Transnational Connected Learning and Experimentation

Using Live Online Classes and Remote Labs for Preparing International Engineering Students for an International Working World

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Dominik May, A. Erman Tekkaya
TU Dortmund University, Dortmund, Germany

Abstract—**Students, who are leaving their home country for taking part in an international study program, face several challenges. Not only the new course of studies can be very challenging but also their whole living conditions may change significantly. This can be a severe clash especially for students who are moving to a country with a totally different cultural background in comparison to their home countries. Moreover, it can profoundly complicate the first weeks at the new university. Knowing about the difficulties the Institute of Forming Technology and Lightweight Construction (IUL) at TU Dortmund University in Germany developed a preparational online course for those international students, who are coming to the IUL for their Master of Science program in Manufacturing Technology (MMT; a special international master program). In context of this course the use of the IUL's remote laboratory equipment was a key aspect. The course itself was implemented and delivered for the first time in 2014. By now a second updated edition was delivered in 2015. It was designed to prepare the students as best as possible for their new studies at a German university and at the same time prepare them for transnational collaboration. Hence, this course is a good example for a meaningful integration of remote laboratories into an innovative online course concept. On the one hand making use of remote laboratories and its practical integration in online courses helps to connect the international students and on the other hand it brings them into the situation to interact in context of a typical engineering situation, the experiment. The paper presents the course itself and experiences from its first and second implementation.**

Index Terms—**intercultural competences, online teaching and learning, remote laboratories, transnational teaching approaches**

I. INTRODUCTION AND COURSE IDEA

The world is more and more globally connected. That counts for the economical as well as for the educational sector. Whereas producing companies distribute their production processes all over the globe, students increasingly seek to gain international experiences by studying abroad or doing internships in foreign countries in order to prepare themselves for working in international environments later on. Programs and opportunities to study abroad are nearly uncountable. In 2014 for example 206,986 international students studied in Germany and 117,576 German students went abroad to gain new international experiences [1]. A special case in this context are international study programs that offer the opportunity to students to not only going abroad for one or two semester but studying a full bachelor or master program at an university outside their home country. These programs are mainly taught in English so that the language barrier could be rather small.

The engineering faculty at TU Dortmund University in Germany offers such an international Master of Science program in manufacturing technology (MMT1). To attract engineering students from around the world, the course offers a compact 2-year English taught program. MMT consists of theoretical fundamentals in machining, materials and forming technology in connection with comprehensively applied hands-on science studies. Students are given the opportunities to carry out their hands-on experiments side-by-side with researchers in highly equipped labs. The included one term thesis should be done with leading companies in the sector manufacturing technology. Based on the experience gained with prior MMT cohorts, foreign students often need some time to overcome some of the typical difficulties, like cultural and academic habits, when starting. The basic idea for the presented course concept was to work out an online course the students could go through before they come to Dortmund. Two different perspectives mainly drive the course idea and its concept.

The first perspective is the students' preparation for their stay in Germany. As the students, who sign up for this international master program, come from all over the world they all have differing cultural backgrounds and are used to different educational systems as well as teaching methods. Hence, on the one hand the idea was to bring them into contact with the German culture and the educational concepts they will be facing during their future studies. On the other hand, we wanted to bring them into contact with their future classmates. From former student cohorts we know that especially students from the same home countries tend to build a closed peer group, which hinders international collaboration during their stay in Germany.

That leads to the second perspective on the course idea: All of the students will work as engineers after their master program, either at scientific institutions or in industry. For both options it can be said that transnational collaboration in the working context is more important than ever. Hence, the students are expected to develop real intercultural competences during their studies. Without going to much into detail about the notion of intercultural competence itself, the following should serve as a working defi-

[1] Official MMT website mmt.mb.tu-dortmund.de

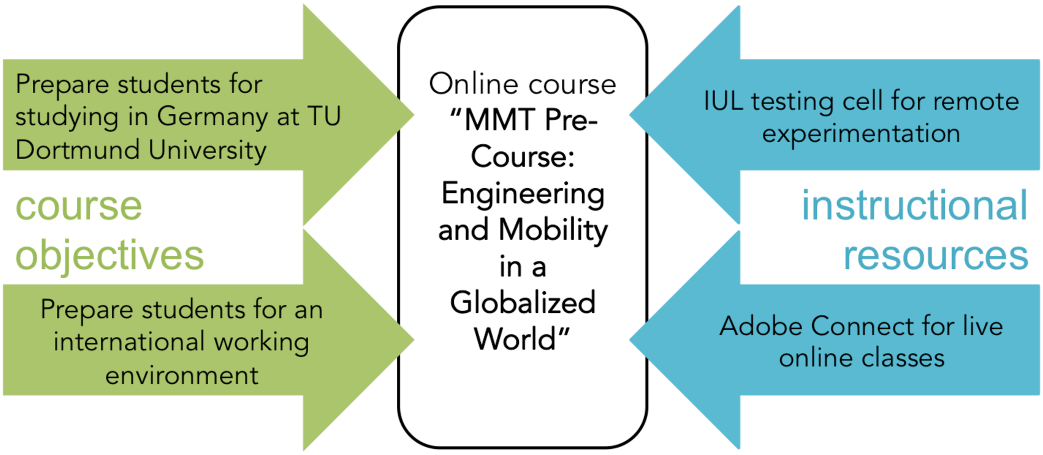

Figure 1. Course objectives and instructional resources for the MMT Pre-Course design

nition: "Intercultural competence describes the ability to effectively and adequately interact in intercultural situations on basis of explicit attitudes as well as the special ability to act and reflect"(own translation) [2]. This definition states clearly that intercultural competence can only be shown in intercultural situations. Consequently, this means that its development can only happen in corresponding learning situations. The developed course should serve as such a situation in the run up to their international experience in Germany.

Both considerations from above inspired the course conception. Summing up, its main goal was to prepare the students for two different contexts: Their stay in Germany and their future working environment. This all should be done in a combined use of modern online communication tools and the comprehensive remote laboratory equipment at the IUL (Fig. 1; for details on the tools and instructional resources see II).

