Learning by doing

Improving academic skills

http://dx.doi.org/10.3991/ijep.v3i3.2827

Katrin Temmen, Thomas Walther
University of Paderborn, Paderborn, Germany

***Abstract*—Engineering faculties generally involve their students in the creation of numerous scientific works and publications. However, students are rarely trained in this area and could well benefit from targeted support: to this end, we propose a specific lecture that addresses the subtleties of scientific research and writing and allows the students to apply and mentally anchor their acquired knowledge while composing a basic scientific term paper.**

***Index Terms*—student-centered/peer group-based learning, academic skills**

I. INTRODUCTION

Although generally well trained in scientific theory, many engineering students experience major obstacles while attempting to apply their knowledge to written scientific works (e.g., progress reports, term papers, or bachelor/master theses). The causes are numerous: lacking communication (e.g. with a supervisor), the tendency to procrastinate, or inefficiency in literature research are some representative examples. These issues seem so much more problematic since there is a fair body of literature on appropriate scientific writing (see, e.g.,[1], [2] or [3]).To explain this apparent antagonism, it can be noted that on one hand their previous educational track hardly required engineering students to address such material. On the other hand, students very rarely need to deal with the subtleties of scientific writing until they have to compose their first important academic work, e.g. their bachelor or master thesis. To help amend this situation, colleagues are beginning to offer specific courses for acceptable scientific practice, or are at least trying to address this topic from within the framework of other lectures. This strategy doubtlessley offers a good starting point; however, we propose to underpin the theoretical knowledge taught in such settings with continued practical experience. Our lecture 'Anleitung zum wissenschaftlichen Arbeiten' ('Introduction to Academic Working Practice') [4] allows our students to test their freshly acquired knowledge in a 'safe area', training their abilities in scientific research and writing step by step.

II. OUR APPROACH

In the lecture, we initially provide each student (electrical, mechanical, or chemical engineering, class size about 15-20 students) with an individual 'working topic'. In contrast to [5] each topic is kept scientifically basic, yet being complex enough to allow practical application of the techniques presented during our course; as typical topics, we use biographies and/or outstanding inventions of famous scientists. At the end of the lecture, the students are requested to submit a short (about 8 pages) term paper on the selected topic and to give a 10-minute presentation describing their experiences and/or difficulties they experienced when preparing the term paper. In the course of the lecture, the term paper should be established in an iterative two-step procedure loosely following ideas of 'instructivism'[6] and 'constructivism' [6]: firstly, the advisor presents a specific topic related to appropriate scientific practice, such as literature research ('instructive' phase). Secondly, the students improve their current knowledge base by practically applying these theories in their work on the assigned topic ('constructive' phase). To keep the scope of the course manageable, we focus the instruction on the baseline elements of scientific writing, including (from [4])

1. definition of science and criteria of scientific quality
2. planning a scientific publication
3. efficient literature research
4. appropriate composition of scientific publications
5. scientific presentation guidelines

After discussing step 2, students are expected to do the practical planning for their own topic and the corresponding term paper. Step 3 allows them to train literature research using standard library catalogues or the World Wide Web. Step 4 is quite central to our lecture; here, the students learn how to actually 'put together' previously acquired information and develop their paper drafts to comprehensive article texts. Simultaneously, scientific presentation techniques are being taught in class (step 5). After the last class session, students are given extra time to finish their papers and prepare their talks, which will then be given in front of an audience made up of their classmates.

III. COLLECTING FIELD DATA

When putting the above theory into practice, we made several interesting observations and discoveries::as expected, many bachelor candidates participated in our 'safe area'-lecture to acquire basic scientific writing skills and become prepared for their bachelor theses. Nevertheless, several master/diploma students joined our course as well to improve their scientific writing/working skills and facilitate their further academic track. Thus, continuous training in scientific working practice seems important throughout the entire academic career. In fact, repeated participation in appropriate courses keeps the students' knowledge in this important field up-to-date and ensures the creation of easy-to-read and scientifically profound academic literature.

A. Peer-group discussions

During our course, it was quite stunning to observe the broad spectrum of experiences reported by the participants. While most of these experiences left their mark on the final talk session (see below), interactivity during the lessons allowed our students to discuss pressing issues with their peers and/or the tutor directly and prompted numerous interesting debates related to e.g.

