Implementation of Multi-campus engineering education through modules of different research expertises

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INTRODUCTION

In Flanders (Belgium), the 1-year Master programme in Biochemical Engineering Technology is organized at 7 geographically dispersed campuses that are associated to three different universities, i.e. KU Leuven, Ghent University, and Antwerp University. However, to sustain all Master programmes, it is clear that a unique education and research profile at each campus is crucial. In addition, institutes of higher education are subject to intense changes: with decreasing government fundings they have to educate more students, in individual flexible programs, and with an increasing variety of backgrounds [1]. It is clear that a rationalization is required in which the use of human resources and infrastructure is optimized. This can be accomplished by establishing "Higher education consortia", which can be defined as "multi-point groupings of higher education institutions which have a limited amount of members and where membership is restricted to particular institutions" [2]. In these so-called "Higher education consortia" there is an increased cooperation among the campuses, for instance by multi-campus education in which there is an increased exchange of lecturers and increased student mobility.

In this paper we describe the development of a multi-campus programme for the Master of science in Engineering Technology: Biochemical Engineering and Master of science in bioengineering technology: food industry engineering, in a higher education consortium, consisting of 4 campuses associated to KU Leuven. The multi-campus programme consists of specialized and research-driven learning modules on one campus that are also available for students of other campuses. In addition, the driving forces, obstacles, and preconditions to establish such a multi-campus programme, the development process, and the implementation of the multi-campus programme, as well as the future perspectives are discussed.

1 DRIVING FORCES AND OBSTACLES FOR MULTI-CAMPUS EDUCATION

Improved performance and cost reduction are certainly major driving forces for establishing cooperating consortia [3]. A study that inquired American pharmacy colleges involved in multi-campus education, also reported other reasons for establishing a multi-campus programme, such as (i) improved student recruitment and/or retention of graduates in a certain area; (ii) better coping with pressure from competing institutions; (iii) a state-wide approach rather than focusing on just 2 cities; (iv) enhanced visibility of the institution in industry; and (v) improved performance by pooling resources of multiple institutions [4]. Regarding the latter, Das and Teng [5] also pointed to the value creation potential of resources that are pooled together as

one of the driving forces for cooperation [5]. In addition, multi-campus education programmes can provide a wider range of learning experiences [6].

However, American pharmacy colleges also report some issues with multi-campus programs, such as difficult acclamation and student adjustment, travel between the campuses, problems with effective distance-learning technology, problems with standardizing operations between campuses, and the inability to communicate effectively between campuses [4]. Indeed, a good relation between the campuses is crucial for a good cooperation, and it is clear that the relation and communication among the individuals of the consortium members play an important role [7]. In addition, a high faculty workload due to multi-campus education was reported [4]. Especially the phase of development and implementation of the multi-campus programme is associated with an increased workload, in particular when teaching involves new technology, such as videoconferencing, blended learning, etc. [8].

2 COMPLEMENTARITY AND COMPATIBILITY: PRECONDITIONS FOR DEVELOPING MULTI-CAMPUS EDUCATION

Beerkens and van der Wende [7] point to the many similarities between international cooperation between firms and the cooperation within a higher education consortium. Consequently, many of the concepts derived from a wide range of studies on international cooperation between firms can be extrapolated to the higher education consortia. For instance, from the “inter-organizational diversity” point-of-view, it is stated that for effective collaboration in higher education consortia, sufficient complementarity as well as sufficient compatibility is required [7,9].

Sufficient complementarity implies the existence of complementary resources and interdependencies, which enable joint learning among the partners. In this regard “resources” must be widely interpreted, ranging from research infrastructure and human resources (experts in a particular research domain, as well as high-quality lecturers), to library collections and educational resources (e.g. specialized courses or programmes). Moreover, the consortium has to consist of members possessing resources which are strategically valuable for the other members [7].