Finally, the course was developed with respect to the guiding theme of mobility and called "MMT Pre-Course: Engineering and Mobility in a Globalized World". Giving the whole course the context of mobility opened up the opportunity to talk on the one hand on core engineering topics like production and material sciences and make use of the remote laboratory equipment at the IUL. On the other hand mobility was identified as an ideal topic to tackle a future global challenge. Furthermore, mobility can be discussed on basis of many differing international perspectives. Hence meaningful discussions in terms of multi-perspective and multi-cultural thinking can be expected discussing mobility with international students. For more details on the course concept and the connected activities see III.

The course is delivered for the first time in August/September 2014 and a second time in August/September 2015, each time in advance of the students' stay for their master program in Germany. That means that all of the students are in their home country at this time. Therefore we take advantage of online tools in order to deliver this course fully Internet based and having the students taking part from their home. In the following the instructional resources and the laboratory equipment will be explained. After that the course itself will be explained more in detail.

II. INSTRUCTIONAL RESOURCES

As the participants for the presented course concept are globally distributed and take part via the Internet, a special focus has to be put on the digital instructional recourses. This is a significant difference to classical classroom based courses, in which all participants come together in one physical existing room. Hence, an adequate online environment has to be used in order to build up meaningful teaching and learning activities. In addition to that a special focus for this class is put on the laboratory work part. The students are expected to carry out real experiments and therefore remotely use the IUL's laboratory equipment. Remote laboratories in general describe physical existing laboratory equipment that can be accessed and used via the Internet. Hence, this technology fits perfectly in the described online course concept. Both, the online learning environment and the remote laboratory, will be explained in the following.

A. Using Adobe Connect for live online learning experiences

The core instructional resource for this course was Adobe Connect [3]. This technology is a classical online meeting tool and gives the opportunity to run live class sessions just as in a real classroom. The only difference is that all the participants are not present in a physically existing room but enter an online room by using their personal computer, a headset, a webcam and, of course, their internet connection. Fig. 2 shows the environment, which the instructor and the students mainly see on their desktop during class.

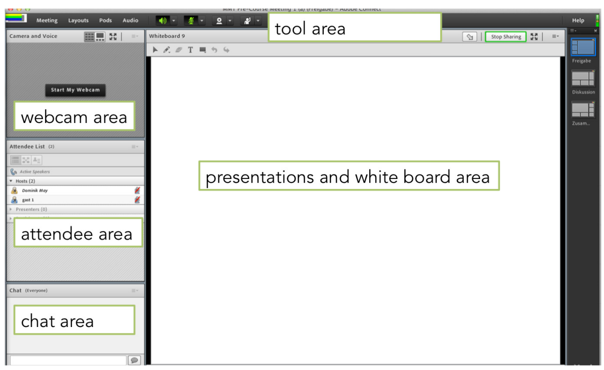

Figure 2. Desktop in the Adobe Connect environment

As it can be seen in Fig. 2 there are different areas in the environment. At the very top left corner, there is the webcam area, where every student can transmit its webcam picture. The tool automatically recognizes the speaking person, so that only her or his picture is transmitted at this time. Below that a list of the current meeting attendees is displayed and the participants can also identify the different attendee roles, e.g. the instructor, participant. In the left bottom corner a chat area can be used in order to communicate in written from. Normally, in the chat area short messages are posted, for example to ask short questions without interrupting an ongoing presentation or to note that the audio quality is temporally low. The desktop's biggest part is the presentation and white board area. This can be used as a classical whiteboard for note making or quick sketching. If a presentation is shown to the participants it is also displayed in this area. This design can be changed and enhanced with other applications, just as it is needed during class.

Moreover, Adobe Connect has many opportunities in terms of instructional tools, depending on which activities should be performed during class. In this course the desktop sharing option was one of the most frequently used application. That means that one of the meeting attendees is able to share his or her desktop with all the others and with this e.g. give a presentation. The shared desktop is also displayed in the white board area.

Another important application for this class was the break out room option. Normally, all participants are in one virtual room so that everybody can speak to all the others or, to put it another way, all the participants can take part in one discussion. The break out room application gives the opportunity to distribute the students to individual virtual rooms. In these rooms they can discuss in smaller groups without hearing the other groups talking. After a period of time the instructor can bring everybody back to the main room and ask them to explain what they recently discussed in the smaller groups. Fig. 3 displays the two main course situations.

B. *The IUL testing cell for live online experimentation*

Another very important technology for this course was the remote laboratory at the IUL [4]. With this it was possible to make the testing machine at TU Dortmund accessible via the Internet. With the help of this technology the students could sit at home in front of their computer, start real experiments, monitor the experiments and download the generated results. For the experimentation we made use of the iLab technology from the Massachusetts Institute of Technology [5].

At the IUL an own remote laboratory on manufacturing technology has been developed. This laboratory gives the students and teachers the opportunity to conduct experiments in the field of manufacturing technologies especially for material characterization. Figure 4 (right) shows the laboratory with two testing machines for sheet metal forming and tensile tests. In addition to that, the lab contains an industrial robot with several grippers for the specimen handling and the needed equipment for the experiments' automation and control. The tensile test is the first implemented experiment in this lab. This test is one of the common and efficient tests to get the material properties of the tested specimen [6]. The determined properties describe the behavior of such material. Furthermore, the properties can be used in forming applications like FEM-Simulations (e.g. simulation of forming processes or production processes). This is why it is a very basic but as well an important test in the context of manufacturing technology.

Due to the global requirements, such as the share of the experiments with other Universities, managements of users, user groups and reservation of timeslots, the iLab shared architecture is used here [7]. Basically the lab is developed so that it can be easily integrated in other platforms like the weblabdeusto [8].

As mentioned above, a user friendly Graphical User Interface (GUI) for the tensile test is implemented and integrated in iLab (see Fig. 4 left). This GUI is divided in four regions. The first region consists of a field of parameters, which can be set by typing a numerical value or selecting a value from a list. In the second region, different actions can be performed "Setting Parameters", "Start", "Pause", "Resume" and "Cancel". With the help of these actions an interaction with the experiment is guaranteed. The captured experiment real time data are shown as numerical value in the third area. This data are the acting force on the specimen, the displacement and the width variation of the specimen. Furthermore to illustrate the data, it is displayed in form of diagrams, too. In the fourth area (last), a video live stream of the experiment is shown. The user can change the observation perspective by selecting another camera. This is very helpful to give the user an all-around perspective of what is happening in the experiment.

