VIRTUAL. INTERNATIONAL. JOB ORIENTATED. – BEST PRACTICE ON HOW VIRTUAL COLLABORATION COURSES CAN SUCCEED.

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Abstract

From April to June 2016 a new and exclusively virtual teaching format – the international STEM¹ Summer School – was provided at the University of Mining and Technology in Freiberg. The paper presents the approach, didactical design, and results of evaluation.

The international STEM Summer School was developed and tested within the project "Holistic International STEMs - Learning with case studies and real-life industry experiences". The aim was to better prepare STEM students for challenges in the current professional world that are characterized by internationalization and digitalization. The project offers some ideas on how to teach the currently required skills and competencies by industry in higher education. The conceptualization of the project was made possible with funding from the Donors' Association for the Promotion of Humanities and Sciences in Germany².

The exclusively virtual collaboration is due to the different geographical distances and locations of the participating students, which generates specific challenges. On the one hand, technical conditions at the particular places of residence have an impact on virtual collaboration. On the other hand, cultural, lingual, and occupational differences, as well as the differing media literacy, play an important role. In addition, the setting of objectives and provision of incentives is decisive for the shared virtual work. The results of the first round of the international STEM Summer School indicate possible solution strategies based on the three areas of media use, interaction, and task orientation.

During the Summer School, students from ten different countries solved real-life job case studies in small interdisciplinary teams. The exchange took place with the help of various e-learning tools like the virtual classroom, wiki, forum and e-portfolio. The participants were mentored by national and international industry partners, STEM professors, and e-tutors. After nine weeks work in intercultural teams they presented their results and learning outcomes during a web conference.

The following article focusses on the evaluation results as well as selected insights and challenges.

Keywords: STEM, internationalization, digitalization, job orientation, employability, quality enhancement higher education, curriculum development

1 INTRODUCTION

The university education is completed; finally finished! Is it all done?

One of the tasks of academic training is to holistically prepare graduates for their professional life. But what awaits them there?

JOB ORIENTATION: A recent study by the German Chambers of Industry and Commerce shows that companies require a strong(er) practice and job orientation approach to education. For instance, through the incorporation of project work during the first semesters at the university, the organization of seminars with entrepreneurs and a more intensive exchange between higher educational institutions and industry, will equip students with the required skills needed by the industry [1]. Thus, graduates from the universities shall have both professional knowledge and practical skills and not only theoretical knowledge. In addition, an interdisciplinary approach, willingness to assume responsibility, decision-making skills, ability to work in a team, flexibility, and intercultural competence are expected [1] [2].

¹ Acronym for science, technology, engineering, mathematics

² Stifterverband für die Deutsche Wissenschaft

INTERNATIONALIZATION: Globalization has drastically changed the overall economic conditions of doing business worldwide [3]. Businesses and organizations face globalized, digitized, and flexible markets. Regardless of their size, companies cooperate, partner-up and have subsidiary companies or projects abroad [4]. As a result, companies expect good to very good language skills (English), intercultural skills, and "social team working skills" from university graduates.

DIGITAL MEDIA: Companies use digital media tools for communication and joint work, regardless of the distances between the individuals [5] [6]. In international companies, digital media tools are used to work in teams at different locations worldwide [7]. Virtual team meetings are common in today's enterprises. This is not experienced as a deficit by the employees but as a useful addition to face-to-face meetings [8]. University graduates are expected to use media in a responsible way depending on the task at hand.

These trends and changes do not yet take place in today's curricula. For this reason, it is necessary to develop new teaching-learning approaches for contemporary university education. This way of thinking, especially for the STEM areas led to the development of the international STEM Summer School.

AIM OF THE STEM SUMMER SCHOOL: Through the work in small international and interdisciplinary teams, a two-way exchange (incoming and outgoing) takes place beyond European borders. The intercultural exchange between the participants is didactically provoked and reflected. Both languages, as well as media use, are learning objects and learning tools. By working on the real tasks of globally operating companies (real-life cases), the students apply their knowledge to the team in a task-specific manner, open up to the complexity of practical problems and learn what they can expect in their later working environment and lives. A central role is the international, interdisciplinary, and virtual work within a team in terms of team roles, different expertise, knowledge development, communication, and project management. The use of different digital media depends on the purpose of cooperation and collaboration over distance and is based on the working conditions/tools relevant to a given profession. The existing media competencies of the students are applied and expanded within the framework of the project for their studies and future work.

