



Friction Stir Welding European Qualifications

Hands-on Approach Seminar | PORTUGAL

24th September to 14th October 2019

Instituto Superior Técnico – Lisbon

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Introduction

The present report focuses on the assessment of the National Hands-on Approach Seminar (E5) performed in Portugal, by ISQ. This assessment was performed considering the previously accorded criteria between partners.

In Portugal, this assessment was made focusing on the materials developed for the EFSW-E profile. The goals of this assessment are:

- The detection of major strengths and weaknesses of the developed materials;
- The collection of suggestions based on the results of the questionnaire to adjust and improve the curriculum and course materials according to the feedback received in the E5.

1. Methodology

Venue and participants

In Portugal, E5 was focused on the evaluation of the developed materials for the Engineer profile. It took place at Instituto Superior Técnico (Lisbon University), with participants enrolled in the 1st year of Mechanical Engineering Master's degree, attending the Mechanical Technology Complements unit, on September 24th, 25th and 26th and October 7th and 14th 2019. This course focuses on production technologies and was, therefore, aligned with the goals of FSW-Tech Hands-on Approach Seminar.

Training Program

The training sessions were divided into three different typologies. These sessions were:

- **Theoretical sessions** – which were composed of two sessions of 1h30 each, focusing on the presentation materials of CU1.

In these sessions, the basics of FSW welding process were presented where it was highlighted the different phases of the process and equipment that is applicable to this welding process. It was also discussed the influence of this process in the mechanical properties of different materials and some actions that can be applied to each.



Figure 1-1: Theoretical session

- **Case study sessions** – these sessions were compound of three 1hour sessions where the CU12 was discussed.

In each session a different group of participants attended. These sessions comprised the presentations of case studies regarding the practical implementation of the FSW process. In these presentations, it was highlighted the advantages of using the FSW over the existing processes focusing on gains given to the company by applying this process. A short small practical session was also implemented focusing on the inspection of Friction Stir Welded samples. During this inspection session, some procedures were applied for the inspection of welded samples.



Figure 1-2: Case Study Session

- **Practical sessions** – two similar practical sessions (of 1h30 each) were implemented to different groups of participants. The following topics were focused in it:

- Preparation and selection of the tool and equipment for welding and definitions of the parameters for the weld;
- Preparation of the materials for welding;
- Performing the FSW process, taking into account some caution to be taken into account during welding;
- Inspection of the weld during and after welding.



Figure 1-3: Practical sessions

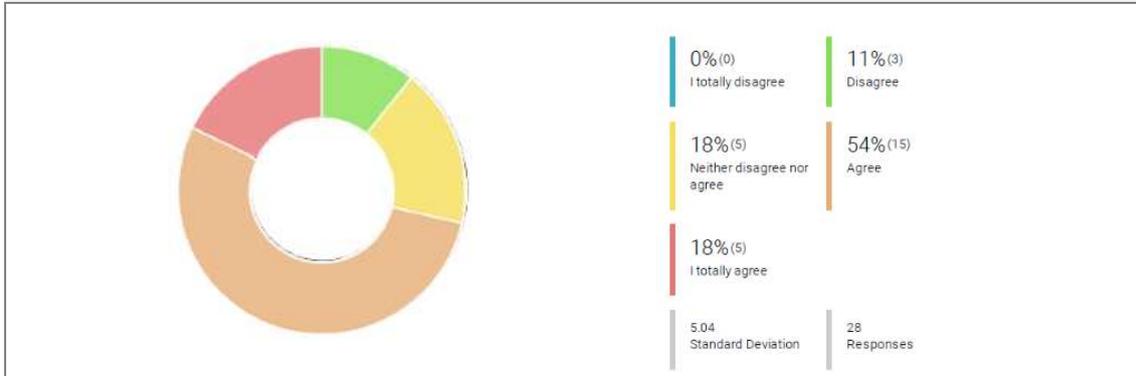
The presentations were made in both English and Portuguese languages due to the fact that these classes are delivered in both languages to help the foreign students. The theoretical sessions were delivered in English while the case studies and practical session were delivered in English or Portuguese depending on the participants. The presentations' language was also selected based on the participants present. The following table shows the programme schedule and attendance of the different sessions:

Session	Date	Attendance
Theoretical sessions	24-09-2019 – from 11h to 12h30	55 attendees
	26-09-2019 – from 11h to 12h30	43 attendees
Case studies sessions	25-09-2019 – from 15h to 16h	11 attendees
	25-09-2019 – from 16h to 17h	10 attendees
	07-10-2019 – from 10h to 11h	49 attendees
Practical sessions	07-10-2019 – from 12h to 13h30	27 attendees
	14-10-2019 – from 12h to 13h30	22 attendees
		69 attendees in total
		49 attendees in total