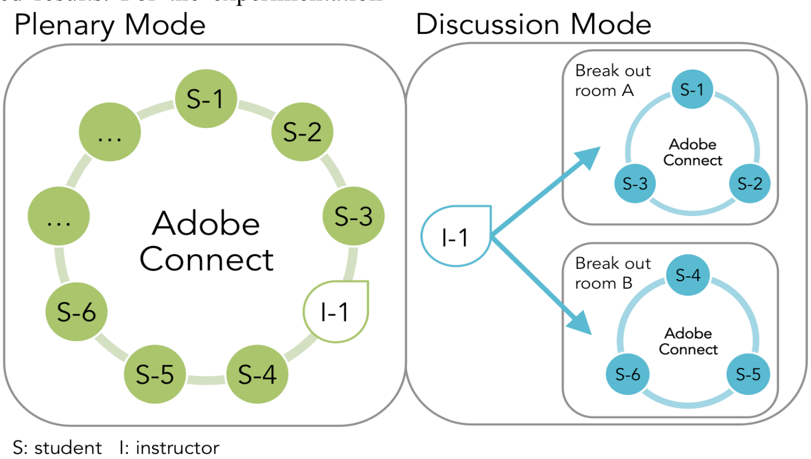

Figure 3. Two mainly used modes during the MMT pre course

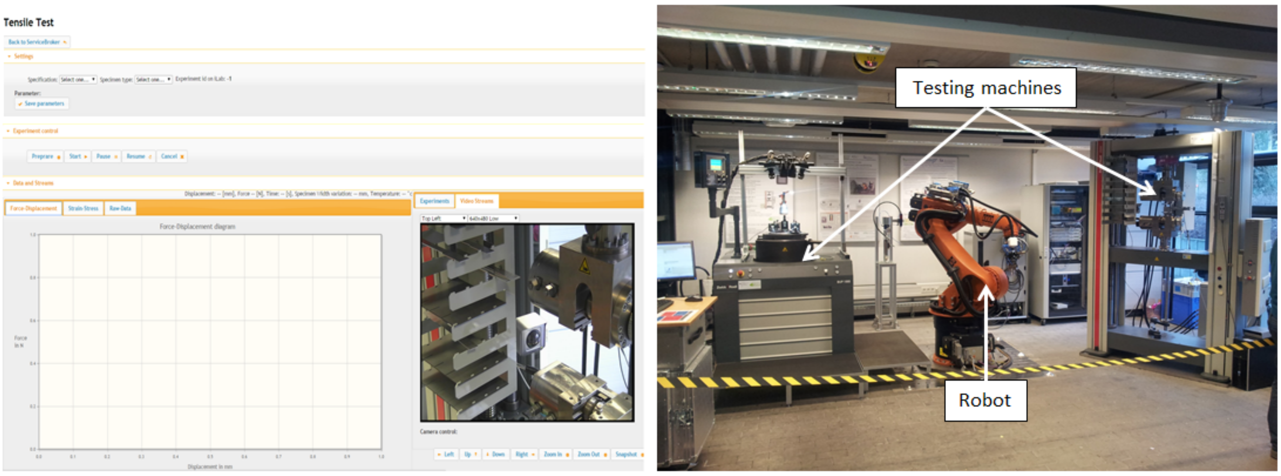

Figure 4. Remote laboratory at IUL: Lab Client (left) and testing cell (right) [4]

III. THE MMT-PRE-COURSE CONCEPT

After having explained the instructional resources and its functionality, the course itself comes into focus. All this technology would be useless if a meaningful integration into an educational setting would be lacking. Hence, in the following the course design concept, the learning objectives and a brief overview of the course activities will be given.

A. Constructive Alignment as a backbone for the course design

Constructive Alignment is a fundamental concept in higher education [9]. Within this concept the intended learning outcome, the teaching and learning activities, and finally the examination are in focus (see Fig. 5). As the name indicates, all three of these course parts have to be aligned in order to design a well-prepared course; meaning they have to be designed so that they show clear conjunctions. Following this model, a course design process ranges in a triangle between these three components and takes them into account - beginning with the intended learning outcome. The intended learning outcomes are the goal for the whole course. These outcomes define what the students should be able to do after having successfully passed the course. Based on them the teaching and learning activities should be planed and designed. That means that the course designers have to take great care in order to design activities that give the students the opportunity to achieve the course goals. For example, if the course goal is to be able to perform experiments and with this to gain material characteristics after the course, there is no other way than letting the students do their own experiments. No oral lecture would fully bring them into the situation to gain such a competence. Finally, the examination has to measure exactly these outcomes. Even if the constructive alignment does not force the designer to begin at any of the three points it proved helpful to begin with the learning outcomes as a guiding factor for the following process. It is not necessary to go on with the activities and finish with the exam as both are in such a close interconnection so that it will be a back and forth process anyway.

In the following the intended learning outcomes and the teaching and learning activities for the MMT-Pre-Course will be explained. As this course does not finish with any exam or something similar this part of the constructive alignment will be left out.

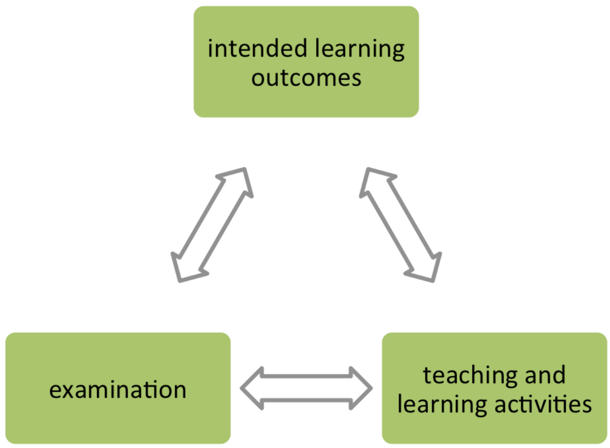

Figure 5. Constructive Alignment as a backbone for the course design process [9]

B. Learning objectives

The learning objectives for this course are heavily influenced by the course objectives displayed in Fig. 1. Hence, a particular emphasis is put on the development of intercultural competence. As intercultural competence has something to do with interaction with others and with self-reflection [2], both of these activities are included in the course concept. In addition to that, bringing the students into contact with their destination's culture and with their future classmates is another focus. Moreover, the fact that the course should prepare the students for an engineering master program profoundly affects the intended learning outcomes. Experimentation is an important part of engineering curricula. Therefore it should be part of this course, too. Hence, the students should do core engineering work, in this case by executing own experiments (a tensile test to be even more specific). By making use of remote laboratories recent technical developments in production engineering education are added to the course concept. In this context seems to be important to us to talk about technologies not only form a technical but from different perspectives. Talking about the technical as well as cultural and organizational aspects of technologies broadens the students' view and gives the opportunity to compare different perspectives on an intercultural level. This approach subsequently leads back to development of intercultural competence.

