uninteresting subjects have their entitlement to study. In order to make the relevance of the study contents more recognizable for later working life, the lead example establishes links between lectures and practical applications.

After various investigations a chainsaw has been selected as a suitable lead example. In Figure 1 the linking of the courses is shown.

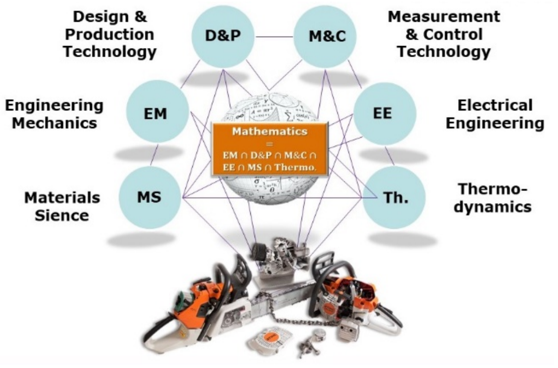

Figure 1. Linking the lectures based on the lead example „chainsaw"

Besides the chainsaw allows a linking of competences as well as a reflection of different teaching contents and an abstraction of the basic knowledge to a practical example. More advantages of the chainsaw are the compact design and the resulting possibility of a demonstration in the lecture hall.

4. Didactic Concept to avoid "inert knowledge"

As a result of the Bologna reform, the university's focus has shifted. It has gone from a purely academic teaching, to a teaching with the mediation of "scientifically based competence for future occupational fields of action" [9]. In recent years, although the universities have partially focused their attention on vocational orientation with the appropriate competence, but according to Gruber, Mandel & Renkl usually still rather "inert knowledge", is mediated. This will allow the students to pass exams, but they will not be able to solve realistic, complex problems, as Gruber, Mandel, and Renkl clearly suggest [10]. On the one hand, metacognitive deficits are crucial for students not being able to use knowledge descriptively and meaningfully in case situations, on the other hand, motivational deficits can also be crucial for students if lectures are too theoretically so that the students lose their interest in relevant topics and appropriate knowledge is not available as needed.

By designing the didactic model, which is used to link the curriculum, the demand of the students for a diversification of teaching materials, a stronger linking between theory and practice and teambuilding activities were considered and continuously adapted to the lead example. The didactic concept founding on this project follows the constructivist, holistic, action-oriented learning approach and is primarily oriented at the method of problem-based learning. In problem-based learning (PBL) real problems from the student's future professional field are used in teaching and learning processes.

The problems should be solved most independently by the students [11]. The complex, realistic problems serve as cognitive and motivating incentives for the learning process. By networking different teaching contents, interdisciplinary competence development can be further promoted. For example Stetter et al. showed, that students in the interdisciplinary project "formula student", where they build student racecars by their own, can better reflect and implement scientifically teaching contents [12].

Statements of the interviewed students also confirm this. Through the gradual transition from problem-based learning to methods of "pure" knowledge transfer, the learning conditions for students of the first semesters should be improved (compare Figure 2).

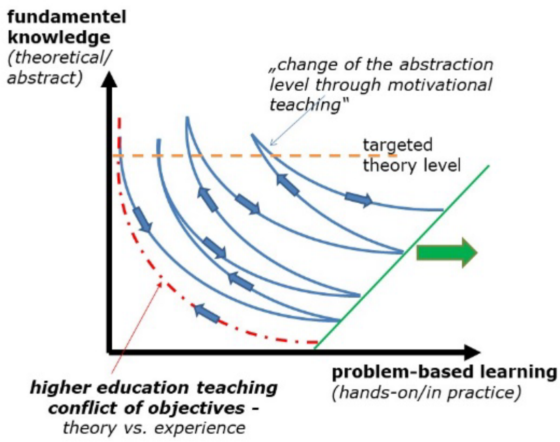

Figure 2. Continuous transition of theory and practice teaching in the basic studies

A high quantity of problem-based learning should promote intrinsic motivation as well as personal, methodological and social competences. With a gradual reduction of the concrete practical part, the abstract theoretical part of the lecture increases to the desired theory level. By the continuous transition between fundamental knowledge and problem-based learning the learned knowledge should be solidified with the help of job-related exercises. It is the aim, that this knowledge can be used at the next lecture by a kind of reminders on the basis of the lead example and bring out a shift in the level of abstraction.

