CHALLENGE-BASED LEARNING: A CASE STUDY IN COMPUTER AIDED ENGINEERING

Salim Mohamed Salim

Swansea University, Faculty of Science and Engineering

ABSTRACT

This paper reflects on a decade of teaching Computer Aided Engineering (CAE) and the enhancements gradually introduced based on the CDIO™ Initiative. It follows the journey of the originally designed-from-scratch Computational Fluid Dynamics (CFD) module first delivered in 2012 and the modifications made over the years in response to industry and employers' needs, software and technological advancements, and class feedback and learning attainment. The corresponding assessments changed from initially including a closed-book exam component to becoming entirely project-based. This was mainly driven by students' response and the general observation of relative performance between closed-book exam and project-based coursework. Additionally, the projects were designed to support students to progressively enhance their skills and knowledge in using engineering analysis software. The coursework tasks become more challenging and built on the experience and knowledge gained from prior submissions guided by individualised formative feedback. The projects encouraged problem-based learning (PBL) and incorporated real-life industrial problems guided by state-of-the-art research work. The lab-focused experiential learning was supplemented with research-led teaching with students encouraged to compare against publish data, and class discussions covering the author's own research publications. The modifications promoted student-centred learning and students from various year-cohorts repeatedly cited that they enjoyed working on the challenges and academically benefited from solving real-life engineering problems.

KEYWORDS

Active Learning, Problem-based Learning, Engineering Analysis, Real-life Applications, Standards: 1, 2, 3, 5, 7, 8, 11.

MOTIVATION FOR ADOPTING CDIO PRINCIPLES

The study of engineering requires a substantial grounding in engineering principles, science, and mathematics. The gradual development of students' critical thinking and analytical ability to solve real engineering problems is the key to their future success (Tittagala, Hadidimoud, & Liang, 2016). Feedback from education stakeholders including Industrial Advisory Boards (IAB), accreditation bodies and pedagogical literature have highlighted the lack of critical thinking abilities and soft skills in typical graduates. These echoes the criticism by Crawley *et al.* (Edward F. Crawley, 2007) that engineering education programs are somewhat failing in ensuring graduates acquire the professional engineering skills desired by industry.

Student-centered pedagogies like PBL, collaborative learning, process-oriented guided inquiry learning, and peer-led learning have been extensively developed and tested in response to the tried-and-test approaches to match the way we teach to the way students learn (Bransford, Brown, & Cocking, 2000). Studies have shown that active learning environments are more effective than traditional lectures (Eberlein et al., 2008). And Mark Deakin (Deakin, 2006) concludes that students value the link between teaching and research, placing particular weight on research led teaching and the bearing which it has on the quality of their learning experiences. Additionally, Taras (Taras, 2002) recommends that students are positioned at the heart of the learning process.

In response, educators throughout the world are increasingly adopting the CDIO educational framework in their curricular planning and outcome-based assessment to address these shortcomings and better prepare graduates who can engineer.

The CDIO approach features active learning techniques such as group projects, experiential and PBL to equip engineering students with technical knowledge as well as develop communication, interpersonal and professional skills. Readers are encouraged to visit www.cdio.org to find out more. This has a bank of useful resources including standards, syllabus, and case studies.

CDIO IMPLEMENTATION IN COMPUTER AIDED ENGINEERING (CAE) MODULE

Initial CFD Module

With the advancement of computer power, increased research interest and rapid adoption of commercial engineering software in the industry, the author saw an opportunity to introduce the highly sought-after engineering simulation skills when he was originally tasked to design a 3-credit CFD module from scratch back in 2012 as shown in Figure 1. This was also influenced and guided by his research undertaking, having just completed his PhD. The inclusion of ANSYS engineering software in the module facilitated students to gain skills and expertise by solving real-life engineering problems thus promoting experiential learning (Kolb, 2014). The subject content, class discussions, and coursework were centred around the engineering software and the author’s research work to make the module more engaging and relevant to students. Mark Deakin (Deakin, 2006) identified that students strongly valued the link between teaching and research.

In the original module design (refer to Figure 2), 28 contact hours were allocated to lectures covering the theory and 20 hours on software demonstration. The first time the author delivered the lab sessions he stood in front of the class and went through step-by-step instructions. This didn’t work well as the author kept getting interrupted to trouble-shot issues and assist individual students struggling with the steps. He realised he needed to change his approach to manage the class better and ensure all students of various abilities had the opportunity to benefit from learning. The following academic year, the author decided to get students to complete self-paced ANSYS tutorials based on online resources instead, while he was available to assist on a need-basis. This reduced the pressures on the instructor and provided opportunity for one-on-one discussions and interactions.