All these considerations lead to the following intended learning outcomes. After the course the students should be able to…

1. …describe their destination on the basis of internet research
2. …describe their own concept of engineering in comparison to others
3. …reflect on the international differences in engineering
4. …use a basic model for describing technology from different perspectives (technical, cultural, organizational)
5. …run experiments like the tensile test and use the gained data for engineering work by connecting theory and practice
6. …explain a general stress-strain-diagram by identifying important points as well as explaining their relevance for forming technologies
7. …communicate successfully with international engineering colleagues using internet technology
8. …organize themselves in a working process and work successfully together in multinational teams in order to fulfill explicit tasks

These learning outcomes can be divided into 4 different groups. Whereas outcome number 1 focuses on Dortmund and the students' destination, the outcomes 2-4 express the necessity of being a reflective engineer who is able to put its own profession and work in context with other fields and finally in a global context. Outcome 5 and 6 focus on central engineering aspects and define the objectives that are connected to the work with the laboratory equipment. Finally, outcomes 7 and 8 have to be seen in a broader context. They express the goals in context with international co-operation with the help of Internet technology. All of these intended outcomes were presented to the students during the first meeting, so that they knew what was expected from them during the coming course.

Based on these intended learning outcomes the course activities are designed. They will be outlined in the following.

C. *Course activities*

The first course edition in 2014 was delivered during a period of three weeks. In the second edition from 2015 we extended this to four weeks as the experiences from the previous year showed, that more time was needed in order to successfully achieve the course goals. However, each course week covers two live online meetings. In these live sessions all participants come together in an Adobe Connect online room (see II). The sessions mainly consist of presentations by the students, discussion groups or explanations by the lecturer in order to introduce a new topic or the next step in class. Even more important are the working phases between the live sessions. In these phases the students do own research on various topics or carry out preparational work for the coming session, mainly in form of group work. Therefore the whole student group is split into smaller working groups. The students are mixed so that every group is a blend of students from different countries with different cultural backgrounds. In these groups they work on the given tasks. Speaking frankly, this is the time were the international students actual have to co-operate with each other with the help of various Internet technologies.

Based on the different topics the course can be divided into three main parts: Local and cultural orientation, global orientation and technical orientation. These parts reflect the different intended learning outcomes. Fig. 6 shows the course concept in total. The details will be explained in the following.

1) *Local and cultural orientation (first part)*

The first course part is dominated by getting to know each other, the course instructor and the course concept itself. However, not too much time is planned for that in order to get into proper interaction with each other as soon as possible. Therefore, in this very early phase of the course a focus is put on the personal orientation in the students' future destination. During this local orientation a short presentation about the Ruhr Area itself and its location in Germany, the city of Dortmund and the TU Dortmund University is given. This presentation is designed so that the students gain a broad overview over the area and

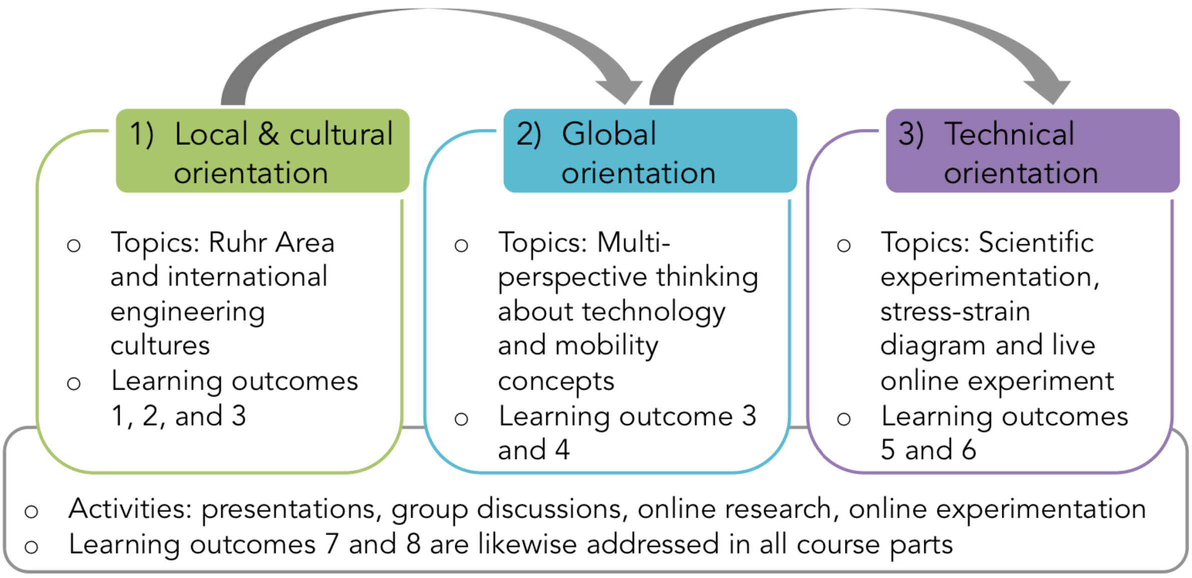

Figure 6. MMT-Pre-Course concept in three phases

are able to start with this knowledge in a first working phase. Divided into three groups the students have to do an online research about their destination for their future master program, led by several guiding questions. These questions lead the students from the local orientation to the cultural orientation, too. The groups have to focus on different aspects during their research. One group has to find out more about regional information and the historical role of engineering in the Ruhr Area. Another group has to focus on current strengths in industry, science and research. The third group concentrates on quality of life and future plans for the region. The task connected to this online research is to find online available information to work out a presentation on these topics. In addition to that, all of the groups are asked to compare their results to their home countries and answer if they find any major similarities or differences. The results are presented and discussed in class during one of the early live sessions. With this the students simultaneously orient themselves in their destination and put that into context with their own cultural background. Furthermore, they are introduced into the home countries of their future classmates.