2 VIRTUAL COLLABORATION

J. R. Berry defines a team as a group of individuals who interact with each other and voluntarily get together or are brought together to achieve certain results or perform certain tasks [9]. According to J. R. Hackman (1987) the following is required for a running team: (a) participants, who support the formation of the team and are available in case of problems/challenges, (b) jointly working together on the given task and the resulting goals and (c) setting a common guideline for behavior in the group [10].

According to Townsend, De Marie and Hendrickson (1998) and S. G. Cohen and C. B. Gibson (2003), a virtual team differs from other teams as the team members are in different locations and the use of "computer-mediated communication technologies" [11] [12].

The participants of the international STEM Summer School:

- are geographically apart from each other as they study at different universities in different countries,
- cannot overcome these distances within the framework of the project, and
- cannot meet face-to-face.

This international teamwork scenario reflects the importance of collaboration as well as social and intercultural competencies for companies. In addition, the goals are to expand the participant's vocabulary (German, English), to improve communication skills, and to learn and to apply project management methods for the management of complex tasks.

Furthermore, the teams are exclusively virtual collaborating teams. This implies that:

- it is communicated and interacted exclusively by means of computer-mediated communication or other distance communication technologies [13].
- each team member is fully involved in the achievement of all the results of the case study.

Digital media thus functions as the hinge between theory (university) and practice (industry).

3 INTRODUCTION OF THE STEM SUMMER SCHOOL

3.1 Idea

In the international STEM Summer School, STEM students from different countries work on interdisciplinary case studies together in small groups for nine weeks. The group work is bilingual (German/English) and virtual, that is, only digital tools are used for cooperation. The majority of the selected e-learning tools are implemented in an online course in the learning management system OPAL³. The teams are supported by e-tutors (students) and expert consultants (teachers and company representatives). The case studies are real-life problems of the participating companies.

Target groups are foreign and German STEM students (primarily) as well as teachers from the STEM departments of the Freiberg University of Mining and Technology and partner companies. These three groups form, together with the project coordinators, the actors of the project. During the STEM Summer School, the actors act in their assigned roles. Fig. 1 shows the actors-and-roles-model.

Fig. 1: Actors-and-roles-model of the STEM Summer School

The coordinator directs the pilot project as moderator. E-tutors support the group processes and media use. During the processing phase of the case studies, STEM professors and employees of international companies appear as consultants. The consultants answer the professional questions of the participants that arise during the case studies.

3.2 Implementation

The international STEM Summer School took place from 3 April 2016 to 10 June 2016 for the first time. Industry partners were from the pharmaceutical industry, the IT industry, and the materials science/automotive industry.

Sixteen team members from ten countries participated in the first run of the STEM Summer School. They worked together on the case studies, which were designed by the project coordinators and the industry partners, in three internationally and professionally mixed teams. The teams used the bilingual online course and the tools of the online course. Each team was supported by one e-tutor.

The Summer School started with a virtual kick-off event with the participants, the e-tutors, the specialist consultants, and the project coordinators. The case studies were introduced by the respective company representative and the e-tutors introduced their teams. To get familiar with the selected e-learning tools, the kick-off event was preceded by a warm-up week. In order to familiarize the participants with the project and the handling of the case studies, the participants were supported by a manual in the form of weekly tasks and portfolio tasks. The results of the case studies were presented by each team to all professional consultants in a web conference at the end of the Summer School. The results were assessed and evaluated by the respective consultant of the company within the entrepreneurial and industry context. The participants received a certificate for the successful participation in the STEM Summer School.

Fig. 2 illustrates the subdivision of the first round of the international STEM Summer School.

³ Online Platform for Academic Learning and Teaching, based on OLAT

Fig. 2: Schedule of the STEM Summer School

3.3 Case Studies

Core to the project is the completion of case studies [14]. In order to ensure the practical angle for the students, real-life problems were dealt with in real-life case studies that were developed in close co-operation with the companies.

The topics of the three case studies were:

- (1) A presentation of optimization proposals for the seasonal flu vaccine production process with regard to a possible cost reduction while maintaining the patient's safety and efficacy of the manufactured product.
- (2) Cost reductions in the manufacturing of superstructures for disaster management vehicles and at the same time to improve the impact of these special vehicles.
- (3) The development of a concept for a mobile app for the visitors' service of the research and visitor mine "Reiche Zeche" of the Freiberg University of Mining and Technology, which can be used both for the introduction of new miner guides and for the leadership team of the Reiche Zeche itself.