On the other hand, the partners in a higher education consortium should be sufficiently compatible, i.e. sufficiently similar in their organizational characteristics. Inter-organizational differences are generally related to the national context, differences in perceiving and thinking, and to historical conformance of universities or institutes to their organizational structures, procedures and routines [7]. Such organizational differences also play an important role in the collaboration process and can restrain the performance of cooperation [10]. Moreover, it has been stated that higher compatibility leads to higher performance of the consortium [7].

However, universities can deal with the institutional differences, by providing information on the existing differences of the members in institutional contexts. Subsequently, consortium members should get used to the institutional context of other consortium members, through meetings, seminars or courses [7]. In this regard, a study of Korean multi-campus medical education also pointed out that a good communication between the partners is crucial for establishing a good partnership [6]. A step further in dealing with the institutional differences is to set up a joint administrative structure [7].

3 DEVELOPMENT OF THE MULTI-CAMPUS SYSTEM

3.1 Establishing the higher education consortium

In order to develop and implement multi-campus education in engineering technology programmes in biochemical engineering, a higher education consortium was established consisting of 4 university colleges in Flanders (Belgium) that are associated to the KU Leuven: campus “De Nayer”, situated in Sint-Katelijne-Waver, the “Technology campus” in Ghent, “campus Geel”, (Master in biosciences: food industry) in Geel, and “campus Diepenbeek”, situated and Diepenbeek,.

As mentioned above, the performance of higher education consortia will be affected positively by the existence of complementarity and compatibility. However, the fact that complementarity is present does not necessarily mean that they are known by the right persons and that they are utilized and exploited [7]. In that regard there is certainly a need for identification, dissemination and exploitation of complementary resources, including the Ms programmes, human resources, research infrastructure, etc.

First of all, the Ms programmes clearly reveal complementarity in education, with each campus having its own focus (*Fig. 1*). Moreover, the focus in the Ms programme strongly correlates to the research activities on the campus. Research at the Technology campus is mainly focused on malting and brewing technology, and to a lesser extent on meat production and rheology. The research focus at De Nayer is microbial process ecology and bio-inspirational management. At campus Geel, research activities are mainly focused on crop diseases and food technology, while at campus Diepenbeek, research effort is put into molecular diagnostics and applied chemistry.

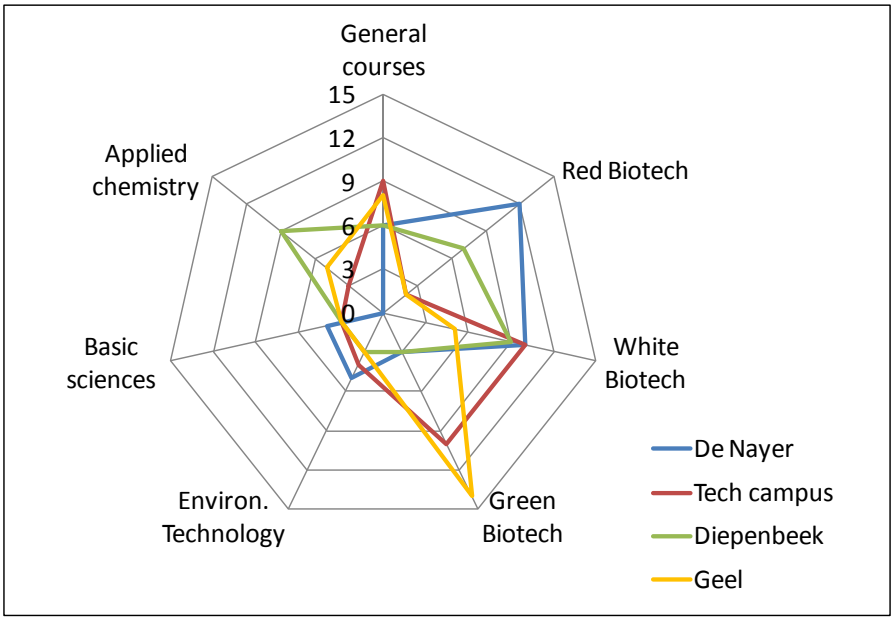

Fig. 1. Comparison of the Ms programmes in Biochemical Engineering Technology at campus De Nayer, Technology campus in Ghent (Tech campus); and the campuses at Diepenbeek and Geel. For each subdomain (general courses, basic sciences, environmental technology, applied chemistry, and red, white, green biotechnology), the number of assigned ECTS points is presented.