After Renkl and in addition to a better applicability and a higher basic level, the intrinsic motivation of undergraduates should be further increased, especially in abstract subjects such as mathematics, technical mechanics and thermodynamics [13]. This should help to increase the self-directed learning of the students, too.

6. Implementation into the curriculum

The findings of the field examination serve the development of didactically adapted, multimedia teaching materials for the improvement of teaching at the RWU. The materials are developed for different learning types and oriented to the lead example.

In the course technical mechanics (statics), for example, the calculation of the center of gravity will be taught through the chainsaw (Figure 3).

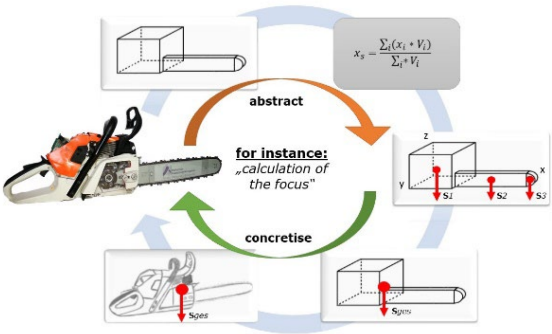

Figure 3. Problem-based learning by the example of technical mechanics

Mathematics as well as technical mechanics offer methods for calculating the center of gravity. These cross-connections help to link the lectures.

By taking into account that a task only becomes a problem when certain boundary conditions are incomplete or even contradictory, whereby the task becomes a certain complexity, the method of problem-oriented learning is used [14]. As a prospective engineer, students must be able to analyze a problem from an engineering point of view and make sensible assumptions about missing sizes, which is often the case in the initial launch of products.

According to Riedl the retention performance can be increased by addressing various sensory channels (read, hear, see, speak, act) [15].

During the lecture the students have the opportunity, through suitable hardware of the lead example, to compare the calculated values of the center of gravity with haptic perception. After Weinert motivational, volitional and social competences should also mediated through concrete extracurricular relationships to internalize the holistic approach of the engineering-scientific and mind-set [16].

For example events at the beginning and during the semester like a product demonstration (Figure 4) or the student's possibility to research a product in a computerized reality, are implemented. These should arouse student's curiosity about "mechanical engineering" through direct contact with the lead example and should help to increase the student's intrinsic motivation.

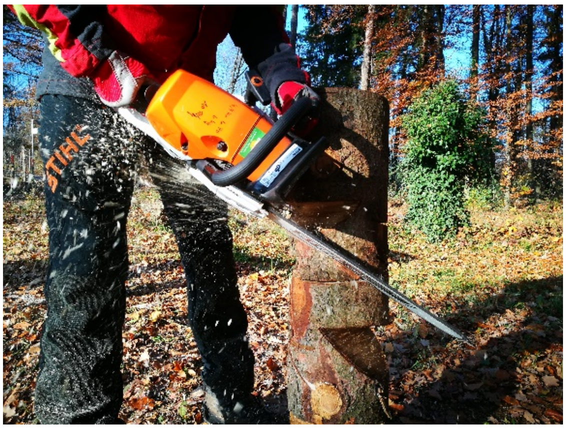

Figure 4. Product demonstration at the beginning of the semester by forestry expert

Students should be able to visualize the significance of mechanical engineering in the past, present and future and to rethink their partly primarily extrinsic motives for taking up the studying.

Unfortunately, the time which the students spent in lectures and tutorials is limited. Consequently, it is nearly impossible to alter the form of education in every lecture in order to enhance key competencies. Thus, a promising possibility to integrate the efforts aimed at supporting the development of key competencies was identified: the parts of the curricula that were already different from other part of the curriculum - the projects intended to learn engineering design.