After the local orientation and the presentations the following meeting is dominated by the several discussions on the engineering profession itself. Therefore, we make use of the option to split the students into smaller groups and send them to several breakout rooms for more intimate discussions. After some minutes they come back and share their discussion results with the whole group. This phase is sequenced into four steps. In the first step the groups discuss the role and the status of engineers in their home countries. Furthermore, in the second step they are asked to describe typical tasks of engineers from their perspectives. Based on that, they work out a list of competences engineers need to fulfill the described tasks. In a third step the students discuss on the necessity of international experiences for the job of an engineer and furthermore they are asked to describe global technical challenges especially engineers face in the future. Again, they finally work out a list of competences that are needed for facing these global challenges.

With these activities learning outcome No. 1 to 3 are in focus. The last two discussion topics explained above are meant as a transitional period from the cultural orientation into the following course part: the global orientation.

2) Global orientation (second part)

The global orientation is characterized by two different working phases. On the one hand the students have to work on a concept to describe technologies by looking at technical, cultural and organizational aspects. Furthermore, they should develop a concept on how technology progress and society development are connected processes and determine each other. This activity is supported by out of class readings (e.g. [10], [11]) and by in-class discussions based on those readings. The important aspect in this phase is to bring the students into the position to discuss on technology from different and even non-technical perspectives. From our viewpoint this is absolutely necessary in order to develop intercultural competences. From our perspective the pure technical understanding of technology is not enough for future engineers, as we consider a meaningful exchange on the implication of technology in different cultural contexts will gain in importance in the future. Even if the retraction on pure technical considerations may be the favored aspect for many engineers about their profession, this won't be enough in order to act successfully in intercultural situations.

In a second step the students have to use the discussed models to work out a presentation on different future mobility concepts from all over the world: The Land Airbus developed in China, the Personal Rapid Transit System used at Heathrow Airport in Great Britain and the Car Sharing system, for example introduced in Berlin, Germany. For this task the students again work in the three smaller groups and in these groups they have to do an in-depth research one of these technologies. Based on that research and the previous readings they have to work out their presentation and answer the following questions:

- What are technical, organizational and cultural issues of that technology?
- What are relevant social groups that might have an interest in the technology or might have an impact on the technology's development?
- What are advantages and challenges of the technology?
- Would that explicit technology be applicable in each of your home countries? If yes/no, why?

Especially the last question indicates that an international comparison of these concepts is an important part of this task. Hence, the students were forced to think about their home country, make a statement on the compatibility of such a technology in their country and compare that to others. The presentations are given during one of the live class meetings and normally lead to highly interesting discussion points. For example one student commented in 2014 that public transport in general is problematic in his country for security reasons. Even if a technology like the Land Airbus would work perfectly and may be a solution for decreasing the traffic in the city center, nobody would use it because of being frightened of being robbed. Comments like that are the backbone of the connected discussions and point out that every technology has cultural as well as organizational aspects, which differ from country to country.

As shown in Fig. 6 this course part references back to outcome No. 3 but mainly addresses learning outcome No. 4. Talking about mobility concepts at the same time is the door opener for the technical orientation in the last part.

3) Technical orientation (third part)

For the technical orientation the remote laboratories come into focus. In the presented course they are connected to the topic of vehicle design, or better, lightweight construction in vehicle design. Therefore the students finally have to do a tensile test with two different materials using the laboratory equipment at the IUL. Before that, they are asked to work out a short overview on stress strain diagrams in general. These diagrams and the connected experimentation are a basic work in engineering in order to gain material properties. These properties can then be used for design tasks. For that first technical task the students are given two simple but differing stress strain diagrams and based on their previous knowledge and additional internet research they have to answer the following questions:

- What do the diagrams show?
- What is the difference between the two diagrams?
- How are they worked out?

- What are important areas?
- Which material properties can be gained through the connected data and how?

After that, the students are introduced into the iLab environment and the experimentation software. Furthermore they are given an explicit component design task. Within this task they have to design a security component for a vehicle: Little pins, which prevent the engine from entering into the passenger cabin during a frontal crash (see Fig. 7). For designing those pins the students have to compare two materials options (stele and aluminum). Therefore, they are asked to execute the live online experimentation with both materials remotely using the IUL's testing cell. For the experimentation itself the students are free to do this whenever they are able to do it in their group. The remote lab is online available and ready to use for three half days. Hence, the working groups have to develop a working plan when to do the experimentation and arrange the experimentation by booking a time slot. In order to jointly do the experiment in their group the students are asked to use Adobe Connect. That means that one of the group members books the laboratory equipment, logs in at iLab, shares its screen via Adobe Connect and does the experiment. With this technique all of the group members can see and discuss what is happening.

Based on the results the students have to work out a short report talking about the differences between the two materials and in how far this has an impact on the production process. Summing up, that means that the students have to

- work out the stress strain diagram based on the experiments' results,
- calculate the respective material properties,
- calculate the component dimension for bot materials and finally
- make a statement on which material would be better for the component.

This preparational work is of highly importance for the following experimentation. As the participating students have bachelor degree from different institutions in completely different countries it is necessary to check if all of them are sufficiently prepared for understanding the experimentation and the connected knowledge and, if necessary, to bring them on the same level of knowledge.

One of the expected statements is that security requirements often are contradictory to lightweight construction goals. Using lighter material often (not always) leads to bigger component dimensions, if the same security requirements should be met. The last live meeting is used to do a final feedback discussion on the class, the course concept, the learning outcomes and the students' expectations coming to Germany after the course.

The last course part mainly addresses learning outcomes No. 5 and 6. The learning outcomes No. 7 and 8 cannot be allocated to one of the three course phases, as there is constant interaction between the participants. Especially during the working phases, in which the students have to do online research, work out presentation or do the experimentation, they learned a lot about international collaboration over the Internet.

After having explained the course in the following the experiences will be explained. This will be enhanced by some insights into the students' feedback.