Secondly, we made an inventory of the resources available at the different campuses, including research infrastructure, research expertise of the lecturers, educational expertise, and didactic infrastructure (e.g. videoconferencing infrastructure). Indeed, regarding research infrastructure, a high degree of

complementarity was observed. The Technology campus, for instance, possesses large-scale bioreactors (up to 500 l), while campus De Nayer disposes of a set of small-scale (1 l) bioreactors. By cooperating, the campuses can thus provide infrastructure for small scale experiments as well as for upscaling to semi-industrial scale, which points to the value creation potential of pooling resources in a higher education consortium. Likewise, some campuses possess elaborate analytical chemistry equipment, while other campuses invested mainly in molecular biology infrastructure.

It is obvious that a better knowledge regarding the resources at other campuses facilitates optimal use and exploitation in multi-campus education, as well as in research, which is already exemplified in several joint research projects.

3.2 Designing the concept of the multi-campus programme

In designing the concept of the multi-campus programme, a steering committee of the consortium, which also comprised student representation, was installed. Clarification of purposes and priorities, and adjustment of the organizational structures are important for effective cooperation [11]. Therefore, the steering committee started with deciding on the joint consortium objectives.

The main joint objective was to develop multi-campus education in favour of the students. First, it was decided to offer a specialized and research-driven learning module on each campus that is available for students of other campuses. By offering specialized research-driven modules to the students, the proposed multi-campus programme is also a way of integrating research into engineering education. Second, the steering committee decided on an accelerated/intensive course of 6 ECTS credits, which is organized in the first 2 weeks of the second semester with full time availability at the research campus, and this for the following reasons: (i) it enables an intense teaching method in which students are immersed in a specific research domain during a residential retreat [12]; (ii) the laboratory require several subsequent days rather than a 1 day per week basis; and (iii) organizing the modules in the second semester enables the students to attain additional foreknowledge in the first semester that may be required to follow a specialized intensive course. Third, considering the fact that the modules differ considerably regarding content, didactic methods, learning outcomes, etc., the steering committee decided the evaluation of a module to be adjusted to the needs of the intensive course. In most intensive courses, however, permanent evaluation is combined with a classic exam, which is organized in the second exam period. And finally, also regarding the admission requirements to the multi-campus programme, a joint decision was made.

However, some of the joint objectives and priorities can only be achieved when the proper adjustments in the organizational structures are executed. For instance, curriculum adjustments enabling the implementation of the specialized intensive course into the curriculum were carried out accordingly. Curriculum adjustments were also necessary to guarantee that the Ms students attain the required foreknowledge enabling them to follow the specialized module. In addition, implementing the multi-campus programme into the current curricula also implied that the schedules at the local campuses had to be adjusted.

3.3 Content of the multi-campus intensive courses

After agreeing on the concept of the multi-campus programme, an intensive course at each campus was developed. The content was defined and appropriate education methods were chosen. The content of the modules is primarily based on the research expertise present at the campus. After implementation of the multi-campus

programme in academic year 2013-2014, Ms students can select one of the following modules: (i) “Use of molecular biology and ecology in bio-industrial processes”; (ii) “At the interface of chemistry, structure and functionality of food stuff”; (iii) “Malting and brewing technology”; and (iv) “Molecular diagnostics” (*Table 1*).

