GEARE: Global Engineering Alliance For Research And Education – For Engineering Students: Extensive Possibilities In Programs Focusing International Project Work and Study and Intern Abroad

Albert Albers[1], Norbert Burkardt[2], Claudia Becke[3]

[1~3]Institute of Product Development, University of Karlsruhe, Germany

albers@ipek.uka.de[1], burkardt@ipek.uka.de[2], becke@ipek.uka.de[3]

Abstract

GEARE is a Global Engineering Alliance For Research And Education founded in 2002. Within the unique GEARE partnership engineering students and universities all over the world get the opportunities to take part in international programs focusing on international student team work in multi-national teams as well as on study and intern abroad programs. Following universities take part in GEARE: Purdue University in the USA, University Karlsruhe in Germany, IIT and UICT Mumbai in India, Shanghai Jiao Tong University in China, and Tecnológico de Monterrey in Mexico. Multi-national education of future engineers is a highly useful preparation for following challenges in the global workspace. To implement these aspects of engineering education in early stages of academic education within GEARE an Undergraduate Student Exchange Program was developed. This comprehensive study & intern abroad program for engineering students focuses on multi-national project work in the fields of design and product development. Students in Undergraduate Student Exchange Program participate in an orientation program including language and culture at their home university, an international internship in an industrial company abroad, one semester of study abroad with fully transferable engineering course credits; and a two-semester multinational design-team project (one semester at home university, one abroad) with students from the international partner universities working on industry-inspired projects. The aspects of the multi-national project work within the Undergraduate Student Exchange Program will be presented in this paper primarily and the exchange program between Purdue University in the USA, Shanghai Jiao Tong University in China and University Karlsruhe in Germany will be focused exemplarily.

Introduction

Today the challenge in engineering education for academic institutes is to enable students to develop professional competence and key competencies. Product development is more and more taking place in global contexts and international aspects gain importance more and more. This does not only apply to the industrial careers of engineers but also to the engineering education of future engineers. Changing constraints and conditions affect the job markets and make the professional competence and international experiences of graduates basic prerequisites. Engineers with professional competence are needed to handle these product development processes. Besides the basic technical and methodical knowledge, today so called key competencies gain importance. International experience is just one of them. Industry made this key competences (such as the ability to work in a team, methodological skills, creativity, time management, frustration tolerance or the ability of bringing ideas into reality) an increasingly important decision criteria when looking for new engineers who want to start a professional career successfully. In order to meet these requirements new approaches in academic education of product development are necessary. Due to the globalization of the economy, engineers of today's world have the responsibility to understand cultural differences and interact appropriately with the people with whom they work. GEARE offers an effective and efficient means of learning this critical knowledge in today's world. GEARE perfectly completes the Karlsruhe Education Model for Product Development (KaLeP) which describes a novel and very successful approach for academic education in industrial product development [3, 4, 5].

KALEP - The Karlsruhe Education Model For Product Development

A new approach in engineering design education, the Karlsruhe Education Model for Product Development (KaLeP) was introduced in 1999 [1, 2]. KaLeP combines different types of course settings in a consecutive sequence of classes on increasing levels, each level is oriented towards certain fields of product development-specific knowledge: Mechanical Design I/II/III (concerning systems), Methods of Product Development (concerning tools and methods) and Integrated Product Development (concerning processes). Both the courses Mechanical Design I/II/III and the course Methods of Product Development are mandatory for all students and are attended by several hundreds of students per year (currently 750). The structure of KaLeP is shown in figure 1 and its elements will be explained in the following [6].

Figure 1: Elements of the Karlsruhe Education Model for Product Development

Karlsruhe Education Model for Product Development
KaLeP Elements

	Systems	Methods	Processes
Degree program	Bachelor of Science	Master of Science	Master of Science
Course title	Mechanical Design I/II/III	Methods of Product Development - Design Process	Integrated Product Development
Setting	• lecture • tutorials • project work	• lecture • tutorials	• lecture • tutorials • project work
Key competencies: Level of acquisition	high	medium	very high
Course contents	• design engineering • team work • self organization • communication • idea transfer	• methodological skills • creativity techniques • processes in product development • problem solving methods	• team leading • team development • project management • presentation • moderation
Number of students per year	~750	~400	~40

Mechanical Design I/II/III:

In the Mechanical Design course team oriented project work was introduced and proved to be a successful means to enable students not only to develop competence regarding machine elements but also to learn how to work and cooperate in a design team. The course Mechanical Design I/II/III is part of the first two years of study for the duration of three semesters. It contains the elements lecture, tutorials and project work. The lecture focuses on theoretical contents of design engineering which will be implemented in the tutorials in example cases. In the project work design teams consisting of five students are set up and all design teams need to fulfill a complex design task with project. Previous tasks have included a ball bearing assembling machine, legs for a humanoid robot and a carousel placed on a car trailer. During the project work in all courses of Mechanical Design I/II/III the teams are coached continuously by faculty staff and experienced and trained student tutors. During these team meetings all students receive individual feedback regarding the individual performance and the team performance. The performance is assessed according to five fields of competence: professional, methodological and social competencies as well as potential of creativity and the ability of transferring ideas. These five fields of competence are shown in figure 2. Recent integral educational approaches [7] emphasize similar skills and competencies required by successfully working development and design engineers [6].

Figure 2: Fields of Competence in the Karlsruhe Education Model for Product Development

Karlsruhe Education Model for Product Development KaLeP Fields of Competence		
1. Professional Comp.	2. Methodological Comp.	3. Social Competencies
▪ mathematics ▪ technical mechanics ▪ machine elements ▪ IT ▪ foreign languages	▪ design methodology ▪ knowledge management ▪ FMEA ▪ QFD ▪ DOE and statistics ▪ CAD and CAE	▪ personal techniques of working ▪ communication and teamability ▪ visualization skills ▪ presentation skills ▪ leadership
4. Abilities in transferring Ideas	5. Potential of Creativity	
▪ customer orientation ▪ awarness of costs ▪ systematic approach of working ▪ ability of decision making	▪ creativity techniques ▪ courage for new solutions ▪ resolving safety thinking	

GEARE:
The Global Engineering Alliance For Research And Education

The history of GEARE began in 2002: First only University Karlsruhe (TH) (Germany) and Purdue University (USA) were involved in GEARE but it became a steadily growing institution and it gained in publicity and importance: Today five universities are involved in GEARE: Purdue University (USA), University Karlsruhe (Germany), IIT/UICT Mumbay (India), Shanghai Jiao Tong University (China) and Tecnológico de Monterrey (Mexico). At University Karlsruhe (TH) (Germany) the Institute of Product Development (IPEK) under direction of Prof. Albers is responsible for coordination and administration of GEARE. IPEK handles the GEARE contacts between University Karlsruhe (TH) and its partner universities. GEARE focuses embedding international project work into the engineering education and it can be perfectly matched with KaLeP. In total four aspects help GEARE to bring great possibilities and advantages to both students and universities:

Comprising KaLeP: GEARE comprises the elements of KaLeP by embedding elements of KaLeP into the different kinds of Student Exchange Programs. Different stages of KaLeP are matched with different stages of GEARE.

Embedding into the curriculum:

GEARE totally fits the curriculums of the partner universities. The classes at the partner universities are geared to match the courses taking place at the home university. Due to this the time to graduation for the students is not affected. ***Full transfer of course credits:*** The student's course achievements at the partner universities are fully transferable to the home university. The acceptation of the course credits is arranged previously by the universities since these courses satisfy the home universities plan of study. ***Exemption of tuition fees:*** Students participating in GEARE stay being registered at their home university for the duration of the exchange program. In addition they are registered at the partner university. The partner universities committed to exempt the partner university students from tuition fees. So each student is responsible for paying the tuition fees at his home university but not at the partner university.

Undergraduate Student Exchange:

The undergraduate student exchange is concentrating on the KaLeP course Mechanical Design III. The duration of about 12 months is scheduled in three thirds with about 4 months each. Students participate in: one semester of study at the home university with students from international partner universities, one semester of study abroad and a two-semester multi-national design-team project (one semester at home university, one abroad) with students from international partner universities working on industry-inspired projects.

1) One Semester Study at Home University (e.g. University Karlsruhe (TH), Germany):

The undergrad exchange program starts at University Karlsruhe (TH) in Germany. First students from Purdue University (USA) and SJTU (China) absolve an industrial internship in an international company in Germany. Then the students attend classes according to their home universities curriculum at University Karlsruhe (TH). Classes are attended at University Karlsruhe (TH) and at the Carl-Benz School of Mechanical Engineering. All relevant classes and KaLeP courses are taught in English to make studying easy for international students who do not speak German sufficiently. All students join the English lecture and tutorials in Mechanical Design III. Multi-national teams are set

2) One Semester Study at Partner University (e.g. Purdue University, USA or SJTU, China):

After the first semester the German students stay at the partner universities for one semester together with their American and Chinese partner students. The German students attend different courses to fit the curriculum at University Karlsruhe (TH).