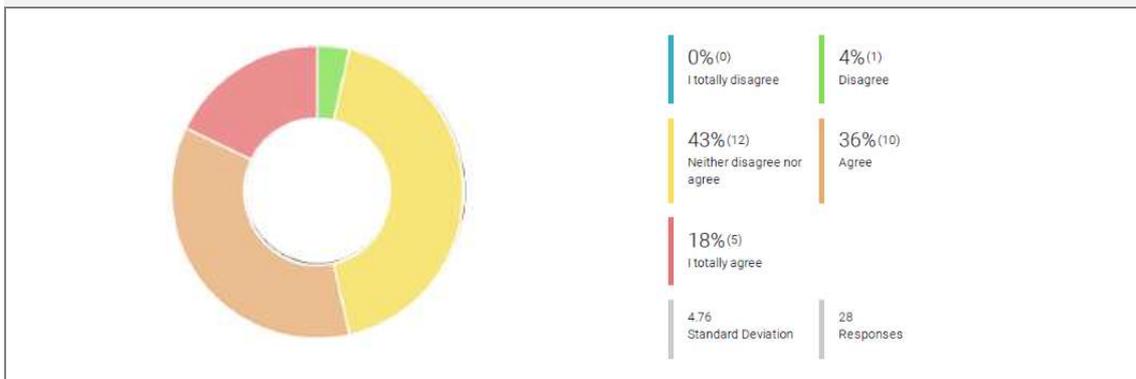
Evaluation

Questionnaires were given to the attendees to evaluate the session E5 (Hand-on Approach Seminar) and the training materials used. The results are summarised as follows:

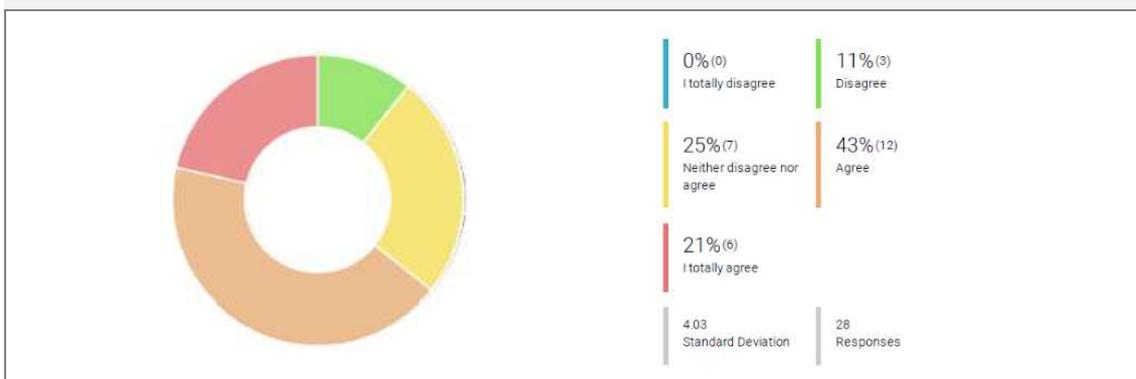
1. Information and training provided were clear and easy to follow



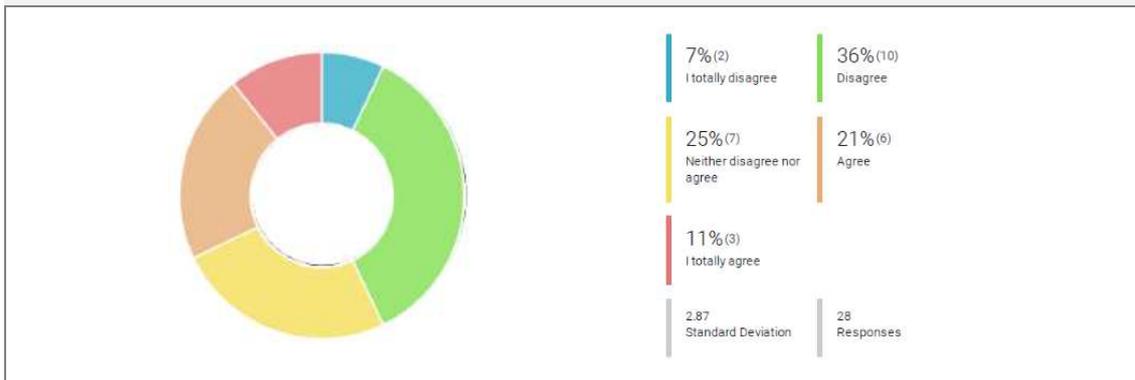
2. The presented information met my expectations