Table 1. Brief description of the research-driven intensive courses in the multi-campus programme

Name module	Institution (Location)	Brief description
The use of molecular biology and ecology in bio-industrial process	Campus De Nayer (Sint-Katelijne-Waver)	State-of-the-art tools to study microbial ecology in industrial processes are discussed, followed by the use of genetic modification in biotechnology. In the practical course, students get hands-on experience in geno- and phenotyping of microorganisms en microbial communities
At the interface of chemistry, structure and functionality of food stuff	Campus Geel (Geel)	Food chemistry and food structure and their relation with texture and rheology are discussed, both from a theoretical as from a practical point-of-view
Malting and brewing technology	Technology Campus (Ghent)	All relevant aspects of malting and brewing are discussed, ranging from quality and economical aspects to flavour stability and process engineering. Students get hands-on-experience on a pilot-scale brewing installation.
Molecular diagnostics	Campus Diepenbeek (Diepenbeek)	The diagnostic tools that are currently used to detect and identify microbial pathogens are discussed. Practical courses and exercises focus on development, validation and quality control of diagnostic tests

4 IMPLEMENTATION AND IMPROVEMENT

As mentioned above, the multi-campus programme will be implemented in the academic year 2013-2014. In the preceding year, possible candidates, i.e. 3rd year Bachelor students were thoroughly informed regarding the multi-campus programme by a brochure and information sessions, to trigger their interest in following an intensive course at another campus.

Once the multi-campus programme is started, the performance of the higher education consortium should be optimized by looking for a higher level of complementarity and compatibility between partners [7]. This can be accomplished by relation management, i.e. the measures that the consortium takes in order to improve communication, the creation of a stable and clear organizational structure and the increase of commitment [7]. At the level of the multi-campus programme, this will be primarily established in the steering committee.

Another point of future improvement of the multi-campus programme is to increase the use of blended learning technology since one can increase students’ satisfaction in engineering courses when it’s properly implemented [13]. Campuses involved in multi-campus education strongly recommended developing more interactive courses and better engaging students at the “distant site” [4]. Nevertheless, it has to be born in mind that “teaching with technology” usually results in an increased workload [8].

Obviously, the multi-campus programme will be evaluated in detail in the first years after implementation. First of all, students that have participated in the multi-campus programme will be inquired regarding the quality of the programme and issues for improvement, because the student's assessment of quality in teaching and training, and the quality of the total student experience are important quality outcomes [14, 15]. In addition to the student evaluation, staff members will also be inquired regarding their experiences in the multi-campus programme education and organization.

5 CONCLUSIONS

In this study, a multi-campus programme was developed for the Ms in Bio-Engineering Technology by offering an intensive course that is also available for students of the other campuses. Such a module is primarily based on the research expertise present at the campus, and comprises 10% of the total Ms curriculum. In developing this multi-campus education system, special attention has been given to the optimal organization of the modules, the evaluation, the required modifications of the current curricula, the practical and legal consequences for students following the module at another campus,…

The main advantage of this multi-campus system is that Ms students are offered a more diverse pallet of research-based modules in the Ms programme, which enables a better match of the Ms programme with the student's interests and future ambitions. In addition, students come into contact with other researchers and gain hands-on experience with state-of-the-art research infrastructure that is not available at the home campus. In this way, the proposed multi-campus system is also a way of integrating research into engineering education. And finally, during the project, it became more and more clear that the participating campuses have complementary research expertises, which already resulted in increased collaboration in several joint research projects.

If the proposed multi-campus programme proves to be successful, the concept can be easily expanded with additional modules, or other Ms programmes could adopt the concept. Already, the Ms in Chemical Engineering Technology programmes of the same Consortium of Higher Education, have adopted the concept and developed 3 additional modules: (i) "Acoustic processing"; (ii) "Treatment of waste (water) through biological, oxidation and fermentation processes"; and (iii) "Material and Energy Management". Furthermore, the modules in the multi-campus programme could also be the start for a joint international programme and/or post-graduate trainings for companies.

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