- **Situations incurred by lacking primary literature**: Quite inherent to the selection of our working topics, older primary literature may indeed be 'hard-to-get', and our students had to learn how to find secondary sources and handle them in an adequate manner.
- **Generic citation issues**: Several questions about quantity and qualification of citation tags evolved during the lessons. With respect to citation quantity, an initial too 'minimalistic' tendency was sensed among our students and could directly be countered by the introduction of more 'complete' citation policies.
- **International literature**: Since several of our students joined the lecture with little or no prior experience in academic working practice, they seemed hardly prepared for English literature research. Thus, they often enough tried to resort to native (i.e. German) literature. While this practice works for some of the given working topics, it is definitely unacceptable w.r.t current academic exigencies. So the course members were encouraged to apply/step up their English language skills and broaden their knowledge base by delving into international scientific literature.

B. Presentation topics

Going beyond such spontaneous discussions, our students had to present their experiences in a final talk. As each presentation had to be held in front of the other course participants, benefit was gained from subsequent discussion. While many of the problems addressed in the talks had been anticipated, others appeared unexpectedly; the following enumeration yields a compact overview of the most frequently disputed issues:

- Although modern information technology provides a variety of convenient ways for data mining, some of our students reported significant inefficiencies when it came to literature research for their working topics: here, original literature could hardly be found in electronic form, or the retrieved results were meaningless for the targeted seminar paper. Thus, the students concerned were urged to resort to more 'traditional' literature sources, e.g.by browsing the university library.
- Presentation tools like 'mind maps' [7] or effective project management techniques (e.g. 'Gantt'[8] diagrams or the like) are rather widespread in business science, nevertheless, they are typically not in the focus of engineering studies. Hence, several talks were geared towards issues on the construction of comprehensive and visually appealing mind maps. Interestingly, hand-written sketches were not completely abandoned in mind map assembly; taking the step from free-hand to CAD construction (e.g. with the 'FreeMind' [9] system) turned up as an important experience. Furthermore, some students discussed the role of mind mapping as a golden thread in the concrete planning of their excerpts and made intense use of available CAD methods to set up purposeful mind map representations for their working topics.

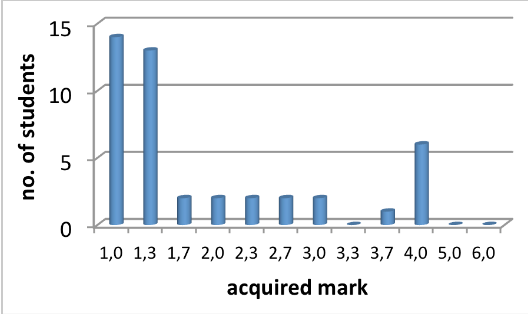

Figure 1. Number of students (total: 44) vs. acquired marks, figures sampled from three academic terms.

Other talks aimed at the creation of efficient project management timetables. Most interestingly, several students had to realize that their well-formed timetables did not work out (due to unexpected disturbances) and had to be accommodated 'on-the-fly'. Discussion of this important experience was of great use not only for the students affected by such issues, but also for the whole engineering audience: testing and discussing project alteration strategies informally in our 'safe area' primed the students with knowledge that might come in handy in 'real-world' (e.g. industrial) project management situations.

- Language issues seem an often-neglected topic in scientific paperwork/presentations. However, adequate linguistic formulation is vital to ease reading and facilitate the understanding of complex academic contents. Surprisingly, some course participants reported significant difficulties with native English literature and reviewed this issue during their presentations. To counter such language problems, we recommend intensifying English language practice throughout the course studies, e.g.by introducing a larger number of English lectures or by urging the students to participate in (technical) language training courses. Going beyond these 'foreign language' issues, the transformation of colloquial German sentences into statements meeting basic linguistic criteria (as taught in the lecture) turned out to be another interesting presentation topic and revealed the importance of precise and meaningful phrasing in academic writing.

C. Analyzing typical stylistic pitfalls

While scientific paperwork is generally peppered with issues related to factual correctness, our students were not urged to step into technical details and thus had the chance to focus on the stylistic propriety of their term papers. However, many of the participants faced this task for the first time and, in consequence, stylistic issues turned out to be a major topic. Without claiming completeness, the following enumeration yields an overview of some typical manifestations of semantic/stylistic bugs:

- Digging deeper into the given working topics often caused our students to set up too complex sentences, resulting, for instance, in 'wrong references'. These imperfections showed unexpected potential to screw basic statements of the written tract. In addition, inept use of punctuation hampered easy reading; in marginal cases the meaning of complete sentences was negated by the wrong use of commas. Hence, we advised the participants to keep their statements as compact as possible to ease reading and facilitate understanding.

