Should engineering students learn about Human Factors at Universities?

One of the biggest challenges related to the practical implementation of human performance (HP) / human factors (HF) is the lack of awareness among very large and diverse groups of people. These individuals range from across the industry and include leaders at all levels of the hierarchy, engineers, HSE professionals, and front-line employees. Further, most of whom may have an engineering or related technical background (see my article on "Everyone has a role to play" https://bit.ly/3bxubt3).

The Oil and Gas industry requires a continual supply of new engineers. Globally, there are thousands of graduates joining the industry every year and it is important to explore if they are getting a strong foundation in HP.

Perspectives on engineering education
In this article, four honourable guests share their perspectives on HF in engineering education, and based on the insights they provide, this article states a call for action for various stakeholders to advance the integration of HF with engineering education.

From Dr Fawaz Bitar, Senior Vice President of HSE and Carbon, BP
"Human Performance will play a significant role in taking our safety performance to the next level"

Traditional ways of managing safety only get you so far. Having a better understanding of human behaviour and the interaction between people, equipment and processes, will provide a more holistic approach to managing safety.

I believe human performance will play a significant role in taking our safety performance to the next level including the use of digital and technology to reduce the likelihood of human error.

However, there are a number of barriers slowing down our progress.

Firstly, the linkage between the HP experts—i.e., those with the detailed knowledge—and those who execute the work could be stronger. To advance HP, we need to raise the awareness of HP at every level including supervisors and senior managers. This could be done through training programs with content tailored to the audience demonstrating the practical value of HP and integrating it into how we lead and operate.

Secondly, we need to increase the uptake of digital and technology to improve safety by moving up the hierarchy of controls, removing the need for human intervention. This could include a range of things: new technologies to get risk information where it's needed (i.e., from the board room to the control room); remote observation tools and robotics to reduce risk; and advanced data analytics to identify trends and help us course-correct faster.

Thirdly, there is lack of uniformity across the industry related to HP. We could benefit by having

a common set of concepts, principles, and language. I am aware that the HPOG.org is making good progress on developing a Human Performance Recommended Practice that should help unify practices, standards and tools.

Finally, there perhaps is an inconsistent approach to teaching human performance at universities, for example as part of an engineering degree curriculum.

By knowing how people work and respond, engineers are able to come up with much better solutions. Teaching HP as a foundational part of engineering degrees, will allow students to join companies well equipped to deal with the challenges ahead of them.

I am privileged to teach human performance and risk management at a number of universities and internally at bp. A collaboration between academia and industry can be very powerful bringing together the best of each community. If we can bring real life experiences together, underpinned with academic theory, we have a winning formula.

From Dr Maria Astrid Centeno - Course Director MSc Petroleum Engineering, London South Bank University

"There are indications that some engineering programmes offer HF, more work to be done"

Internationally, the content of the engineering degree programmes is based on the frameworks set by the international engineering alliances such as:

1. the Washington Accord,
2. the Sydney Accord and
3. the Dublin Accord

In the UK, the Quality Assurance Agency for higher education (QAA) provides the framework for all UK higher education programmes across all subjects. Moreover, the QAA also supports the Engineering Council and professional engineering institutions in order to provide support to Engineering courses offered by higher education providers across UK universities. As the Engineering Council is a full member of the Sydney and Washington Accords, UK engineering programmes are designed following international standards.

According to those standards, engineering programmes in higher education must provide students with six aspects, even though the syllabus for each engineering program may vary between providers:

1. The learning and application of the adequate level of mathematics and science.
2. The skills and experience to apply engineering analysis to solve relevant real cases.
3. The knowledge and understanding of the engineering principles, and procedures associated with the design.
4. The application of innovation processes to solve real engineering problems.
5. The learning and application of the evaluation of essential needs, including economic and environmental impact, legal obligations, and health and safety so that graduates are able to propose solutions, develop process guidance to broadly define problems.
6. Transferable skills such as communication, reporting, working with relevant engineering software, problem solving, leading and managing.