In the selected design of case study design [15], the practical problems are explicitly introduced and framework conditions are defined. The focus of the method is to identify different solution approaches and to elaborate on strategies for coping. Furthermore, the decision-making process of the developed solution strategies is of great importance.

The structure of the case studies has been defined as follows:

- I. brief introduction to the task/background (e.g., to remain competitive in the world market)
- II. explanation of the task with the most important background information, which defines the order and the conditions
- III. definition of the desired results
- IV. company description with a brief explanation of the "regular" process

3.4 E-Learning Tools

The international STEM Summer School was implemented as semi-open Open Online Course. Semi-open refers to the combination of a public and a protected area. The project introduction and presentations could be accessed publicly during the web conferences, i.e., the kick-off event and the final presentation. The work on the case studies and exchange in the groups took place in the online course available on OPAL which is used as the common platform to organize information and for interaction. There were e-learning tools such as wiki, forum, blogs, e-mail, e-portfolio, and access to the virtual classroom (VC).

The e-learning tools were selected for the purpose of individual <-> within the team, synchronous <-> asynchronous usage.

- **wiki** [16]: for the exchange of information between the team members, peer-to-peer communication [17], presentation of a current work situation, information collection
- **forum**: to ask questions, find answers already given, a collection of information
- **virtual classroom** (Adobe Connect): to conduct meetings and agreements, to meet the respective consultant, for the web conferences for the kick-off and the closing event, to conduct interactive feedback events

- **e-portfolio** [18]: to document and to reflect on the learning progress of the respective participant (individually), especially in the field of intercultural learning

The participants also had the option to freely use their private communication channels such as e-mail, telephone, social media, instant messaging.

3.5 Evaluation

In order to evaluate the first round of the international STEM Summer School, the participants and the consultants, as well as the e-tutors, were both interviewed during and after the STEM Summer School. Fig. 3 explains the techniques used and the time of the application.

Fig. 3: Techniques of evaluation along the schedule of the STEM Summer School

4 DESIGN OF THE VIRTUAL TEAMWORK

On the basis of the experiences of this first round, the critical issues of successful virtual teamwork will be presented. These critical issues are classified into media use, interaction, and task orientation.

4.1 Media use

4.1.1 Solving Technical Difficulties

The basic prerequisite for virtual teamwork is the availability of a functional technological base (internet access, bandwidth, hardware). However, reliable and constant internet access is not available in all countries, with the exception of most universities.

A technical problem that is likely to occur, e.g., is that flash-based content does not play.

Challenge: Dealing with technical problems

Solution: In order to react to technical problems, a support area was implemented in the online course on OPAL. Within the forum, the STEM students were able to ask questions and to find answers already given. Furthermore, the participants were able to contact technical support directly and the project coordinators via an e-mail function.

4.1.2 Media Competencies

Media competency is not just knowledge on media. It also includes the ability to efficiently use, to critically assess and to creatively adapt media [19] [20]. Especially these skills are of paramount importance for the success of the virtual collaboration. It is the goal of the STEM Summer School to map and train such skills.

Challenge: Applicability and solution-oriented use of digital media for solving the given tasks and achieving the set goals

Solution: Before the kick-off event and, thus, before the actual working period, short virtual meetings (one per day) on the individual e-learning tools, such as the virtual classroom⁴. Wiki, forum, and the e-portfolio were offered. In addition, OPAL, as an online learning platform, and the online course were introduced. The meetings consisted of ten minutes lectures each and a question time of five minutes each. About six to nine participants of the Summer School and a total of sixteen participants used these virtual meetings on each of the five days to prepare themselves for the nine weeks of case study work. By introducing the technical information and usability possibilities at the introductory phase of the project, it was easier to get into the working phase within the team. This also had the advantage that the e-tutors were able to start with the team building immediately after the team composition was announced.

4.1.3 Organizational Framework

In order to participate successfully in the virtual STEM Summer School, it was essential that the participants are:

- a) registered on OPAL and
- b) enrolled in the online course for the STEM Summer School.

This was the only way to access all necessary information such as schedules, deadlines, or weekly tasks.

Challenge: Granting of access to all necessary information even if the participant has not yet registered on the e-learning platform or registered in the online course

Solution: To guarantee access to the information, especially during the initial period, e-mails were sent at the beginning of each week to the e-mail addresses of all participants. Additionally, information was provided on OPAL. The weekly e-mails contained the upcoming tasks and a review of the tasks of the past week(s), the goals for the current week, and the deadlines to be complied with. Based on the positive feedback from the participants about this form of information, the sending of such e-mails was maintained until the end of the STEM Summer School.