Taylor's University

School of Engineering

Scheme of Work

SOW/SoE/09/12

Subject	Computational Fluid Dynamics (CFD)	**Subject Code**	MEC4513
Semester/year	7 / 4	**Date Prepared**	29th August 2012
Lecturer	Dr Salim Mohamed Salim	**Credit Hours**	3
Period	3rd Sept – 14th Dec 2012	**Date(s) of Revision**	N/A
Subject Synopsis	Present the essential concepts and skills in computational fluid dynamics including applications using CFD software.		
Contact hours	Lectures: 28 hours Labs: 20 hours		
Learning Outcomes	On completion of this subject, students will be able to: 1. Demonstrate the applications and limitations of CFD 2. Describe the governing equations of fluid flow 3. Analyse turbulence and its modelling 4. Assess fluid flow problems using computational software 5. Solve the Navier-stokes equations numerically		

Assessment Methods	Distribution	(%)	LO 1	LO 2	LO 3	LO 4	LO 5	
	Individual Project 1	20	√			√		
	Individual Project 2	30	√		√	√		
	Mid-term	10		√				
	Final Examination	40		√	√		√	
	Total	100						

Main References	1. H.K. Versteeg, W. Malalasekera. "An Introduction to Computational Fluid Dynamics: The Finite Volume Method." 2nd Edition. Prentice Hall, 2007.
Additional References	1. T. J. Chung. "Computational Fluid Dynamics." Cambridge University Press, 2002. 2. J. D. Anderson. "Computational Fluid Dynamics." McGraw-Hill Science/Engineering/Math, 1995

Figure 1. Syllabus of the CFD Module first introduced in 2012

Subject Name	Computational Fluid Dynamics (CFD)
Subject Code	MEC4513
Subject Status	Elective
Credit Hours	3
Pre-requisites	None
Mode	Lectures: 2 hours per week Labs: 1.4 hours per week (average) Coursework project: 0.9 hours per week (average)
Evaluation	Continuous 60 % Final 40 %
Lecturer	Dr. Salim M. Salim Ph.D. (Mechanical Engineering)
Semester offered	Semester 7
Subject Objectives	To introduce the principles and applications of computational fluid dynamics (CFD)
Learning Outcomes	On completion of this subject, students will be able to: 1. Demonstrate the applications and limitations of CFD 2. Describe the governing equations of fluid flow 3. Analyse turbulence and its modelling 4. Assess fluid flow problems using computational software 5. Solve the Navier-stokes equations numerically
Subject Synopses	Present the essential concepts and skills in computational fluid dynamics including applications using CFD software.

Subject Outline	**Contents**	**Lecture Hours**	**Course work Project**	**Lab Hours**
	1. Introduction to Computational Fluid Dynamics (CFD): concept, application and problem solving using CFD	2		
	2. The governing equations of fluid mechanics: Mass, momentum and energy conservation equations	4		
	3. The Navier-Stokes equations: Navier-Stokes equations for a Newtonian fluid, conservation form of the governing equations; differential and integral forms of the general transport equations	4		
	4. Turbulence and its modelling: definition; transition from laminar to turbulent flow; characteristics of simple turbulent flows, Reynolds-averaged Navier-Stokes equations and turbulence closure schemes	6		
	5. The finite volume method (FVM) for diffusion problems: Introduction, FVM for one-dimensional steady state diffusion; FVM for two-dimensional diffusion problems	4		
	6. The finite volume method for convection-diffusion problems: introduction; steady one-dimensional convection and diffusion; central differencing scheme.	4		
	7. Errors and uncertainty in CFD modelling: numerical errors, input uncertainty; physical model uncertainty; verification and validation; guidelines for best practice in CFD	4		
	8. Flow simulation using CFD software: grid generation; implementing boundary conditions; near-wall treatment; turbulence modelling; convergence criteria; post-processing.			20
	9. Project		12	
	Total Hours	**28**	**12**	**20**
	Lecture Hour Equivalence	**28**	**4**	**10**
	Total Lecture Hour Equivalence	**42**		
	Total Credit Hours	**3**		

Main References	1. H.K. Versteeg, W. Malalasekera. "An Introduction to Computational Fluid Dynamics: The Finite Volume Method." 2nd Edition. Prentice Hall, 2007.
Additional References	1. T. J. Chung. "Computational Fluid Dynamics." Cambridge University Press, 2002. 2. J. D. Anderson. "Computational Fluid Dynamics." McGraw-Hill Science/Engineering/Math, 1995.