IV. EXPERIENCES AND STUDENTS' FEEDBACK

As mentioned above, the course was delivered in 2014 for the first time. A second edition was delivered in 2015, so that we can look at experiences from two editions by now. Hence, these still are the first hands-on experiences the instructor team made with the instructional activities and laboratory's usage in a transnational course concept. Therefore, this chapter is divided into three main parts. Firstly, a short overview on the participants of each edition is given. Secondly, the experiences that were made with the laboratory equipment and its usage will be explained. Thirdly, the students' feedback will be explained.

A. Course participants

In 2014 edition of the course all in all 12 students from 10 different countries took part, speaking 10 different mother tongues (the students came e.g. from India, China, Pakistan, Nigeria, Brazil, Turkey, to name just a few; see also Fig 8). These different countries meant practical challenges for the course design as they the students lived in very different time zones. In order to have synchronous online course parts, which were seen as essential for the course success, this fact made it necessary to split the participants into two groups from the beginning on. One group consisted of participants from Far East countries (from Iran to China) and another group of the most west-

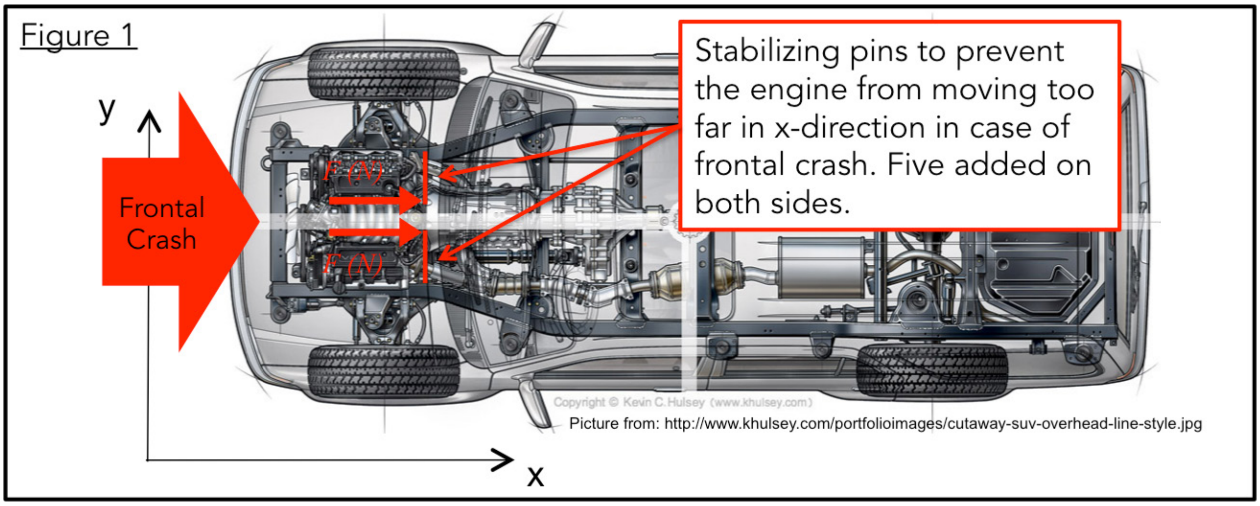

Figure 7. Context for component design task [12]

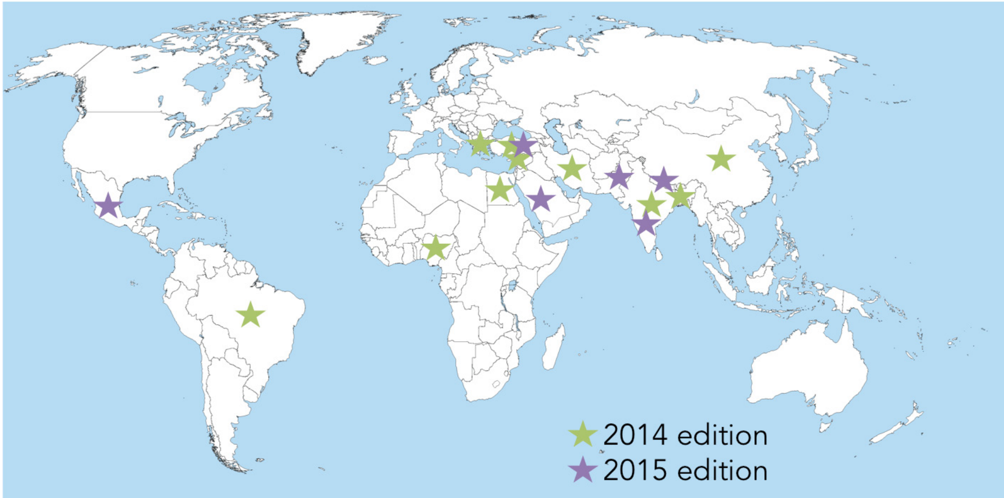

Figure 8. Course participants and their home countries [13]

ern located participant from Brazil and the students from the near east (Lebanon was the most eastern located country in this group). Even if it would have been better to put all participants in one group in order to have a more intercultural mixed group, there was seen no other option to face the time-zone problem. 11 of the participants were male, one female. 7 of them were between 21 and 24 years old, whereas 5 of them were between 25 and 29. All of them either learned English during earlier education or because it is a second official language in their country. In terms of earlier intercultural experiences only for stated that they did not have any. Most if them commented that they have parents from different cultures, already studied abroad, worked with international colleagues or had other experiences with different cultures.

In the 2015 course edition at the beginning 16 students (5 between 20 and 22, 7 between 23 and 25, 2 between 26-28 and 2 between 29-31) took part. Due to several reasons this number dropped to 14 participants. The students came from 6 different countries: Mexico, Turkey, Iran, Pakistan, India, and Nepal (Fig. 8). All of them (except for 4 students) stated that they already gained intercultural experiences through friends or personal experiences abroad.

B. *The remote laboratory experience with international distributed student groups*

In the 2014 MMT-Pre-Course the students performed a total of 13 tests. Each student performed at least one experiment. Some of the experiments were reserved but not performed or canceled by the conduction. Due to security issues (bugs in the safety network of the machines) the control unit interrupted some of the tests. But these issues have been resolved within few hours, so that the students could restart there interrupted experiments. Some of the students complained that the captured real time data are not displayed correctly in the diagrams, after some investigations we could found the problem. This was related to the bandwidth and to the process power of the used device. The problem was fixed by separating the data transmission from the display process.