- While modern text processors are standardly equipped with real-time or post-processing correction engines, a substantial number of spelling errors remained in the submitted papers. Here, a broad spectrum of faults could be observed, running from occasional typos to severe orthographic/grammatical flaws. In anticipation of such issues, we continuously encouraged our students not only to rely on automatic correction tools, but also to double-check their written work and, in best case, to have 'externals' check the final paper for adequate grammar and orthography.
- As some of the course participants had to operate on a scientific paper for the first time, correct typesetting of formulae and/or images turned out to be unexpectedly difficult. Though the students were not asked to derive complex mathematical relationships in their work, insertion of at least one formula and one image was mandatory; while contemporary text processing systems inherently offer appropriate formatting tools for both entities, the corresponding software mechanisms must be thoroughly trained. Without such training, wrong indices (formulae), inconsistent notation (formulae) or missing/undescriptive subtitles (formulae/images) become likely and might easily degrade the overall scientific quality of the given work.
- Facing the multitude of technical difficulties to be explained in scientific paperwork, appropriate handling of language issues often goes by the board. Such practice though paves the way for semantic constructions that are hardly adequate in academic writing. To be more precise, ordinary language should not slip into proper scientific tracts, and so we urged our students to take extra care of such nasty flaws and avoid 'slang' expressions to the utmost possible extent.

Despite the above admonitions, a non-negligible number of semantic/stylistic issues generally remained in the final term papers. Uncovering these flaws, we invited our students to profit from an individual discussion of their work; hereby, each participant was given the chance to receive extended feedbacks on her/his presentation and to thoroughly analyze semantic/stylistic bugs observed in the seminar paper.

While this practice helped consolidate acquired academic working skills directly in the aftermath of the lecture, we recommend installation of a more extended, continuous mentoring program in scientific working. By that, the students' knowledge in this important field would be kept up to date and could be fine-tuned to the specific needs of the curriculum. We are currently thinking of setting up such continuous training programs inside our new 'Lernzentrum Elektrotechnik' ('Learning Center for Electrical Engineering Students'), which is briefly presented below.

IV. INTRODUCING THE 'LERNZENTRUM ELEKTROTECHNIK'

Contemporary curricula generally confront electrical engineering students with a permanently growing amount of domain-specific knowledge. However, the currently applied ex-cathedra teaching style does neither consider individual learning preferences nor encourages the students to discuss their ideas and exchange information in order to consolidate acquired knowledge.

To amend these drawbacks, our learning center steps into the breach: the basic idea is to set up a technically well-equipped boardroom environment allowing our electrical engineering students/course members to gather in a convenient environment with the chance to exchange their thoughts and possibly engage complex academic tasks within an evolving peer group.

Furthermore, the extended presence of a qualified research assistant ensures adequate supervision and allows possible addressing of topics not fully understood in the lectures. However, our supervision does never aim at providing complete solutions to complex exercise courses; instead, we stick to the maxim 'learning by doing' and guide the students to find required answers themselves. To that end, we explicitly take care of different learning types: though peer-group learning is encouraged, individual learners are equally welcome to work in a calm, protected atmosphere, and, ideally, to eventually join one of the surrounding work groups.

Beyond the above efforts, the learning center provides an adequate basis for talk sessions or discussions on advanced topics. Within this convenient infrastructural framework, a voluntary refreshment course in scientific working could well complement the original lecture on a monthly basis, including short presentations given by all volunteers. Facing the good resonance to our 'Anleitung zum wissenschaftlichen Arbeiten', this idea does not seem too idealistic.

V. RESULTS

Positive results of our 'learning by doing' approach could be observed directly: the constructive phases allowed the students to practically apply learned theories and, at the same time, urged them to overcome difficulties typically inherent in the creation of scientific (paper)work. While the latter issue was mainly handled on an individual basis (e.g. by literature work or discussions with the advisor), it also caused vivid peer-discussions in the lessons and after the talks, thus generating a major benefit for all participants. Collegiate feedback was quite positive and mainly geared towards the chance of practicing the students' scientific working/writing/presentation skills in a 'safe area' prior to beginning major scientific compositions (e.g. bachelor/master theses). The results from the combined (presentation/seminar paper) exam were, in general, of acceptable quality (fig. 1) showing the students' interest in the topic. As an additional motivation, our lecture was designed as part of the so-called 'studium generale', offering 3 ECTS credit points for successful participation.