4.2 Interaction

4.2.1 Team Building

Successful working on the respective case study within the summer school requires a functioning team. Since face-to-face meetings between the participants are not possible, it is necessary to stimulate other ways of getting participants to know each other.

Challenge: Successful formation of a team that is able to process the tasks assigned and to present a joint solution strategy of the case study

Solution: Within the framework of the STEM Summer School, the teams were supported by e-tutors, who supported the group processes within the teams. The Scaffolding⁵ [21] [22] [23] approach has been chosen as the method for the guidance and support of the participants. In this specific case, this involved the close supervision of the participants at the beginning and the transfer of responsibility for time.

A personal e-tutor was assigned to each team. At the beginning of the teamwork, the tutors presented, organized, and recorded deadlines and timings for virtual meetings. The teams defined joint goals and guidelines for behavior within the group. The respective e-tutor supported the implementation and published goals and guidelines in the internal group work area (intra-group). Therefore, they could be accessed at any time by any group member. The guidelines included, e.g., how to reach decisions, form and time schedule of group meetings, methods for keeping records, conflict resolution strategies and information distribution within the group.

⁴ The Adobe software for web conferencing – Adobe connect – was used.

⁵ Scaffolding, defined by Pauline Gibbons: “temporary assistance by which a teacher helps a learner know how to do something so that the learner will later be able to complete a similar task alone” [21].

Over the course of time, the participants took over the planning responsibilities for meetings from the e-tutors. This introduced self-organization within the team.

The e-tutors themselves had the required background (international/technical) in their assigned roles. They had very good language skills in German and English, high communicative and organizational abilities, as well as high self-initiative for the guidance and cooperation with intercultural groups. In addition, they were trained in teaching and moderating in virtual classrooms with an action-oriented approach. The training comprised dealing intensively with specific incidents, technical and social disturbances, and working out possible solution strategies. To assist the e-tutors, the project coordination organized meetings between all of them. The tutors presented their approaches and reported on their experiences to each other. They discussed difficulties (professional, technical, cultural), alternatives, and solutions. It was precisely this exchange among each other that the e-tutors felt to be very helpful.

4.2.2 Reflection

The aim of a joint case study in virtual teams is the reflection of virtual work in comparison to face-to-face teamwork and the reflection of individual intercultural competency.

Challenge: Explaining the knowledge gained about virtual collaboration and intercultural differences

Solution: An E-Portfolio [24] was used to reflect the case study work and the virtual teamwork. The e-portfolio is an online collection. The students collect, systematize and reflect their topic-related learning results or learning outcomes in so-called artifacts. Within the framework of the STEM Summer School, the participants were given a concrete structure for the processing of the e-portfolio by means of a task/specification (internship or course portfolio). A portfolio is regarded as competence-oriented as it marks a change in perspective from input to outcome [25].

Within the framework of the e-portfolio, the participants individually reflected on the following topics:

- how to recognize cultural differences within the team and teamwork,
- how to identify lessons learned (communication, teamwork, used methods, etc.) as well as
- how to influence individual work by the team or the teamwork, and
- how to reach common team goals as well as individual goals with possible reasons for success or failure.

4.3 Task orientation

Since the presented case studies are complex topics or subject areas, the teams faced organizational and professional challenges. The participants were supported didactically on how to solve case studies and on how to work with the cooperating partners from industry. In addition, the quality of the case studies and the joint processing of these problems within the teams were accompanied by quality assurance measures.

4.3.1 Weekly tasks

At the beginning of the STEM Summer School the participants were introduced to:

- the technical and organizational framework for the participation,
- the knowledge and use of the online course and the e-learning tools,
- the formation of the team, and
- the understanding of the case studies.

This variety of tasks can initially overwhelm the participants and caused them not to know how to start. Overload can lead to termination of the project.

Challenge: Ensuring a successful start into the Summer School and continual work with the team to solve the case study, as well as to understand the current work situation within the group

Solution: In order to facilitate the start within the project and the handling of case studies, the teams were supported by a manual in form of weekly tasks and portfolio tasks. The weekly tasks gave orientation to the participants, but at the same time, they represented a high level of work. Every week there were, next to the team-specific tasks, also individual reflections.