7. Development Project

Several internationally recognized educators and researchers agree that teaching engineering design is the most challenging and simultaneously the least straight forward part of the curricula in engineering studies [17]. Evans et al. [18] specify: [engineering design] "seems to occupy the top drawer of a Pandora's box of controversial curriculum matters, a box often opened as accreditation time approaches". The general insight that the most promising form to teach engineering students the ability to design (not theoretical knowledge about design) are realistic, open ended problems to be solved in teams, i.e. project based learning, is stated in several publications [e.g. 17, 19]. The central characteristic of this kind of design projects is that they lead to experiences in accordance to Kolb's model of experiential learning [20].

As part of the so called development project, a practice-related task is performed by the students. The goal is a simple, possibility to start a chainsaw. The importance of this goal is illustrated during an introductory kick-off meeting with forestry experts. The importance of poor starting behavior and its effects are not only demonstrated, but also tested by the students.

The methodological material selection takes place with the help of the CES EduPack, which provides a comprehensive database of materials and process information and can be visualized depending on the exact boundary conditions. Students are encouraged to contribute to their learning by defining requirements and boundary conditions, as well as commenting on the sustainability of their materials selection.

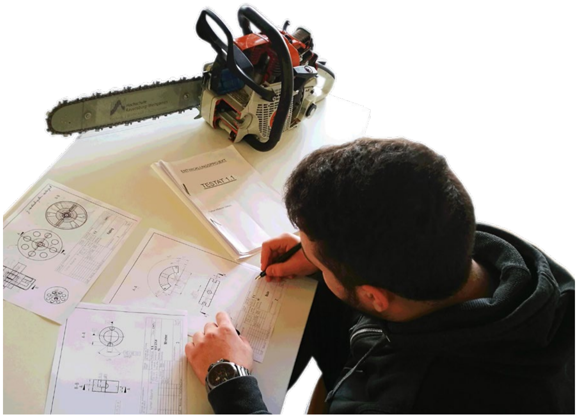

Figure 5. Apply the construction methodology

Finally, students prototype their solution using additive manufacturing (Figure 6). In the course of regular project meetings, results and prototypes are presented and discussed with the forestry experts.

Figure 6. Additive manufactured student solutions

This interdisciplinary teaching concept promotes the connection and comprehension of key engineering competences such as mechanical design, material science and advanced mathematical concepts with the real end users' problems.

8. Conclusion

In order to improve the teaching in the field of mechanical engineering at the RWU, a new concept is currently being applied to reduce the abstractness of the basic subjects by integrating a lead example in teaching. Through the targeted transition from practice (e.g. problem-based learning) to theory (basic mediation) and vice versa, the lead example is intended to improve a gradual transition between the capacity for abstract and an engineering-scientific mind-set. Regular evaluations, continuous quality assurance procedures and the inclusion of the latest research results serve to develop a didactic concept with adapted, diversified teaching materials. The lead example is broken down to individual learning modules and contributes to connect the curriculum of the university.

Through enthusiasm the lead example is intended to increase the intrinsic motivation of students in the undergraduate studies and provide above all, in addition to critical thinking and the teaching of skills, a strong basis for their further study.

First research results have shown that the lead example is mainly positive perceived by the students and that there is a demand for a stronger presence and further lead examples. The so called "red line", which is drawn by the lead example through the undergraduate studies, helps the students to establish links between the lectures and the teaching contents.

10. References

[1] R. Schulmeister, C. Metzger and T. Martens, „Heterogenität und Studienerfolg. Lehrmethoden für Lerner mit unterschiedlichen Lernverhalten“, *Paderborner Universitätsreden*, P. Freese (ed.). Online available at: http://www.rolf.schulmeister.com/pdfs/zeitlast_pur.pdf, retrieved January 23, 2018.

[2] U. Heublein, Presentation on „Aktuelle Entwicklungen beim Studienabbruch – Herausforderungen für Lehre und Beratung“. *Symposium: „Wie viele Studienabbrecher *innen will sich unsere Gesellschaft leisten?“*, Stuttgart, June 15, 2018.

[3] HIS Hochschul-Informations-System GmbH, „Leistungsprobleme als subjektive Begründung des Studienabbruchs“, *VDMA Abbrecherstudie – ausgewählte Grafiken*, VDMA. Online available at: http://www.vdma.org/ documents/105628/211099/09-1209% 20VDMA_Abbrecherstudie_Grafiken.pdf/fdf 3f0de-f384-40a3-9394-2d8ed3c38e26, retrieved February 25, 2018.