During the 2015 edition severe problems occurred on one of the experimentation days. The case is not completely explained yet, but it seemed to be problem between the browser, which is used to log into the iLab experimentation software, and Adobe Connect. It seemed to us that the desktop sharing application of Adobe Connect overlaid the browser window in a way so that the students were not able to click several buttons in the graphical user interface for the experimentation. Even if we saw the students clicking on these buttons, nothing happened. Hence, the students were not able to prepare, start, and finish the experiment. This problem was the reason for canceling one of the experimentation sessions completely and retrying it the next day. Changing over to the Chrome browser solved that problem on the next day so that the course participants could carry out 21 experiments. However, this will be one task for the future. As international co-operation and building transnational student working groups in context with laboratory work is a main focus for our work, we have to find out an adequate solution for jointly executing remote experiments in online groups, either with an additional tool like Adobe connect or directly with the used graphical user interface.

C. *Students' feedback in 2014*

After the 2014 course edition the students' feedback in general was very positive. On a scale from 1 (not enjoyable at all) to 5 (highly enjoyable) all of the students rated the MMT-Pre-Course with a 4 or 5. They appreciated very much the opportunity to get into contact with their future classmates and to learn something about the Ruhr Region. In addition to that especially the online experimentation part was rated as highly interesting as most of them never had worked with such equipment before. In order to get a more detailed impression of the students' feedback, they filled out a short questionnaire after the class. Answering the question "What was your favorite part of the course?" 8 out of 12 students stated, that the experimentation with the tensile test was their favorite part. Others indicated that the the component design task was the most interesting and one student stated that the international collaboration in general was the best.

In general most of the students indicated that they were satisfied with the course outcomes. Their principal personal goal (in addition to the intended learning outcomes posed by us) was to get to know their future classmates and their destination, which was achieved. Others commented that this course helped them to "switch their minds" back into study modus as they finished their bachelor degree some time ago. A critical comment on the course was that even more about the daily life in Dortmund could have been learned. Asked for the major benefits they experienced while working with students from other countries, the students mentioned the insight in different cultures and countries in the context of technology application. Furthermore, they found it important to make first experiences in working with students distributed all around the world. For example having the different time zones in mind and its impact on working processes was new to some of them.

As a major challenge for the collaboration different English language accents and the weak Internet connectivity of some participants was identified. That even had some negative influences on the live online classes. Whereas some participants obviously had a strong connectivity and regularly could take part in all meetings, some of the students had bigger problems with that. Some of the students experienced the problem of repetitively loosing the Internet connection, so that they had to reconnect and rejoin the online meeting several times. In one case one student even missed a whole class as his home city was undergoing an electricity shutdown for a couple of hours. A bad Internet connectivity also had negative impacts on the audio transmission so that some participants were hard to understand or sometimes even could barely follow the course, as they did not understand the speaking person.

Finally the students were asked about their personal interaction with their international classmates. On a scale from 1 (no interaction) to 5 (high level of interaction) the students rated their personal level of interaction on an average with 4. In additional comments on this question the students stated that they regularly met between the classes in order to fulfill the given tasks and that everybody's point of view were considered. Some even founded new and course bound Facebook groups.

D. Students' feedback and course evaluation in 2015

Based on the feedback and additional focus interviews the course concept was slightly edited for the 2015 edition. As already indicated above, the course concept–e.g. the intended learning outcomes, the three course parts and the used instructional resources–basically remained unchanged. However, we expanded the course time from 3 to 4 weeks and a major change can be seen in a more in-depth evaluation process, which was carried out during the 2015 edition. This evaluation was based on a newly at TU Dortmund developed holistic model for online course evaluation with a special focus on the online experimentation. This concept is composed of several online questionnaires done by the students at several points of measurement throughout the course. Explaining the whole model of evaluation here goes beyond the scope of this paper. The full concept and more detailed research results will be explained in additional papers and contributions to the respective conferences in the future. However, some of the results will be shown in the following.

11 students took part in the final questionnaire, which was meant to receive general feedback on the course concept. The results from the 2014 course edition could be confirmed in 2015. 82% of the students rated the course as "Highly enjoyable". Moreover, 64% of them were highly satisfied with the course outcome (36% answered "satisfied"). Especially the group work and the online experimentation (despite the technical problems) again was favored by the students, as three of the students' comments show:

"I really enjoyed team working in this class."

"Interaction with other students was very much helpful to improve my knowledge and I also learned a lot about remote experimentation."

"Get to know most of my future course mates and doing the online experiment was great."

The latter two statements are supported by the fact that 73% of the students rated the remote experimentation as the most interesting course part.

In another part of the applied evaluation model we had a closer look on the impact the remote experimentation has on the students' level of proficiency in context with several learning objectives for engineering instructional laboratories. Therefore we asked the students to assess if they think that their perceived level or proficiency in context with fifteen aspects of laboratory work (see items Table 1) has changed during the experimentation task. The asked items mainly base on the work of [14] and [15].

TABLE I.
USED ITEMS AND QUESTIONS TO EVALUATE THE LEVEL OF PROFICIENCY IN CONTEXT WITH EXPERIMENTATION

1.	…handling laboratory equipment, measurement tools and software for experimentation.
2.	…identifying strengths and weaknesses of engineering specific theoretical models as a predicator for real material behavior.
3.	…planning and executing common engineering experiments.
4.	…converting raw data from experimentation to a technical meaningful form.
5.	…applying appropriate methods of analysis to raw data.
6.	…designing technical components or systems on Basis of experiments results.
7.	…recognizing whether or not experiment results or conclusions based on them "make sense".
8.	…improving experimentation processes on basis of experiment results, that do not "make sense".
9.	…relating laboratory work to the bigger picture and recognizing the applicability of scientific principles to specific real world problems in order to solve them creatively.
10.	.…choosing, operating and modifying engineering equipment.
11.	…handling technological risks and engineering practices in responsible way.
12.	…presenting experimentation results to technical and non-technical audiences in written form.
13.	…presenting experimentation results to technical and non-technical audiences in oral form.
14.	…working effectively in a team.
15.	…applying professional ethical standards in terms of objectivity and honesty in context with data handling.
Question: Please state if your level of proficiency in context with the above named aspect of experimentation…	
○	**… has *decreased* since the beginning of the online experimentation task during the course.**
○	**…is *unchanged* since the beginning of the online experimentation task during the course.**
○	**…has *improved* by doing the online experimentation task during the course.**

