

ASSESSING THE QUALITY OF CORROSION EDUCATION IN THE UNITED ARAB EMIRATES

PRESOJA KVALITETE IZOBRAŽEVANJA NA PODROČJU KOROZIJE V ZDRUŽENIH ARABSKIH EMIRATIH

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The economic consequences of corrosion failure can be minimized by an engineering workforce well trained in corrosion fundamentals and management. The United Arab Emirates (UAE) incurs the second highest annual cost of corrosion after Saudi Arabia, given its large petroleum industry. Hence, this study examined the quality of corrosion education in engineering programs of the universities in the UAE. Using a single-embedded case-study design, academia and industry respondents were surveyed on the competence of engineering undergraduates/graduates in corrosion. The findings showed that the dedicated corrosion courses and engineering courses integrating corrosion into the curricula are available in the UAE universities. Regarding the competence of engineering students/graduates, the consensus view was that there was an insufficient fundamental knowledge of corrosion engineering. The industry respondents were highly critical, believing that graduate engineers had a superficial understanding of corrosion in real-life design contexts. The effectiveness of engineering curricula in corrosion is determined by both the competence in corrosion knowledge/skills and the availability of resources (qualified staff and new knowledge from research) to support corrosion education. The findings showed that most departments would not hire new corrosion specialists. However, the aspect of research was more encouraging with the universities reporting availability of departmental research and industry partnerships in corrosion research. This paper gives recommendations for improving the knowledge and skills of future engineers in corrosion management and for enhancing corrosion training to better meet the industry needs.

Keywords: corrosion, engineering education, case study, United Arab Emirates

Ekonomske posledice korozijskih poškodb je mogoče zmanjšati z inženirji, ki so dobro izobraženi na področju osnov korozije in upravljanja s korozijo. Združeni arabski emirati (ZAE) imajo za Savdsko Arabijo drugi največji letni strošek zaradi korozije v svoji veliki naftni industriji. Zato ta študija posega na področje kvalitete poučevanja korozije pri inženirskih programih na univerzah v ZAE. Z enotno obliko študija primera v obliki ankete so bile pregledane akademije in industrija o pristojnosti inženirjev in diplomiranih inženirjev glede korozije. Ugotovitve kažejo, da so namenski tečaji o koroziji in inženirski predmeti, ki vključujejo korozijo, vključeni v programih univerz v ZAE. Glede pristojnosti študentov tehnike in inženirjev je bilo soglasno potrjeno, da ni dovolj temeljnega znanja s področja obvladovanja korozije. Anketiranci iz industrije so bili kritični, da imajo inženirji pomanjkljivo razumevanje korozije pri projektih v realnem okolju. Učinkovitost inženirskih programov glede korozije je določena tako s kompetenčnim znanjem in izkušnjami s korozijo ter z razpoložljivimi viri (usposobljenimi delavci in novim znanjem iz raziskav), ki naj bi podpirale izobraževanje o koroziji. Rezultati so pokazali, da večina podjetij ne bi zaposlila novih strokovnjakov za korozijo. Vendar pa je vidik raziskav bolj spodbuden na univerzah, ki poročajo o možnosti raziskav in partnerstvu z industrijo na področju raziskav korozije. Članek se konča s priporočilom po izboljšanju znanja in izkušenj bodočih inženirjev pri upravljanju s korozijo, kot tudi spodbujanje korozijskega svetovanja za boljše zadovoljevanje potreb industrije.

Ključne besede: korozija, izobraževanje inženirjev, študij primera, Združeni arabski emirati

1 INTRODUCTION

The United Arab Emirates (UAE) incurs a high annual cost of corrosion of US\$ 14.26 billion (2011), which is about 5.2 % of the country's GDP over three years (2009–2011), due to its large petroleum industry¹. Corrosion is a deterioration of metals or materials due to chemical, biological or environmental agents^{2,3} resulting in serious health, safety and environmental (HSE) risks. When poorly managed, corrosion affects the equipment integrity and serviceability, raises the risk of discharge of flammable fluids and gases that companies can be held liable for⁴. Since it is impossible to eliminate corrosion, engineers in the petroleum industry need to be competent in corrosion fundamentals and management to minimize the economic, environmental and social consequences of a corrosion failure. Much of this competence is gained

through higher education. Yet, 54 % of the corrosion-protection practitioners have not taken a corrosion course in their formal education. Also, 45 % of the currently active and experienced corrosion technologists are likely to retire in the next 10 years⁴. Furthermore, there is little research on the quality of corrosion education in the UAE. Hence, this study aims to assess the quality of corrosion education in engineering programs of the universities in the UAE. The research questions are:

RQ 1a: What is the level of corrosion training available at the universities in the UAE?

RQ 1b: Why is this level of corrosion training characteristic of the UAE universities?

RQ 2a: How competent are the engineering undergraduates/graduates from the UAE universities in corrosion knowledge and skills?

RQ 2b: What resources are available to the UAE universities to support effective corrosion education?

2 CASE STUDY RESEARCH DESIGN

A single-embedded case design was used where, within a single case, attention is also given to subunits.^{5,6} This design enabled in-depth analyses of the subunits providing an insight into the main case. The main case is the engineering education program of the UAE universities, while four universities were the subunits in the primary case. Through purposive sampling, four institutions were identified that met the following criteria: location in the UAE; availability of engineering programs, for which corrosion is relevant; at least one cohort of graduates; reliable accessibility to the participants. Due to ethical considerations, the universities were pseudonymised.

