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Competence in Teaching in the Renewable Energy Field - an Encouragement for Exchange

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Abstract
In order to achieve a sustainable transformation of the energy supply systems on regional, national and global scales an integrated knowledge about the ecological, economic and social consequences of the new energy systems will be needed – on learners' side (later decision maker and stakeholder) as well as on teachers' side. In this context, to deal with complexity, incomplete knowledge bases and risks is essential for all actors in order to make informed and sustainable decisions in this area. Thus the integration of inter- and transdisciplinary competences into the learning and teaching process, such as the ability to assess the validity of acquired knowledge or to continuously reflect on the impacts of a particular system, become of fundamental importance. But teaching these competences goes far beyond traditional, mainly content-oriented university teaching approaches in the natural sciences. Participative, competence-oriented and student-centred methods are required instead. The university as institution however only reacts very slowly to these educational challenges. To develop solutions in such context finding or creating alliances for exchange on teaching experiences and new learner-centred teaching methods might be of great help.
Based on a theoretical (literature review) and empirical (results from a faculty workshop) approaches, the paper identifies lines of action for encouraging and promoting the necessary shift to learner-centred, creative and cooperative teaching approaches in the field of renewable energy.

1. Introduction
Renewable energy (RE) is a highly dynamic work and research field expected to contribute to sustainable energy systems on global scale. While physical laws governing the energy systems are long well understood, vivid discussions on suitable assessment methods and the subsequent conclusions of a widespread implementation of different RE systems flourish both in the scientific and implementation arenas. In this context the integration of inter- and transdisciplinary competences into the learning and teaching process becomes of fundamental importance. For this aim participative, competence-oriented and student-centred methods are required.
While these innovative approaches are found in relevant concept papers even on the European level [1], its real implementation in the field of natural sciences and engineering university education is rather scarce (see section 2). Trials of "best practice" modules stay isolated attempts to cope with an unsatisfying situation where teaching and knowledge have left the disciplinary boundaries behind.
The paper shares results form a 3-day workshop on "Future RE Programs" [2] held by the University of Oldenburg in September 2015, organised to foster discussion and exchange with teaching colleagues in the energy field in Germany and Europe. The relevance of the proposed teaching approaches and their particular importance for the RE field as well as current deficits preventing their implementation are analysed based on a comprehensive literature review.

2. Need for teaching shift in the RE context
"Some people talk in their sleep. Lecturers talk while other people sleep." - Albert Camus
There is extensive scientific evidence on the benefits of active teaching approaches in higher education (HE) [3-7]. On a general level active, and to a great extend self-directed involvement of the students in learning arrangements is seen as the basis for developing competences reaching far more than factual knowledge [3]. Applied to the engineering and natural sciences field, both of great relevance for the renewable energy area, active learning approaches have shown to promote better

performance and increase student's motivation [4,5] as well as lead to deeper understanding of scientific principles involved [5]. In the words of W.B. Bonvillian and S.R. Singer: "*The accumulating evidence challenges the model that has long dominated higher education: the sage on the stage; that is, the lecture*" [7].

Yet despite such evidence, plenty of scepticism towards active teaching approaches exists: "*One big reason [for this], she says, is that for many scientists, active learning is sharply at odds with their beliefs about teaching. (…). Researchers often feel that a teacher's job is simply to communicate content: the factual knowledge covered in the course. That is a big stumbling block for active learning, because time spent on team discussions and the like can seem like time taken away from that content*" [5].

2.1 Student-centred teaching methods: state of the art in the RE field

To check the popularity and implementation of student-centred teaching methods in disciplines related to the RE field a quantitative sampling of available literature was carried out. For this, published papers on three major relevant journals on innovative teaching approaches in HE were sampled and classified depending on their implementation discipline. The chosen journals were "*Higher Education - The International Journal of Higher Education Research"* [8], *"Research in Higher Education"* [9] and "*Innovative Higher Education"* [10] from Springer Publishing. The sampling was carried out taking into consideration all online available papers published until December 2015. Figure 1 shows the results for different keywords related to student-centred teaching methods found in the mentioned journals altogether but classified depending on their respective taught discipline.

