 2003, pp. 147-164

Graduates should be able to independently and professionally participate in and manage projects concerning aspects of materials in conceiving, designing, implementing and operating products, processes and systems. They should also be able to independently and professionally participate in and lead industrial or academic materials research.

1. **KNOWLEDGE AND UNDERSTANDING:** Graduated students should be able to:
   1.1. attain a basis of deep disciplinary knowledge to be able to recognise and describe properties for metals and explain how these are coupled to the structure at an atomic as well as microscopic scale
   1.2. attain a basis of deep disciplinary knowledge to be able to recognise and describe properties for polymers and explain how these are coupled to the structure at an atomic as well as microscopic scale
   1.3. attain a basis of deep disciplinary knowledge to be able to recognise and describe properties for ceramics and explain how these are coupled to the structure at an atomic as well as microscopic scale
   1.4. evaluate and draw conclusions concerning different materials' fields of application based on knowledge of material properties
   1.5. explain how different processing methods can influence the structure of a material and whereby its properties
   1.6. describe and draw conclusions based upon the scientific foundation and proven experience of materials science as well as show insight into current research and development work
   1.7. demonstrate knowledge and understanding that is founded upon and extends the learning objectives for materials science, mathematics, applied mechanics, manufacturing technology and thermodynamics associated with bachelor's level
   1.8. *For Engineering Materials:* apply fundamental concepts concerning materials' behaviour at the microstructural scale in improving mechanical properties of the material, joints between materials or a resultant product
   1.9. *For Functional Material:* describe and discuss concepts concerning materials' electronic, optical and magnetic properties on nano- and microscale in applications where these properties are of primary interest
   1.10. *For Materials and Manufacturing:* describe and choose methods for machining and joining for different materials and discuss influence of different manufacturing parameters on materials' resultant behaviour on both micro- and macroscale
   1.11. *For Materials and Applied Mechanics:* compute and dimension for safety, perform simple simulations using constitutive models being aware of the differences in material behaviour, ageing, and failure on a mesoscopic and a macroscopic scale

2. **SKILLS AND ABILITIES:** Graduated students should be able to:
   2.1. critically, independently and creatively conceive, design, implement and operate products, processes and systems such as design of materials, materials selection, failure analysis and prediction of properties.
   2.2. describe, address applicability of characterisation methods and within given constraints plan and carry out qualified tests using e.g. hardness measurements, tensile testing, optical, scanning electron and transmission electron microscopy or X-ray, Auger or ESCA analysis
   2.3. participate in research and development to create new knowledge and develop originality in ideas.
   2.4. create, analyse and critically evaluate different technical solutions
   2.5. critically and systematically integrate knowledge and predict and evaluate material behaviour and events, also with limited or incomplete information
   2.6. consider relevant scientific, societal and ethical aspects fulfilling human needs and the society's goals for sustainable development in the context of materials science
   2.7. work with projects in a group, solving open problems while being aware of different stages in project work and group dynamics
   2.8. communicate, in a dialogue, their conclusions and the rationale underpinning these, to both specialists and non-specialists, nationally and internationally, based on fundamental concepts, results from material characterisations or theoretical predictions

3. **FORMULATION OF JUDGEMENT AND ATTITUDES:** Graduated students should be able to:
   3.1. formulate judgement concerning selections of materials or development of new materials that include reflecting on scientific, social and ethical responsibilities and to demonstrate awareness of ethical aspects on research and development work
   3.2. demonstrate insight concerning consequences for manufacturing, product behaviour and environmental load during the full life cycle
   3.3. draw conclusions showing insight into the possibilities and limitations of materials science, its role in society and the responsibility of humans for its use, applying social, environmental and ethical considerations
   3.4. identify their need for more knowledge, and to continuously develop their competence

Biographical Information

Maria Knutson Wedel is a Professor in Engineering Materials and Coordinator of Advanced Engineering Materials Master´s Programme at Chalmers University of Technology, Göteborg, Sweden. She has been working with application of CDIO at Chalmers since 2002. Her teaching area is Materials Science as well as Environmental adaptation of products.

Johan Malmqvist is a Professor in Product Development and Dean of Education at Chalmers University of Technology, Göteborg, Sweden. His current research focuses on information management in the product development process (PLM) and on curriculum development methodology. He served as Co-Chair of the 3rd International CDIO Conference.

Rodney Rychwalski is a Professor in Polymeric Materials and Composites, previous coordinator for the International Masters' Programme Advanced Materials at Chalmers University of Technology, Göteborg, Sweden. His teaching area is polymer science and engineering.

Mikael Rigdahl is a Professor in Polymeric Materials at Chalmers University of Technology, Göteborg, Sweden. His teaching area is polymer science and engineering.

Gert Persson is a Ph.D in Mechanics and Vice Head of Department of Materials and Manufacturing Technology at Chalmers University of Technology, Göteborg, Sweden. His research is within mathematical modeling of Nondestructive Testing (NDT) and his teaching area is Theoretical and Applied Mechanics.

Birger Karlsson is a Professor in Engineering Metals with research mainly focused on mechanical behaviour of various materials.

Corresponding author

Maria Knutson Wedel
Department of Materials and Manufacturing Technology
Chalmers University of Technology
SE-412 96 Göteborg, Sweden
Tel: +46(0)317721533
e-mail: maria.wedel@chalmers.se