While HF is not mentioned as a separate area, there are some relevant HF topics embedded in many syllabi already. For example, as per the Engineering Council specification students should be able to "*Design solutions for complex problems that meet a combination of societal, user, business and customer needs as appropriate. This will involve consideration of applicable health and safety, diversity, inclusion, cultural, societal, environmental and commercial matters, codes of practice and industry standards*." (Engineering Council, 2020).

Some programs include the use of a well control simulator, which support the development of HF related to people behaviour and decision making.

By comparing the learning outcomes provided by engineering programmes with the list of HF topics (see figure 1), it can be noticed that there are some knowledge gaps, which mainly associated with people's behaviour at work, and their behaviour related with the process and available technology.

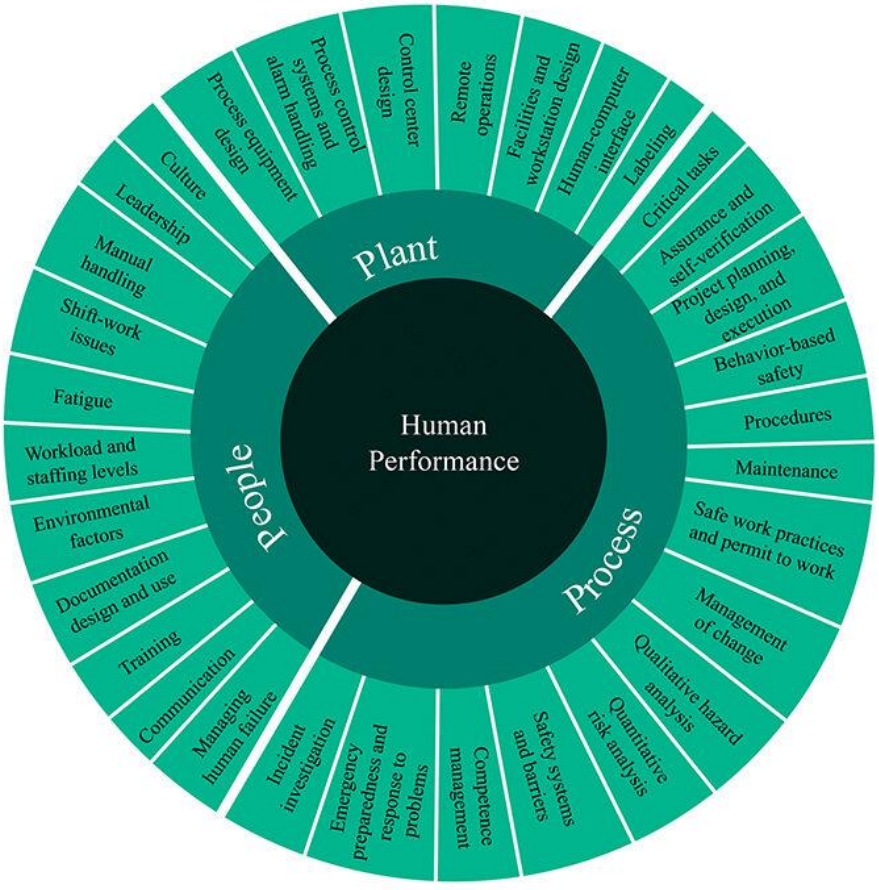

Figure 1: A range of human factors considered to enhance Human Performance

Although there are some indications that some engineering programmes offered by some members of the international Washington Accord include the learning and application of HF that are associated with the process management and process design, engineering students may not

be getting enough experience in other relevant aspects of HF such as understanding why front-line operators do not follow the rules, preventing and managing fatigue, workload and staffing levels, managing human failure or shift-work issues.

In practice, the learning outcomes provided by accreditors of academic programs are not strictly prescriptive in terms of the way students will be learning and assessed on each learning outcomes, and each programme provider has the responsibility to design their own descriptors based on the engineering learning outcomes and with specifications related with the engineering speciality which is given by the professional accreditation body.

The process of reviewing and updating engineering courses include the feedback from different stakeholders such as academic specialists, employers, accreditation bodies and students/alumni (see figure 2).