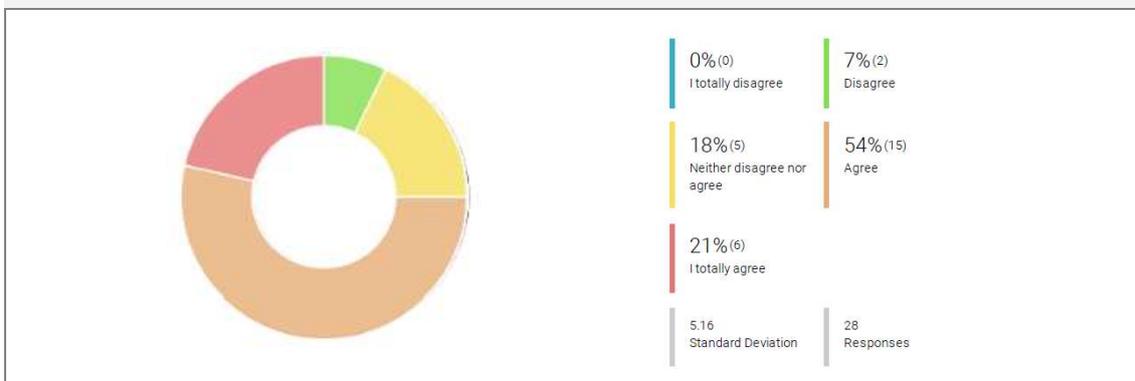
3. The training enhanced my understanding on the subject



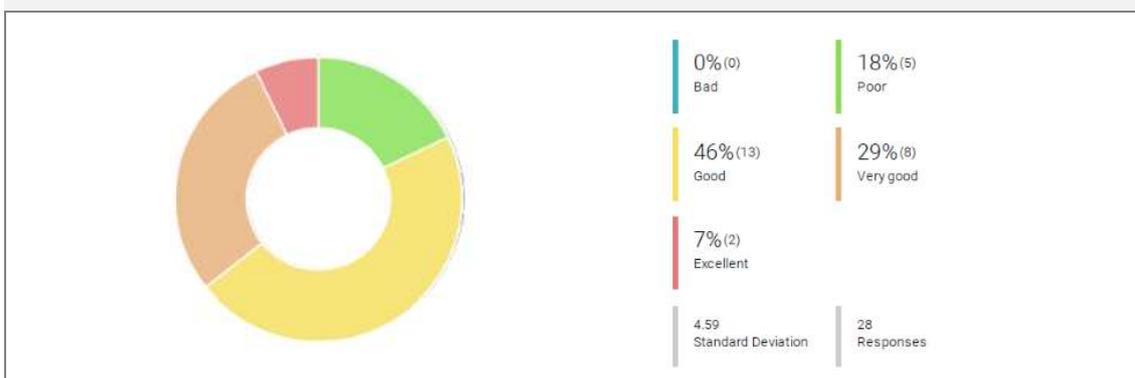
4. Communication style kept me focused and interested



5. Provided clear explanations on each topic discussed



6. Overall, how would you rate the seminar



By analysing their responses, the overall satisfaction with the seminar scored 82% positive feedback. Additionally, 72% of the participants considered the information clear and easy to follow, 64% considered the seminar enhanced their understanding of the subjects and 75% considerer the explanations on each topic clear. The two less positive dimensions were the meeting of expectations scoring 54% positive feedback and the ability to maintain participants focused through the communication style receiving positive feedback of 32%.

Training Materials Evaluation ¹

How do you rate the sequence and flow of the slides presented	Was there a clear separation between the seminars's units?	Did the presentation included adequate number of dynamic resources/elements (e.g. video, exercises, practical examples)
<ul style="list-style-type: none"> ● Very good ● Good ● Poor ● Very poor 	<ul style="list-style-type: none"> ● Yes ● No 	<ul style="list-style-type: none"> ● Yes ● No
Was the quality of the content consistent throughout the seminar?	Did you notice any unnecessary repetitions in the content?	Did you feel that some content was lacking?
<ul style="list-style-type: none"> ● Yes ● No 	<ul style="list-style-type: none"> ● Yes ● No 	<ul style="list-style-type: none"> ● Yes ● No
How do you classify the overall quality of the supporting materials (slides presentation) used in the seminar?	Please highlight 2 positive aspects about the training materials	Please remark 2 aspects for improving the training materials
<ul style="list-style-type: none"> ● Very good ● Good ● Poor ● Very poor 	Explicit and simple	More videos and more real-life examples

¹ This survey was only answered by 4 attendees

2. National recommendations for implementation

ISQ highlights the importance of pedagogical basis of the delivered training, especially in this kind of technical training which can be very dense, to allow and promote satisfactory student engagement.