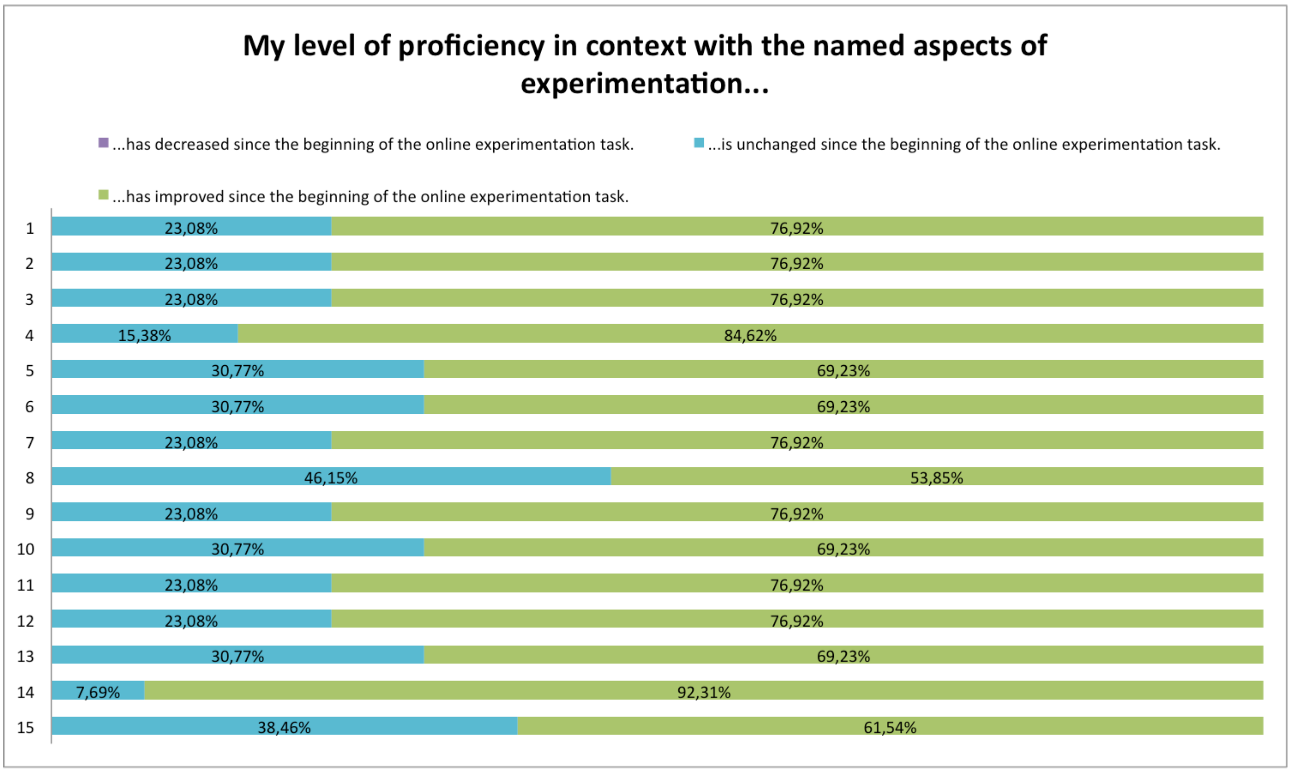

Figure 9. Self-reported development of level of proficiency with regards to different aspects of experimentation (the numbers on the vertical axis correspond with the item numbers in Table 1; n=13)

All in all 13 students took part in the laboratory evaluation. Fig. 9 displays the results. For us these results are more than encouraging, as in none of them a perceived decrease is reported and in the vast amount of the items the students stated a perceived improvement of their personal proficiency. In 9 out of these 15 aspects over 75% of the course participants had this positive impression.

V. CURRENT LIMITATIONS AND FUTURE WORK

The experiences displayed in this paper base on two course edition delivered so far. In the future a third edition of the course will be taught. Changes to the concept will be implemented with respect to each year's feedback results. Even if such a course concept is highly innovative, there remain explicit limitations so far. In each of the first and second edition only a small group of students took part. It is not answered yet, if such a concept, which heavily relies on interaction and discussions, can be scaled up to a larger number of students. However, it will be a task for the future to scale up such concepts in order to reach even more students and having them participate in such transnational course concepts.

Another question will be, if the students, who took part in class, behave–once they are in Germany–in a different way than those who did not take part. This question goes in the same direction like the measurement of the learning outcomes. At the end of the 2014 course edition it was not measured in any way, if and in how far the students reached the intended learning outcomes. Only on basis of the internal evaluation it could be assumed that this happened. Nevertheless, this measurement task is important for designing effective instructional course concepts. Hence, for the 2015 course edition a holistic evaluation concept was designed and applied. The data displayed in IV D. only shows a small portion of the evaluation results. More detailed results on the development of intercultural competences, the achievement of the intended learning outcomes, and even on the IUL's remote lab's effective integration will be broadly discussed in additional papers. This paper mainly served for explaining the course and its design process. Nevertheless, the evaluation model will be improved on basis of the 2015 experiences and applied to the future course edition and even to other courses, in which the remote lab plays an important role.

However, once again we would like to emphasize the positive experiences the students and we as instructors made during the first two course editions. All of the participants would recommend the course to their classmates and future MMT students. Moreover, it is successfully proofed that remote laboratories can be used for online courses with students coming from all over the world, even if they are only connected via the Internet. Hence, from our perspective this approach in general opens up the opportunity to include remote laboratories in international educational online contexts in manufacturing technology. With this the design of totally new instructional concepts against the background of a globalized industrial and educational world will be possible. We just have to take advantage of these opportunities.

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AUTHORS

Dominik May is Research Associate at the Center for Higher Education at TU Dortmund University, Dortmung, Germany (dominik.may@tu-dortmund.de).

A. Erman Tekkaya is Head of Department at the Institute of Forming Technology and Lightweight Construction at TU Dortmund University, Dortmund, Germany (Erman.Tekkaya@iul.tu-dortmund.de).

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