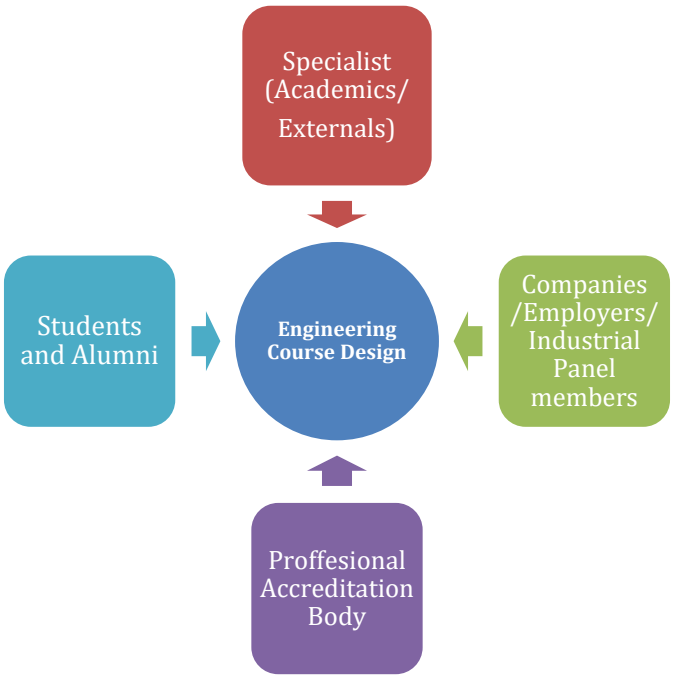

Figure 2: Course design and feedback from stakeholders (adapted from QAA, 2019)

There is a growing feedback from the Oil and Gas companies of the need to equip engineering graduates with more knowledge, awareness and practical experience in HF. Thus university programmes could contribute by either incorporating relevant practices of HF as embedded in existing descriptors or provide students with a special training or practical workshop associated with relevant HFs related with the professional practice. Those special workshops can be also led by accreditors to support universities and students' employability. For example, IChemE provides accredited chemical engineering programs with special workshops as part of safety and loss prevention.

From S. Camille Peres – Associate Professor Environmental and Occupational Health,

Texas A&M University; Assistant Director of Human Systems Engineering Research with Mary Kay O'Connor Process Safety Center

"Different types of engineering programs likely need to learn different levels or types of information about HF."

Although all engineers should have some background in HF, some need to have a deep understanding of HF (e.g., Industrial Engineers), while others may need to know the general principles and how to integrate the skills and knowledge of an HF professional into their work (e.g., Electrical Engineers). This suggests that standardization of the appropriate HF content for all engineering programs may need to be adjusted to the type of the course. However, it is reasonable to assume that all engineering graduates should have a baseline of understanding regarding HF principles, methods, applications, and the risks associated with not considering HF when designing systems and interfaces.

In principle, it would seem that requiring an introductory level course to HF would suffice for this. However, a challenge for this—at least in the United States (US)—is that most engineering degree programs have limited room for another course. Indeed, at Texas A&M University, the chemical engineering degree only has one elective (and it is a science elective) and the petroleum engineering degree has none.

Most engineering and technology degrees programs in the US are accredited by ABET and to maintain accreditation, degree programs must adhere to the curriculum requirements set by this organization as well as those set by other organizations (e.g., in Texas there is a common core curriculum requirement). For there to become "room available" in the engineering curriculum (in the US anyway), ABET would need to adjust some of its requirements. This would require clear and consistent pressure from industry and regulators regarding the need for the changes to improve the safety and functioning of the systems the engineers are designing.

From Promise Ahante - Graduate Petroleum Engineer, Imperial College London, past President of the SPE Student Chapter
"HF learning can be done across departments"

My exposure to the topic of Human Factors (HF) as part of engineering education was fairly limited. During my undergraduate study in Petroleum Engineering, I have heard that "about 60-80% of accidents are due to human error" with no detail about its contributing factors.

During my master's degree, I did learn more about how weak safety cultures represent a major factor responsible for human error which may lead to accidents. However, the two modules which mentioned the importance of safety culture (drilling and well-testing) were taught by industry professionals who had decades of experience as drilling managers.