The tasks had three foci:

- professional, e.g., the reflection of the individual professional expertise and learning requirements with regard to the case to be processed

- linguistic, e.g., creating a short video of the experiences with the joint teamwork during the STEM Summer School in German or English
- intercultural, e.g., the preparation of guidelines for the joint work in the virtual team

The students had an average of one week to complete the tasks and submitted the solutions to the project coordination via the online course on OPAL. There, the tasks were stored. The schedule with content and outcomes was accessible to all participants as well. In addition, they got weekly e-mail comprising the tasks and objectives. For further questions and problems, the participants could ask their e-tutors or the project coordination, e.g., via e-mail or virtual meeting.

Fig. 4 shows the weekly content and outcome developed by the teams (T) or individual participants (I).

	Contents	Outcome
Week 1	Registration Getting to know the tools	Registration in the course (I) Completed profile (I) Active participation in a VC (I) Wiki article (I)
Week 2	Teambuilding	Rules for the team (T) Completed Portfolio (I)
Kick-off (VC)	Presentation of the case studies and the subsequent e-tutors and consultants	
Week 3	Analysis of the case studies	Portfolio task (I) Catalogue of questions (T)
Week 4	Literature research, Information	Knowledge collection in your group wiki (T)
Week 5	Organization, Task allocation	Completed Portfolio (I)
Week 6	Decision and development of three solution strategies	3 solution strategies (max 10 A4 pages, Arial, font size 11, 1.15 line spacing) (T)
Week 7		Learning diary (I)
Week 8	Detailed planning of the suggested solution	Revision of personal approaches (T)
Week 9	Preparation of the presentation	Final presentation including favored solution (T)
Final event (VC)	Presentation, feedback from the consultants	

Fig. 4: Weekly tasks of the STEM Summer School

4.3.2 Working with Partners from Industry

When dealing with the cases, the participants were confronted with topics and subject areas which they have not yet encountered within their studies and their experience. As a result, they are repeatedly confronted with knowledge gaps and potential misunderstandings.

Challenge: Answering technical questions and ensuring a professionally correct and meaningful solution approach

Solution: The consultants of the companies and the university are available to the participants for technical questions related to the case studies or the topics addressed in the case studies. The company consultants stay in close contact with the teams in order to see the current workflow and to identify possible difficulties and necessary help. Within the context of these virtual meetings, the consultants are able to provide background information and food for thought and additionally, explain the problem in more detail.

The close contact to the e-tutors, to the expert consultants, and to the project coordinators was positively emphasized by the participants. Especially an early meeting between the teams and the respective consultant was considered very helpful by the participants, e-tutors, and the consultants. The consultants were able to identify already at the beginning whether the students and the team understood the case/problem that had to be solved. Important questions concerning the case study and the underlying topics could then be clarified. In addition, goals and desired work outcomes of the joint work could be defined.

Since the direct contact with the companies is the special feature of the STEM Summer School, this early collaboration with the companies provided an opportunity to keep the participants within the project. The feedback from the participants confirmed this.

4.3.3 Quality Assurance Measures

In order to ensure the quality of the international STEM Summer School, quality assurance measures were implemented for all project phases (including preparation and implementation). Both, industry partners and university internal consultants, as well as the e-tutors, were involved. The selected measures are shown in Fig. 5.

Fig. 5: Quality assurance measures

5 CONCLUSION AND OUTLOOK

As a conclusion of the STEM Summer School, we state a quite positive resonance, for the concept as well as for the first run. At national and international conferences, in particular, university lecturers expressed great interest in the concept. With the first run, we met the expectations of the students as well as teachers and companies. The participants from nearly all over the world were satisfied and extraordinary motivated. They could show that exclusively virtual teamwork can work across national boundaries, language barriers and different disciplines.

The evaluation of the Summer School shows three key factors of virtual collaboration success:

- the competent application of the e-learning tools,
- the close mentoring by the e-tutors and specialist partners and
- the motivation through professional incentives.

At the moment we are developing the concept in two directions:

As a recruitment tool for international talents in the area of STEM (both for companies as well as for universities) and curricular as an integral part of the virtual preparation studies of the University of Mining and Technology in Freiberg.

On the one hand, we are glad to have two approaches for further development. On the other hand, we deal with a fundamental dilemma in STEM education: scholarships and talent recruitment against assistance for a basic education. It would be great to invite the expert audience to a discussion about finding a happy medium.

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