[4] W. Derboven, G. Winkler, *„Ingenieur-wissenschaftliche Studiengänge attraktiver gestalten“*, Springer, Berlin/Heidelberg, 2010, p. 19, cf. Table 2.2.

[5] U. Heublein, G. Besuch, C. Hutzsch, J. Schreiber, D. Sommer, *„Zwischen Studienerwartungen und Studienwirklichkeit – Gründe für den Studienabbruch. Ergebnisse einer bundesweiten Befragung von Exmatrikulierten in Maschinenbau-Studiengängen.“*, Impuls-Stiftung, Stuttgart, 2009, p.38-39, cf. Fig. 4.1.

[6] M. Dumschat, R. Stetter, A. Kaufmann, J. Rottmann, „Vom Konkreten zum Abstrakten - Wissensvermittlung anhand eines Leitbeispiels“, *Tagungsband zum 3. Symposium zur Hochschullehre in den MINT-Fächern*, B. Meissner, C. Walter, B. Zinger (ed.), Nürnberg, 2017, p. 55-62.

[7] D.S. Rychen, L.H. Salganik, M.E. McLaughlin (eds.),”The Definition and Selection of Key Competencies - Executive Summary”, OECD, 2005.

[8] Hochschulrektorenkonferenz (HRK), „Fachgutachten zur Kompetenzorientierung in Studium und Lehre“, HRK, Berlin, 2012, p.10.

[9] K.-H. Gerholz, P.F.E. Sloane, „Lernfelder als universitäres Curriculum? – Eine hochschuldidaktische Adaption“, bwp@ Berufs- und Wirtschaftspädagogik – online, No. 20, p.1-24.

[10] H. Gruber, H. Mandl, A. Renkl, „Was lernen wir in Schule und Hochschule: Träges Wissen?“, *Die Kluft zwischen Wissen und Handeln: Empirische und theoretische Lösungsansätze*, H. Mandl, J. Gerstenmaier (ed.), Hogrefe, Göttingen, 2000, p. 139-156.

[11] I. Ulrich, *„Gute Lehre in der Hochschule – Praxistipps zur Planung und Gestaltung von Lehrveranstaltungen“*, Springer Fachmedien, Wiesbaden, 2016, p. 223.

[12] R. Stetter, M. Till, P. Eckart, “Concept for a Modular Rave-Car-Frame for Conventional, Hybrid and Electrical Applications”, *Proceedings of the Fisita EAEC Conference*, Valencia, 2011.

[13] A. Renkl, *„Lernen durch Lehren“*, Deutscher Universitätsverlag, Wiesbaden, 1997.

[14] B. Zinn, U. Faßhuber, „Ein problembasiertes Lernszenario aus der Perspektive von Studierenden“, *ZFHE Jg.7/ No.3*, T. Brahm and D. Euler, St. Gallen, 2012

[15] A. Riedl, *„Grundlagen der Didaktik“*, Franz Steiner Verlag, Stuttgart, 2004, p. 137.

[16] F.E. Weinert, „Vergleichende Leistungsmessung in Schulen – eine umstrittene Selbstverständlichkeit“, *Leistungsmessungen in Schulen*, F.E. Weinert (ed.), Beltz Verlag, Weinheim und Basel, p. 27ff.

[17] C.L. Dym, A.M. Agogino, O. Eris, D. Frey, L.J. Leifer, “Engineering Design Thinking, Teaching, and Learning”, Journal of Engineering Education 1, 2005, pp. 103-120.

[18] D.L. Evans, B.W. McNeill, G.C. Beakley, “Design in Engineering Education: Past Views of Future Directions”, Journal of Engineering Education, Vol. 69, No. 4, 1990, pp. 517-522.

[19] A.H. Hoffman, K.N. Liadis, B. Boettcher, “Work in Progress - Developing a Project Based First Year Design Course”, Proceedings of the 35th ASEE/IEEE Frontiers in Education Conference, Indianapolis 2005.

[20] D.A. Kolb, “Experiential Learning. Experience as the Source of Learning and Development”, Prentice-Hall: 1984.