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Guest Editorial: Teamwork Assessment in Engineering Education

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Nowadays, one of the key issues in any situation is the effectiveness of the stakeholders involved. In the labor market companies and institutions require that their workers have a very high-performance level. In order to guarantee this, professionals should be prepared to work in varied ways, and one of most common is to work with their peers as a team [1, 2].

Teamwork competence can be understood as the ability of people to work together in a creative and productive relationship within a process, leading to enhanced and assured quality in products and services [3]. It is one of the competences most appreciated by the educational institutions and also in the professional endeavors [1], because an effective team increases the probability of achieving set results for any project, process, product or service, including learning [4]. This means that educational institutions should help the future professionals to develop teamwork competence; something supported by the Bologna Process that considers teamwork competence as key competence to be acquired by the students [5]. In fact, these institutions are devoting lot of effort and investing great quantities of money to promote and foster teamwork competence. However, it is necessary to assess if the competence has been acquired or not. This is a difficult task that requires the evaluation of multiple pieces of evidence and not only in a summative but in a formative way [6].

The evaluation and development of teamwork competence is especially relevant in engineering contexts, because in this case most of the professional tasks are addressed by teams [7]. In addition, engineering education use to have a practical component related to Project [8], Problem [9] or Challenge Based Learning Initiatives [10], and these activities are carried out by student teams. In these cases, it is not enough to evaluate the students by the final result of the team submission. We need to assess what happens during the different stages of the learning activity and what each team member has done. This is not a trivial task and there is lot of work to be done.

This special issue aims to explore this issue taking specially into account work that is in the field of Engineering Education to: describe teamwork activities; propose various methods, tools and applications for assessing teamwork; deal with the teamwork competence acquisition; address the problems related with the evaluation of the individual development of teamwork competence; present activities for formative and summative teamwork assessment; discuss about the effectiveness of teamwork; and provide good practices and lessons learned about teamwork acquisition. Related to these topics the guest editors have selected several papers after a strict peer review process.

Working in Large Teams: Measuring the Impact of a Teamwork Model to Facilitate Teamwork Development in Engineering Students Working in a Real Project (Homero G. Murzi, Tahsin M. Chowdhury, Jurij Karlovšek and Bianey C. Ruiz Ulloa) is focused on assessing a teamwork model shared with the students before facing a design project to solve a real problem in large teams. They use mixed methods approach to understand the experiences of students working in large teams in a Project Based Learning (PBL) environment. In particular, they combine a survey applied before and after the teamwork experience, with a set of interviews. Despite several problems to implement the PBL, the results show that the teamwork model used before starting the design project was effective to achieve the required teamwork competences.

Engineering Students' Conceptions of Collaboration, Group-Based Strategy Use, and Perceptions of Assessment in PBL: A Case Study in Qatar (Xiangyun Du, Khalid Kamal Naji, Saed Sabah and Usama Ebead) explores how civil engineering students develop group based strategies, what forms of collaboration they develop, and their perception of the assessments approaches in their first project-based learning experiences. The methodology used to conduct the study combines a qualitative phase with a quantitative phase. The authors have identified three partners related to self-regulated learning and the conception of collaboration in collaborative

learning environments, but more teamwork projects should be developed to support the understanding of the students regarding the perceptions of the alternative assessment in PBL.

Students' selection of teamwork tools in software engineering education: Lessons learned (Ricardo Colomo Palacios, Cristina Casado-Lumbreras, Terje Samuelsen and Xabier Larrucea) presents a case study focused on the selection and the adoption of software engineering tools by students when they follow a project-based learning approach. In particular, the study analyzes de decision behind the selection of the working groups between Taiga, the software recommended by the teachers, ZenHub and GitHub. The results of the qualitative study provide a set of lessons learned, not only for software engineering teachers, but also for engineering students to use in their activities.

Applying Multiple Modes of Assessment to Evaluate the Team Work Competence (Lisa B. Bosman, Julius C. Keller, Nathan Mentzer and Anthony E. Sparkling) provides a methodology to assess teamwork based on the students' reflections collected in five stages, pre, mid and post-assessment, why this matters, and lifelong learning. In particular, authors conduct the study with undergraduate students from three different engineering courses using two approaches, the online tool CATME (Comprehensive Assessment of Team Member Effectiveness) to support peer evaluation as a way to get teamwork reflection; and standard teamwork reflection. The results provide relevant information for guiding students through self-regulated learning and skill development associated to the teamwork competence.

Improving Teamwork Competence applied in the Building and Construction Engineering Final Degree Project (Silvia Necchi, Enric Peña, David Fonseca and Marc Arnal) is focused on the design, implementation and assessment of a methodological change applied in the Final Degree Project (FDP) of Building and Construction Engineering degree in order to improve the acquisition of the teamwork competence. The idea is to change the nature of this final work going from being an individual work to a teamwork. In order to do so the authors propose evolving FDP methodology based on Project Based Learning towards a CBLI approach (Challenge Based Learning Initiatives). This requires of a collaborative work between student teams, assessing what happens during the different stages of the learning activity and what each team member has done.