Figure 2. Lesson Plan of the CFD Module first introduced in 2012

Early student feedback reassured the author that learners appreciated the delivery style:

“Additionally, we were given the opportunity to work on an assignment in which, for the first time, I was able to apply my engineering knowledge to design a given task. This has never been done in other Engineering classes and should strongly be taken into consideration.”

Modified CAE Module

The author inherited an existing CAE module on taking up a new post at a different institution in 2015 and deduced from reviewing previous feedback and class performance that students had previously struggled to master the learning outcomes due to poor results. He identified that the module was designed and delivered in a traditional way: monotonous lectures with prescriptive lab classes. Therefore, the author decided to overhaul the module by injecting CDIO principles and research-led teaching. The module eventually evolved to keep up with the latest industrial development, by combining Finite Element Methods (FEM) with CFD to further develop students' engineering analysis skills in what is termed Fluid-Structure Interactions (FSI) as shown in Figure 3.

The revised module expanded to become a 20 UK (≈ 6 US) credits yearlong module with an emphasis on developing software skills, while the theory lectures played a secondary role of supplementing understanding. The updated learning plan (Figure 4) required completion of weekly self-paced online tutorials based on an open course by Cornell University (now hosted on the MOOC edX) and had the advantage of flexibility: on-demand through guided YouTube videos and external resources. Additionally, students were required to compare their results against published validation/benchmark studies and signposted to external user communities such as www.cfd-online.com for resources.

This aimed to accommodate different learner preferences and supported diverse student groups including those with carer responsibilities and/or part-time jobs. The student projects were designed in partnership with industry to ensure assignments and case studies were based on real-life industrial applications.

For the supporting theory lessons, the author employed various active learning and student-centred approaches to stimulate learning, to engage with the students, and to cater to the diverse learner preferences. He combined slides, whiteboard (to demonstrate derivations), and required students to read journal papers at home so they could discuss in class (flipped learning). Students found value in this approach:

“I think the way you prepare lectures is brilliant. You use your own words and own slides to explain and utilize the whiteboard to help us understand better.”

Module specification and supporting information[1]

Applicability	All ME Students

Section 1: Module specification	
Heading	**Details**
1.1 Module title	Computer Aided Engineering
1.2 Module code	ME40001
1.3 Scottish Credit and Qualifications Framework (SCQF) level and credits	SCQF level 10, 15 SCQF credits, 7.5 ECTS credits.
1.4 Aims	This module provides an introduction to the use of computational tools for solving general engineering problems in the areas of fluid dynamics and structural analysis. Students will learn and apply the basic computational methods that are necessary to solve real engineering problems.
1.5 Indicative content	Theory of Finite Element Method (FEM), Computational Fluid Dynamics (CFD) and Fluid-Structure Interaction (FSI) including: • Governing Equations • Mathematical techniques involved • Uses and limitations • Navier-stokes equations • ANSYS Software for Structural Analysis and Fluid Dynamics • Combination of FEM and CFD in FSI
1.6 Intended learning outcomes	**Knowledge and Understanding:** (Finite Element Methods) The student will gain an appreciation of the science and mathematics of FEM and the practicalities involved in producing meaningful results using a commercial analysis package (ANSYS). (Computational Fluid Dynamics) Students will gain a basic understanding of CFD methods and their applications. They will also have sufficient knowledge to enable them to deal with more complex problems involving turbulence. (Fluid Structure Interactions) Students will be able to apply both FEM and CFD to investigate responses of structures due to fluid loadings. **Skills and Abilities:** (Finite Element Methods) On completion of this module students will gain experience in using a commercial finite element package to carry out structural analysis (Computational Fluid Dynamics) On completion of the module, the students will be capable of using CFD to compute fluid flows and appreciate the applications and limitations. (Fluid Structure Interactions) Students will gain the knowledge to carry out FSI investigations.