Regarding the presentations, some remarks as points for further improvement for the correspondent EWF working group responsible for this qualification approval and implementation:

- Adjustment of the font size to a minimum of 24 points;
- Integration(organization of the information through bullet points, each representing a concept instead of full text to make it less dense and easier to follow
- Adding more videos and digital resources;
- Complementing the presentations with online interactive tools as games/quizzes and student response systems to enhance student engagement and understanding;

Special attention should be put in Technical training, in what concerns pedagogical and methodological aspects. It is important to use different training methodologies.

In this seminar mainly an expository method (directive, deductive and demonstrative) was used. We recommend trainers to practice and apply exploratory methods (inductive, exploratory, reflective, problem solving, inquiry, etc.) in order to keep students' interest and improve the overall learning objectives achievement.

Trainers besides the technological knowledge must also keep in mind the need for continuous development of their pedagogical skills and methodological knowledge to maximize the learner's full achievement of the learning objectives.

ISQ as a result of the experience recommends the incorporation of a more comprehensive case study where all the stages of the process development are reviewed, instead of only the final results.

The visit to the laboratory showed to be a very important step in the process of consolidation of acquired knowledge, providing students with the opportunity to see in loco the equipment used in FSW process as well as several samples, namely with defects, allowing for a discussion about the possible causes for such defects.

3. Conclusions

The overall evaluation of the hands-on approach seminar was very positive and met its objectives. The Mechanical Engineering master's students were interested in the topic and answered positively to the invitation which was addressed to attend the multiple seminar sessions on FSW.

The materials used were developed under IO3 consisting mainly of PowerPoint presentations. There is room for improvement mainly by enriching each session with other interactive online tools (games/quizzes) to the presentations developed, in order to engage participants.

The case study sessions can incorporate the standards to develop FSW parameters to engage participants as well. The main recommendation regarding this subject would be to have a more interactive class in the case study by making the use of the standards to develop the parameters for FSW.

Another topic could be to have a more comprehensive case study where all the stages of development are approached instead of only the final result.

Overall, ISQ, considers that the developed Guideline is presently ready for approval and to start its implementation in Portugal. The recommendations herewith included should not limit in the short term the guideline approval by the respective EWF Working Group and should be seen as points for future improvement. Likewise, it should be suggested to make periodic evaluation satisfaction reports, to guaranty the principles of Continuous Quality Improvement.

4. Annexes

CU 1 – FSW Fundamentals				
<p>Objective for Engineer:</p> <p>Provide highly specialized and forefront knowledge including original thinking, research and critical assessment of:</p> <ul style="list-style-type: none"> – FSW fundamentals – Welding equipment and processes – Parent materials 				
Objective for Specialist: NA				
Objective for Operator: NA				
Scope	Qualification Teaching hours	Engineer 3 (8)	Specialist NA	Operator NA
Introduction to FSW FSW equipment FSW Design Parent Materials		1,5 (3) 0,5 (1) 0,5 (2) 0,5 (2)		
<p>Learning Outcomes for Engineer:</p> <ul style="list-style-type: none"> – Explain the main mechanisms (detail according to the fundamentals) of the process – Explain the design limitations of the process – Explain the limitations of the process for the different materials + thicknesses – Discuss the weldability of the material in correlation with the influencing factors – Identify the metallurgical properties for each parent material 				
Learning Outcomes for Specialist: NA				
Learning Outcomes for Operator: NA				

CU 12 – Case Studies				
Objective for Engineer: Provide highly specialized knowledge and critical assessment of theory, principles, and applicability for the analysis of highly complex construction projects				
Objective for Specialist: NA				
Objective for Operator: NA				
Scope	Qualification Teaching hours	Engineer	Specialist	Operator
		1 (2)	NA	NA
Simple and basic FSW welded projects: <ul style="list-style-type: none"> – Autoclave fixtures – Vibration test tables – Crack repairs – Solar panels – Underground vehicles – Naval shipbuilding panels – Others case studies (if relevant) Standards and specifications Choice of materials Tools and welding procedures Tolerances on weld preparation and fit-up Post weld heat treatment, NDT and quality control Visual Inspection practice		1 (2)		
Learning Outcomes for Engineer: Evaluate complex construction projects on aluminium and other materials used in FSW construction structures, such as Autoclave fixtures, vibration test tables, crack repairs, solar panels, underground vehicles, and naval shipbuilding panels, to define the best welding conditions to achieve the proper quality requirements.				
Learning Outcomes for Specialist: NA				
Learning Outcomes for Operator: NA				