I've been most exposed to various elements that may contribute to human error, such as fatigue from working extended shifts, personal issues and not having prerequisite training during my

internship in an oil and gas processing facility. However, I'm not sure I fully understood these distinctions between psychological, organizational and other HF components in a way that made me realize their significance.

I believe engineering students should learn solid foundations of human factors in their education but I'm not convinced the industry incentivizes that. For example, I have never seen my colleagues indicate HF knowledge on their CVs, or heard employers expressing interest in graduates having HF knowledge as a job prerequisite. Investing effort into developing HF knowledge does not seem to make a difference when searching for a job after graduation.

There may also be an absence of guidance on what should be taught and how to teach it, and the absence of HF specialist knowledge at Universities.

To address these, HF awareness must be acknowledged by engineering universities or departments as significant beyond just being mentioned. It should be incorporated through immersive/practical or scenario-based learning. While some engineering departments may not have HF specialists, HF learning can be done across departments, through integration and shared learning between engineering and core HF disciplines.

From Dr Marcin Nazaruk - Chair of the SPE Human Factors Technical Section and Human Performance Leader at Baker Hughes.

A call for action.

Having read those reflections about the importance of HP / HF and the growing interest of the industry, it is clear that more work is needed to specify how exactly to close the gap between what the industry needs and what universities can provide.

There is a broad range of institutional stakeholders involved in setting the curricula who have a role to play and some possibilities for this are outlines in Table 1. Through this article, I hope to promote a debate on integrating HF into and raise ideas on what the next steps could be. If the stakeholders listed below did take action and initiate dialog, we may be able to accelerate the progress and make our industry safer.

Table 1. List of proposed actions for specific stakeholders to increase engineers' knowledge of HF in the Petroleum Industry.

WHO	PROPOSED ACTION
All readers	- Share this article with the stakeholders listed below and others who may help - Join the SPE Human Factors Technical Section to continue the discussion and learn more about HP / HF
Leaders of the international engineering alliances:	Explore the most practical ways of engaging institutional stakeholders to inform the evolution of engineering degree

1. the Washington Accord, 2. the Sydney Accord and 3. the Dublin Accord	teaching curricula to account for the industry needs and incorporate human factors topics: - HF engineers and HF experts representing employers - Human Factors committees of the international industry organisations, such as Energy Institute, IOGP or HPOG - Professional HF bodies, such as the International Ergonomics Association and country specific bodies e.g. UK Chartered Institute of Ergonomics and Human Factors or the US Human Factors and Ergonomics Society
Executive Leaders of O&G companies	- Develop awareness of HP in practice, e.g., through the e-learn http://bit.ly/2wmw8Yt - Join HPOG.org and incorporate HP tools and processes as part of your management system - Discuss with HR leaders how the integration of HF can be used as a selection criteria for choosing which universities to recruit from and/or which candidates to recruit.
HR leaders responsible for graduate recruitment	- Explore how to integrate HF as an expectation for graduates and how to communicate this expectation to the prospective and future candidates
Leaders of the professional accreditation bodies, e.g. ICheme, ABET and others	- Explore how to integrate HF topics into your existing accreditation frameworks - Provide a learning map required for engineering graduates to fulfil minimal requirements for HF
Engineering degree course directors	- Explore the best ways to integrate HF topics into the programs and syllabi - Connect with HF experts who could provide guidance and expertise
Leaders of the international industry organisations and associations, e.g. IOGP, SPE, IADC, EI and others	- Explore ways of promoting and incentivizing the integration of HF with the engineering curricula via your networks and mechanisms
Leaders of the HF / HP Professional Societies such as the International Ergonomics Association, UK Chartered Institute of Ergonomics and Human Factors, US Human Factors and Ergonomics Society and their equivalents in other countries	- Explore how to promote the value of HF / HP among the institutional stakeholders listed in this article - Contribute the expertise in building HF / HP skills and competencies - Explore how to support the companies to promote HF / HP among senior leaders and HR departments
Students	- Learn about HF / HP and add HP skills to your CV