Validation of a Semantic Search Engine for Academical Resources on Teamwork at Engineering (Ángel Fidalgo-Blanco, María Luisa Sein-Echaluce, Francisco J. García-Peñalvo and María Sánchez-Canales) presents an empirical validation of an ontology-based search engine for academic resources associated with teamwork. In order to validate the system efficiency, the authors conduct two experiments with a population from three different Spanish universities, an experiment with teaching staff with teamwork experience and other with master students. The paper outlines the current system and how it helped students and teachers on pursuing their goals during the course and related tasks.

Individual Assessment Procedure and its Tools for PBL Teamwork (María-José Terrón-López, Yolanda Blanco-Archilla and Paloma J. Velasco-Quintana) introduces agile methodologies to facilitate student's teamwork when using PBL. The proposal uses Scrum to focus on supporting the project process instead the final results of the teamwork activities. Furthermore, the authors complete the proposal with two rubrics, one for self-assessment and another one for peer assessment, in order to support teachers when evaluating the performance of the team and the involvement of its different members.

A Checklist to Diagnose Teamwork in Engineering Education (Jensine Paoletti, Tiffany M. Bisbey, Denise L. Reyes, Matthew A. Wettergreen and Eduardo Salas) conducts a qualitative study based on interviews to determine effective and ineffective behaviors in teamwork. It is a longitudinal study; interviews were conducted one time per week during the duration of the teamwork. Based on the results of the study, the authors propose an instrument, a checklist, to measure teamwork behaviors. It serves as a guideline to identify how student teams are working and where focus the efforts.

Ten Teamwork Findings from Student Design Teams (Allison Traylor, Matthew Wettergreen, Gary Woods, Z. Maria Oden and Eduardo Salas) summarizes the findings across three years of investigating teamwork of undergraduate engineering teams. In order to do so they use their own research projects, thesis and dissertations as a knowledge base to identify good practices in the research processes associated to teamwork. In particular, they identify ten reflections about teamwork that emerges from the combination of the results and methodologies used in other works. Each finding is supported by one or more research based on qualitative and mixed method approaches that provide with deeper understandings of phenomena according to the sample size.

Acquisition of Teamwork Competence in a Hardware Course: Perceptions and Co-regulation of Computer Engineering Students (Birol Çiloğlugil, Birim Balci and Nilüfer Atman Uslu) is focused on examining the co-regulation and perceptions of

computer engineering students in teamwork-oriented approaches in a hardware course in Turkey. Most of the studies about teamwork in computer engineering are focused on software, so this study provides a valuable contribution in hardware courses. The authors combine a set of quantitative instruments, Co-regulated Learning Questionnaire applied as pre-post testing, and self and peer assessment using the Teamwork Evaluation Form, with interviews and focus groups to get the reflections of the participants concerning their experience during the teamwork process. The results show that teamwork-oriented approach increases the co-regulation skills of students in a significant way.

Assessing the work of geographically distributed teams in engineering-design: time allocation in the design process as a form of in-class analytics (Constanza Miranda, Julian "Iñaki" Goñi, Isabel Hilliger and José Lugo) is a study around the development of projects between teams from different institutions located in different regions of the world. The study explores the benefits and challenges related to the culture and language differences, the working habits and the time-allocation in the teamwork dynamics between teams from Chile, Finland and USA. Using the data collected from 15 teams (distributed and co-located) the study outlines that there are no particular statistical differences between distributed and co-located teams.

Adaptive Tests as a Tool for Evaluating Work Groups in Engineering (M.A. de la Rubia and G.M. Sacha) deals with the idea of measuring the impact of teamwork on engineering learning. In order to do so the authors have used adaptative tests and other techniques. They have analyzed data from various theoretical and practical tasks carried out individually or by groups, in order to measure the influence of teamwork in engineering learning. From these data the authors conclude that teamwork can be of great interest, but several issues should be taken into account before planning group tasks. Specially with the idea to avoid inadequate academic performance of some students due to a wrong planning. Students should be focused on the tasks they should carry out with an active attitude in the group.

Effect of Personality Traits in Team Dynamics and Project Outcomes in Engineering Design (Justine Boudreau and Nanan Anis) discusses how personality impacts team dynamics. In order to do so they analyze students in a project-based learning environment, a context where the students take courses that introduce them to collaborative project-based learning, engineering problem-solving and prototyping. The authors are specially focused on how team member's openness, conscientiousness, extraversion, agreeableness and neuroticism impact on how team works with regards to their project throughout the semester. The study shows, as the result of the application of multiple regression analysis, the relationship between the Big Five personality traits as well as gender and project grades in project-based engineering design courses.