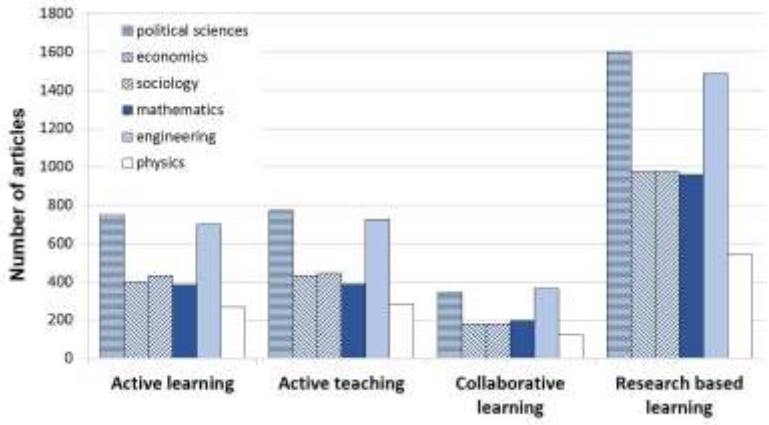

Figure 1. Number of published papers referring to different student-centred teaching approaches in [8-10] until December 2015 classified by discipline or area of implementation.

Figure 1 clearly shows two main trends: 1) there is a wide implementation of innovative student-centred teaching methods in the engineering field, showing these teaching approaches a similar impact as on social sciences fields; 2) the implementation of such teaching approaches in the physics area seems to be significantly lower than in other natural science or social science disciplines. The incidence of the sampled keywords corresponding to innovative teaching approaches in the physics field is between 26 and 43% than the next worst performing discipline.
The RE field is related both to the engineering field (application, technology development) as well as to the physics field (improvement and optimization of technology components). Thus, at least from the physics-related subjects significant room for a wider implementation and use of student-centred teaching methods is found.
Figure 2 shows the answers about the popularity of student-centred teaching methods for 10 (out of the 21 attending) participants to the workshop on "Future RE Programs". The student-centred teaching methods explored in the workshop were collaborative, research based and flipped/blended learning approaches.

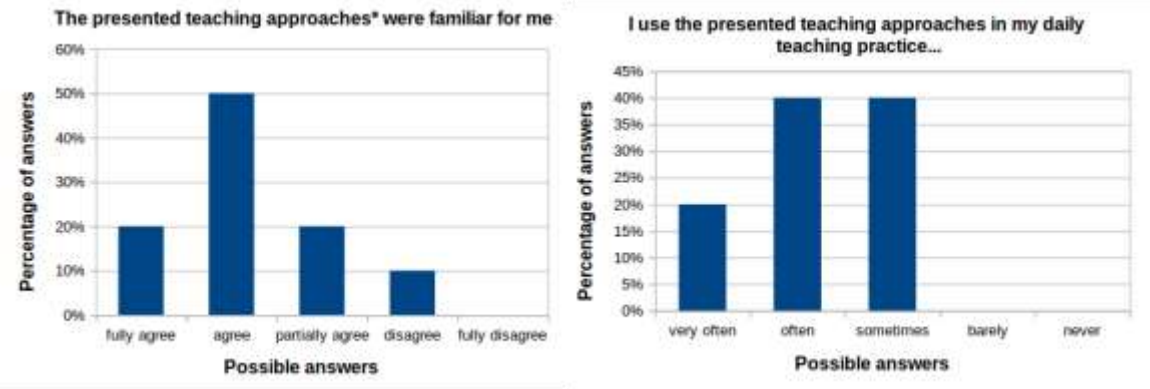

Figure 2. Answers of workshop participants concerning their knowledge about and use of the innovative teaching approaches discussed in the workshop.

Results from the literature review are clearly more pessimistic regarding the implementation and penetration of innovative student centred teaching approaches than the answers from the participants to the workshop (Fig. 2). A possible reason for this might be the fact that participants attending the workshop represent the motivated faculty members open for and interested in the implementation of such approaches. In spite the facts that the workshop was free of charge and that it included internationally renowned speakers (see footnote 1) in the field of the innovative teaching approaches the low attendance of 21 faculty members as participants to the workshop (as compared to the invited 120 faculty members involved on teaching in different disciplines related to the RE field across Europe) supports this statement.