VI. CONCLUSION AND OUTLOOK

As the lecture 'Anleitung zum wissenschaftlichen Arbeiten' did evoke significant resonance among our engineering students, we deduce that such courses are strongly demanded by the students and could well be extended: while courses spanning a single semester are well-suited to prime the scholars with basic knowledge of scientific working practice, a cyclic update of such knowledge seems inevitable. To that end, continuative lectures lend themselves, possibly as a compulsory part of the curriculum.

However, notwithstanding the positive results above, we can state that plenty of work still remains to be done:

- The rather qualitative observations made during the lecture have to be underpinned, e.g. by having the participants fill in appropriate questionnaires, for a valid quantitative analysis of the students' opinions.
- It should be checked if the lecture truly improves the students' skills in scientific working. To that end, exam (e.g. bachelor/master thesis) results could be quantitatively evaluated, ideally revealing a positive correlation between lecture participation and increasingly better marks.
- The endowment of our learning center could be well enhanced: a dedicated reference library would enable the course participants to assess a broader range of information and simultaneously complement mandatory access to the university library.
- One important topic currently underrepresented in our lecture is the adequate handling of modern text processors. For this, several alternative systems should thoroughly be discussed, letting the students opt for the ideal tool. However, such elaborate discussions take up plenty of time and would possibly exceed the lecture's scope. Therefore, a self-contained, additional course on the 'text processor' topic might be set up in the near future.
- In the more distant future, however, the installation of common standards in scientific working seems a desirable goal. To that end, different faculties/universities could cooperate by exchanging domain knowledge and/or employing conjoint lecture notes. We assume that such functional homogenization is likely to result in a significantly increased quality of future scientific tracts.

We finally conclude that our lecture 'Anleitung zum wissenschaftlichen Arbeiten' constitutes an adequate approach to enhance our engineering students' skills in academic working. Certainly, other faculties (cf.e.g. [10]) provide similar ideas, yet our method takes sort of an island position by complementing ex-cathedra teaching with constructive elements specifically suited for engineers. In addition, our 'learning by doing' scheme allows the students to directly consolidate acquired information and benefit from peer-group discussions. Notwithstanding these positive aspects, it must be clearly noted that our lecture might be enhanced according to the ideas presented above; however, these enhancements cannot be jump-started and shall be installed bit by bit in the course of the following terms.

REFERENCES

[1] H. Balzert, C. Schäfer, M. Schröder, U. Kern, *Wissenschaftliches Arbeiten – Wissenschaft, Quellen, Artefakte, Organisation, Präsentation*.: W3L-Verlag, 2010.

[2] M.R. Theisen, *Wissenschaftliches Arbeiten – Technik – Methodik – Form*. München: Verlag Vahlen, 2009.

[3] W. Rossig, J. Prätsch, *Wissenschaftliche Arbeiten – Ein Leitfaden für Haus- und Seminararbeiten, Bachelor- und Masterthesis, Diplom- und Magisterarbeiten, Dissertationen*.: Print-Tec Druck und Verlag, 2008.

[4] K. Temmen, "*Anleitung zum wissenschaftlichen Arbeiten*," 2012.

[5] A. Perdigones, J.L. Garcia, V. Valino, C. Raposo, "*Assessing heterogeneous student bodies using a methodology that encourages the acquisition of skills valued by employers*", Assessment & Evaluation in Higher Education, Vol. 34, No. 4, pp. 389-400, 2009 http://dx.doi.org/10.1080/02602930802071056

[6] Z. Bulbulia, C. Blewett, R. Quilling, and P. Kanyiwamuyu, "*Student challenges in a virtual collaborative learning course spanning multiple countries*," in Teaching & Learning Conference, Pennsylvania, 2010.

[7] T. Buzan, B. Buzan, "*Das Mind-Map-Buch. Die beste Methode zur Steigerung Ihres geistigen Potenzials*," Heidelberg, 2002.

[8] W. Clark, W. N. Polakov, F. W. Trabold, *The Gantt Chart - A Working Tool of Management*. New York: The Ronald Press Company, 1923.

[9] J. Müller and others. (2011) *FreeMind*. [Online]. http://freemind.sourceforge.net/wiki/index.php/Main_Page

[10] E. Amann. (2012) MIKRO Chair of Microeconomics. [Online]. http://www.mikro.wiwi.uni-due.de/en/teaching/lectures/wintersemester-1112/wiss-arbeiten-3582/

AUTHORS

Katrin Temmen and **Thomas Walther** are with the Department of the Didactics of Technology in the College of Electrical Engineering, University of Paderborn, Paderborn, Germany (Katrin.Temmen@upb.de)

Submitted 23 May 2013. Published as re-submitted by the authors 26 June 2013.