The primary data sources were the academics (*n* = 58) from the four institutions and the engineers from the oil/gas industry (*n* = 8). The latter were interviewed to understand the employers’ perspective on the competence of engineering graduates in corrosion. The total sample consisted of 66 respondents. Surveys and interviews (individuals, focus groups) were used to gather quantitative and qualitative data that were statistically and interpretively analyzed, respectively. The questionnaires provided information on the respondent demographics, the level of the existing engineering curricula in corrosion, the effectiveness of engineering curricula in corrosion, and recommendations for enhancing the corrosion knowledge and skills. **Table 1** summarizes the

constructs and questions that constitute the operational measures.

The first construct, *the level of the existing engineering curricula in corrosion*, is defined as the extent of the corrosion training available. The construct is operationalized by Q.10 measuring the availability of corrosion training on the scale from having a dedicated corrosion course, teaching corrosion as part of other courses (integrated) to not teaching corrosion at all. The second construct, *the effectiveness of the existing engineering curricula in corrosion*, is defined as the degree, to which a course produces the desired educational outcomes measured as (a) the level of competence in corrosion knowledge and skills of engineering undergraduates/graduates (Q.34-35); (b) the availability of the resources to achieve the desired outcomes (Q.29, 32-33).

3 RESULTS

Regarding *the level of corrosion training*, this study found that the dedicated corrosion courses and the engineering courses integrating corrosion into the curricula were available at the UAE universities. Detailed findings on the structure of the dedicated and integrated corrosion courses are reported in the author’s expanded publication⁷. For *the competence* in corrosion knowledge and skills, the consensus was that there is *insufficient fundamental knowledge* of corrosion engineering due to the limited scope of corrosion in the curricula. Another dimension of the competence is the ability to *apply theoretical knowledge in practice*. Interestingly, while academia respondents held a positive

Table 1: Questions relating to constructs and measures

Tabela 1: Vprašanja glede načrtovanja in ukrepov

| | |
|---|--|
| Construct – Level of the existing engineering curricula in corrosion | |
| | <p>Q10. Does your department offer a course or courses specifically in corrosion? Yes, my department offers course(s) specifically in corrosion No, my department teaches corrosion as part of other courses No, corrosion is NOT taught at all in my department</p> |
| Construct – Effectiveness of the existing engineering curricula in corrosion | |
| <i>Level of competence in corrosion knowledge and skills</i> | <p>Q34. Do you think engineering undergraduates/graduates (from your university) have a sufficient fundamental knowledge of corrosion engineering? Please explain.* Q35. Do you think engineering undergraduates/graduates (from your university) have a sufficient understanding of the importance of corrosion in engineering design? Please explain.*</p> |
| <i>Availability of resources (manpower, knowledge)</i> | <p>Q29. Would your department consider hiring a faculty member whose technical focus is corrosion? Yes No Q32. Is your department doing any corrosion-specific research? If so, who is funding it? No Yes, funding organization(s): _____ Q33. Do you have any actual or potential partnerships with the industry to study corrosion or develop continuing education for practicing engineers? No Yes If so, please describe your partnerships with the industry to study corrosion.</p> |

*Industry respondents answered the variation of Q34/35 that excluded the phrase "from your university"

Table 2: Availability of resources to support corrosion training: faculty and research
Tabela 2: Razpoložljivost virov za podporo poučevanja korozije: fakultete in raziskave

| | University A | University B | University C | University D |
|--|--------------|--------------|--------------|--------------|
| Recruitment of corrosion specialists* | | | | |
| Hiring corrosion specialists | 0 % | 8 % | 6 % | 55 % |
| Not hiring corrosion specialists | 100 % | 92 % | 94 % | 45 % |
| Research efforts in corrosion* | | | | |
| Corrosion research carried out by department | 10 % | 0 % | 25 % | 55 % |
| Industry research partnership available | 0 % | 0 % | 13 % | 25 % |

*Based on 58 academic respondents who are instructors in mechanical, civil and chemical-engineering departments of the universities

view that the students had *a sufficient understanding* of the importance of corrosion in engineering design, the industry respondents were more critical, believing that the graduates had *a superficial understanding* of the corrosion in real-life design contexts.

The effectiveness of engineering curricula in corrosion is determined by both *the competence in corrosion knowledge/skills* and *the availability of resources* (qualified staff, new knowledge from research) to support corrosion education. Unfortunately, the engineering departments in three out of the four universities *would not hire* corrosion specialists as other topics have more priority. However, the aspect of research is more encouraging, as two universities reported the availability of both departmental research and industry partnerships in corrosion research (Table 2).

In terms of the overall quality of corrosion education, this study concluded that while corrosion is part of most engineering programs of the UAE universities, there are inadequate resources to support corrosion education with respect to hiring corrosion specialists or gaining new knowledge from department research and industry partnerships in corrosion research.

4 RECOMMENDATIONS AND FUTURE RESEARCH

Respondents were asked to propose the strategies for enhancing the corrosion knowledge and skills of engineering undergraduates. Three main themes were identified and the following recommendations are offered for improving the corrosion training to better meet industry expectations:

Set corrosion courses as mandatory courses in the curriculum framework of engineering fields, where corrosion is particularly relevant so that a common level of knowledge and skills can be established.

Integrate the corrosion theory with practical experience in engineering courses and senior design projects so that the undergraduates can be actively involved in applying the corrosion theory to actual design processes.

Promote the awareness of the corrosion impact through campus-wide activities to raise the appreciation of the need for corrosion mitigation and management.

Future research in this area could include comparative studies examining the differences in quality of corrosion education in other Middle-East countries. The major oil/gas producing countries such as Qatar, Saudi Arabia and Kuwait have established universities offering extensive engineering programs, for instance: Texas A&M University in Qatar, Qatar University, King Fahd University of Petroleum and Minerals, and Kuwait University. Hence, such studies could capture a more complete picture of the quality of corrosion education in the region, where corrosion prevention and management are crucial for its petroleum-based economies.

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