An Exploratory Study of Teamwork Processes and Perceived Team Effectiveness in Engineering Capstone Design Teams (Mehrnaz Mostafapour and Ada Hurst) explores teamwork in the context of the culminating course of Engineering students. They work in teams designing a project and the authors aims to study the teamwork experiences, skills and gaps of students during these projects. The study involves 12 instructors and more than 600 students. The authors gathered information on team formation, roles and task distribution, the methodologies applied to manage the projects and the possible issues experienced. With this information they have described the potential links between those variables and team effectiveness and enjoyment. The findings about such relationships are described in the paper and also the associated implications and the decisions that can be made from them.

Teamwork in Engineering Training: the case of an intervention in a Worker Recovered Factory in Brazil (Tarcila Mantovan Atolini and Francisco de Paula Antunes Lima) studies the teaching-learning processes in an engineering team, in the context of an intervention in a self-managed company. The authors explore teamwork in real working context due to the limitations of academic contexts to facilitate the acquisition of such competence. The intervention aims to analyse and propose solutions to company problems from a participatory process, which involved undergraduate, masters and doctoral students in various areas of engineering and levels of training and also company workers. Through the intervention if was possible that to obtaining a supervised apprenticeship process and facilitate students teamwork development.

Modalities of Peer Assessments in Team Project Based Design Courses (Patrick Dumond, Mohamed Galaleldin) deals with the evaluation of the individual development of teamwork competence and team dynamics by using peer review techniques. In this case the authors use a specific metric to explore five concrete dimensions (Teamwork, Professionalism, Communication, Organization and Discipline and Technical Contribution). These issues are assessed following two strategies: two assessments over the term or one assessment after each deliverable. Results show that two peer assessments are not enough to provide sufficient

scaffolding to problematic individuals or teams whilst multiple assessment contributes to improve both individual and team performance.

Teamwork Assessment in Collaborative Projects through Process Mining Techniques (Juan Antonio Caballero-Hernández, Antonio Balderas, Juan Manuel Dodero, Manuel Palomo-Duarte, Antonio J. Reinoso and Pablo Delatorre) studies one of the main issues of teamwork assessment that is how to deal with the high number of interactions produced during engineering projects. The authors present an architecture based on wikis to explore the students evidences from a quantitative and qualitative perspective. In order to do so they apply Process Mining techniques and tools to extract knowledge from real processes and discover models. These models make possible to study the team behavior and dynamics that later will be used with assessment proposes.

Development of a Teamwork Skill Scale for Engineering School Students (Jiyoung Han) aims to identify teamwork skills and their subordinate areas to solve conflicting problems in the field of engineering education regarding measurement of teamwork skills as well as to develop the scales to measure such skills. In order to do so the author develop a literature review and a survey with 343 answers. After a factorial analysis, a teamwork skill scale was developed by dividing team roles into five roles based on those that require common skills and those that require individual skills. Taking this roles into account five factors for common and individual skills were included in the scale: cooperation, a sense of responsibility, listening courteously, and adaptability were selected as the common skills; and for the individual skills, the roles of leader, innovative executor, mediator, terminator, and judge were suggested.

Impact of Team Formation Approach on Teamwork Effectiveness and Performance in an Upper-level Undergraduate Chemical Engineering Laboratory Course (Erick S. Vasquez, Matthew J. DeWitt, Zachary J. West and Michael J. Elsass) is a work that explore an important issue when developing team work, the groups formation. The authors aim to study how team formation can affect teamwork effectiveness and performance in the context of Chemical Engineering subjects. They carried out an experiment with three different approaches: teams defined by the instructor, self-selected teams and a combination of both. Later, the activity is assessed using a rubric and taking into account the team leader feedback about each of the team members. The results shown that depending on the context one solution can work better than the other and the best solution can be a combination of both during the semester.

The Effect of Team Conflict on Teamwork Performance: An Engineering Education Perspective (Xaver Neumeyer and Susana C. Santos) is focused on analyzing the teamwork according to the composition of the teams, with a special focus on gender perspective. Authors identify conflicts as an important factor in the performance of the teams. Moreover, they highlight the gender diversity as a positive aspect due to female members help in the coordination tasks and because they provide a different perspective.

Teaching Teamwork in Logistics Engineering through a Board Game (Emiliano Labrador, Eva Villegas, Ruth S. Contreras, Xavi Canaleta and David Fonseca) discusses the design and implementation of a board game to facilitate Logistic Engineering students the acquisition of specific issues related with the subject and develop the teamwork skill. The game has been designed following Fun Experience Design methodology and qualitative information was gathered before and after the design and implementation. The results of the application of the game have shown that the game help the students to acquire the expected knowledges and also to develop the teamwork competence.

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