2.2 The institutional perspective on student-centred teaching methods in RE field

Institutions and stakeholders engaged in HE [11-14] promote a change in university teaching practices in general, which also would be applicable to the RE and natural sciences field. Ministries of education, teachers in HE, the universities themselves, associations on HE didactics [11] and industry associations, like private fund organisations address the improvement of the quality of teaching and its importance for societal development.
The *Leuven Communiqué* in 2009 [1], one of the follow-up releases of the Bologna-Process by the European ministers of education, pointed out that the quality of teaching and its purpose shall be to "maximize(s) the talents and capacities of all its citizens" and to "widening participation in HE". Here "student-centred learning" is targeted to "help students develop the competences they need in a changing labour market and….empower them to become active and responsible citizens".
This challenge on a new, verifiable quality oriented teaching culture is flanked by joint initiatives of economy and politics as reflected e.g. in the "Charta of Good Teaching" [12] emphasising the importance of the involvement of, not only the teachers, but explicitly the overall HE institutions.
From the field of sustainability research [13] a deeper approach comes. The transformation of teaching practices is identified as a precondition to cope with challenges on societal level. Here research based knowledge creation becomes open to participation and allows direct cooperation between and

amongst researchers, student groups, and the civil society promoting the idea of a permanent reflection process, leaving the tradition of a "singular logic of excellence" behind [14]. This process of exchange within and as part of teaching practices sets steps towards a democratisation of knowledge creation, whereby directly recognizing the importance of student-centred teaching methods.

3. Lines of action

The above presented literature review and results shown, allows recognizing two main implementation levels and promoting structures for the required innovative teaching methods.

3.1 Personal networks

Much of the literature reviewed in section 2.2 focus on the individual implementation of student-centred teaching approaches by single faculty members. Their personal engagement becomes thereby a crucial role for the ultimate penetration and popularity of such teaching methods. In this process the exchange and communication of good-practice examples as well as of the benefits achievable and underlying such approaches can play a significant role for motivating faculty members to embrace this transformation process of traditional teaching practices.

Results from the evaluation of the 3-day workshop[1] support the importance of promoting such exchange among faculty members. The workshop was organized in such a way that each innovative teaching approach discussed consisted on a 30 minutes talk by a renowned speaker and 2,5 hours discussion by the participants. This great time span for structured discussion was very positively evaluated by the attendants, allowing them to develop ways of transferring the presented approaches to their daily teaching practice. Without this room for discussion the fruitful exchange among faculty members leading to the concrete development of new student-centred teaching concepts for some particular courses that were later implemented in reality would have been impossible.

Lines of action that can be identified within this field for promoting the exchange among faculty members on a personal level are:

- Creating exchange networks among faculty members covering the following areas:
  - Identifying the requirements for good innovative teaching practices
  - Promoting debates on results from implementation examples
  - Promoting didactic qualification offers for faculty members
  - Promoting expert input from research groups on the field of HE

3.2 Institutional structures

However, a too big responsibility and commitment is burdened on teachers, if their personal engagement is the only driving factor for the above mentioned transformation process (see section 2.2). Results from a four year project on concepts for excellent structures in RE-related study programmes at the University of Oldenburg indicate the necessity of overarching coordination processes between study programs and university entities. Such coordination process would make the expertise spread within the decentralised units a valuable source for further developments in the required teaching transformation.

Leaving instead the transformation process to engaged individual members of the university solely might end up at least slowing its pace and at worst making the whole transformation process fail. Thus, some lines of action for building up institutional structures required for fostering that process for the RE field on a university level are presented here:

- Anchoring structures: defining coordinators to guarantee a communication and exchange process exchange amongst the entities of the university and teachers linked to regular meetings
- Establishing projects and funding structures for research on didactics in HE in the field of science and energy education to gain experience on new teaching methodologies.

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