3) Internship (e.g. USA or China):

While participating in GEARE all students take part in a 3 months internship program abroad with an international company. The internship is part of a 20 week internship which is mandatory for the students at University Karlsruhe (TH). The students work as interns in international companies to gain insight not only into the working environment of an engineer but also into the working environment in an international context.

4) Two Semester Global Design Team Project (e.g. University Karlsruhe (TH), Germany and Purdue University, USA , or University Karlsruhe (TH), Germany and SJTU, China):

The two semester design team project consisting of two parts takes places during the study at University Karlsruhe (TH) and later at the respective partner university:

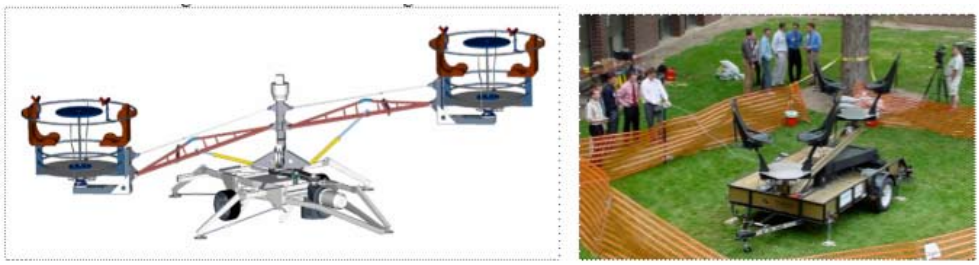
Part1- Mechanical Engineering III Project Work at University Karlsruhe (TH):

For the project work multi-national student teams of five students each are built. The teams are coached and supervised by especially trained student helpers and faculty staff.
The colloquial speech in the team and in the team meetings is English. The students have to fulfill a complex design task. The tasks vary and pose new challenges for the students each year, to keep up the high quality of the tasks. The tasks encompass the development and the design of a technical system. Hand drawings, CAD models and real prototypes are built by the student teams. An example for these tasks is the design of a transportable carrousel for private garden parties mounted on a car trailer.

Part 2 – Senior Design Project at Purdue University, USA or SJTU, China:

The second part of the two semester design team project takes place at the partner university respectively. New multinational student teams are built to continue working on the design task. The virtual prototypes need to be optimized to develop a more detailed design of the technical system. At the end a real prototype of the system which can be used under realistic conditions is built by the student teams. This includes the manufacturing of the real prototype and the acquisition of all needed parts for the prototype. The student teams can take pride in their team work which was continued for two semesters. This is a great conclusion for the students and the year they took part in GEARE. Virtual and real prototypes of a corousel designed within the project work of Mechanical Design III are shown in figure 3.

Figure 3: Virtual and real prototype of a corousel designed within the project work of Mechanical Design



Summary

GEARE proved to be an effective and efficient means for a valuable source of engineering education today. The student project work introduced in KaLeP could be successfully implemented into an international student exchange program. A two-semester multinational design-team project was developed and has been conducted successfully for several years. Thus undergraduate students get the opportunity to get involved into working in multi-national teams on industry-inspired projects. This is a unique element in the academic education of engineering students. The multinational design-team project could be introduced into the exchange programs with Purdue University (USA), Shanghai Jiao Tong University (China) and University Karlsruhe (Germany). It was shown that student project work and international aspects in engineering education can be matched perfectly. Students report about the positive effects taking part in the multinational design-team project within GEARE had for their academic and personal life. Students comments show that GEARE is a great program bringing benefits to both the universities and the students:

"I learned a lot about myself and what I am capable of accomplishing." - "The GEARE program has helped me to define my career goals by exposing me to new possibilities. But the GEARE experience is much more than school and work."

[Students from Purdue University in the USA at University Karlsruhe (TH) in Germany]

"This is the most unforgettable experience in my life. I have gained a lot of unique experiences which will benefit me in my future life." - "Taking part GEARE was the most unforgettable and eye-opening experience for me. It provided me with an opportunity to observe and meditate my study, my life and the world around me in the light of a different culture and civilization. This unique experience will exert a lasting influence on my whole life."

[Students from Shanghai Jiao Tong University in China at Karlsruhe (TH) in Germany]

"Taking part in the Undergraduate Student Exchange changed me both in professional and in personal respect. I could enhance myself and I'm thankful for having gotten this opportunity. We became friends with the international students and our friendships don't allow to forget the great time and experiences." - "GEARE is a great program with outstanding possibilities concerning academic studies and transferability of credits as well as gaining experience in a multi-national design team. Last but not least: You get to know and live in a foreign culture and have a lot of fun!"

[Students from University Karlsruhe (TH) in Germany at Purdue University in the USA]

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