Figure 3. Modifications made in new module Computer Aided Engineering (CAE) in 2015

ME40001 – Computer Aided Engineering

Learning Schedule Semester 1

University of Dundee

ANSYS Lab:

Week	Lab Activity
1	Introduction: Module Overview
2	CFD tutorial 1: Laminar Pipe Flow
3	CFD tutorial 2: Turbulent Pipe Flow
4	CFD tutorial 3: Flat Plate Boundary Layer
5	CFD tutorial 4: Steady Flow Past a Cylinder
6	Coursework 1
7	Coursework 1 Due 28th Oct
8	CFD tutorial 5: Unsteady Flow Past a Cylinder
9	CFD tutorial 6: Flow over an Airfoil
10	CFD tutorial 7: Turbulent Pipe Flow (LES)
11	Coursework 2
12	Coursework 2 Due 2nd Dec

Lectures:

Week	Lecture
2	Lesson 1: General Procedures of CFD
3	Lesson 2: Fluid Governing Equations – Conservation Laws
4	Lesson 3: The Navier Stokes Equations
5	Lesson 4: General Transport Equations
6	Lesson 5: Turbulence: An Introduction
7	Lesson 6: Descriptors of Turbulence
8	Lesson 7: RANS
9	Lesson 8: Revision

Resources:

https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules (CFD)

www.cfd-online.com (Online community)

Figure 4. Lesson Plan of new module Computer Aided Engineering (CAE) in 2015 for Semester 1

CHANGES IN ASSESSMENT STRATEGY

Initial CFD Module

Back in 2012, the 3-credit one semester CFD module had an equal split of closed book written examinations and project report submissions (see Table 1).

The author observed that by linking the subject content to real-life application and current state of research, students became motivated and demonstrated a better understanding of the material as evident in some good reports that were produced and presented at international conferences including positive feedback in module evaluations.

Table 1. Summary of Assessments in Initial CFD Module

Project	Weightage	Short Description of Task
1	20%	2D CFD Modelling Project Report
2	30%	3D CFD Modelling Project Report
Mid-term test	10%	Written examination
End-term examination	40%	Written Examination

Modified CAE Module

As presented in the previous section, the original module was assessed by a combination of coursework and written examination (see Table 1). On analysing the class performance (break-down of different assessment components) the author observed that students were learning and performing more effectively in the coursework compared to closed-book exams. Student informally shared sentiments similar to Richardson's (Richardson, 2015) account that they prefer to be assessed by coursework. Therefore, when the author took up a new role at the University of Dundee, he converted the existing 20 credit module to 100% coursework as summarised in Table 2 in the modified 6-credit module.

This continued blending formative and summative assessment to stimulate incremental learning. The structured coursework became progressively harder and required knowledge and skills gained in preceding assignments. This was supplemented with report rubrics and exemplar student reports for guidance. Students were tasked to solve real-life problems, compare against published data, and communicate through scientific-styled reports.

Table 2. Summary of Assessments in Modified CAE Module

Project	Semester	Weightage	Short Description of Task
1	1 (Autumn)	20%	2D CFD Modelling Project Report
2	1 (Autumn)	30%	3D CFD Modelling Project Report
3a	2 (Winter)	20%	FSI Comprehensive Literature
3b	2 (Winter)	30%	FSI Modelling (combining FEM + CFD)

To check understanding and reinforce learning the lessons were punctuated with a combination of summative and formative assessments. As a result, student satisfaction and class performance improved. Students were tasked to solve real-life problems, compare against published data, and communicate through scientific-styled reports.

A student stated:

"Throws you into the deep end for assignments, which builds initiative to look (for) sources and ways to complete the assignment. Overall, a great learning experience coupled with fair assessments."

The structured coursework (Figures 5 and 6) became progressively harder and required knowledge gained in preceding assignments supported by comprehensive written and oral feedback provided for each successive coursework and supplemented with report rubrics and exemplar reports for guidance.

University of Dundee

ME40001 – Computer Aided Engineering

Coursework 1 (20 marks)

This is an individual assignment.

Instructions for Submission

Compile all your work in PDF format (including theory, simulation data, results and appendix) and submit a single PDF file on MyDundee by 28th Oct, 10pm. Delayed submission will be penalized according to the School policy.

There is a page limit of 15 including references and appendix.

The report should include Introduction (problem statement, brief literature review, project objectives, etc.), Research methodology (computational domain, choice of turbulence models, physical models, solution setup, etc.), Results (including validation with experimental/benchmark data widely available in the public domain) and Conclusion. Remember to include proper referencing. **Marks will be deducted for plagiarism**.

The report has to be concise. See samples of reports posted in MyDundee.

You would not only be judged on the accuracy of your numerical results, but on the overall presentation and demonstration of the procedures taken to arrive at your final solution. Make comparisons based on computational time and agreement with benchmark/experimental data.

Project Titles

Solve the 2D flow problem that corresponds to your allocation:

A. Laminar cavity driven-lid flow
B. Turbulent flow over backward facing step
C. Laminar flow past a square/cube
D. Turbulent flow past a square/cube

Resources

Validation cases: https://www.cfd-online.com/Wiki/Validation_and_test_cases

Scopus/Google Scholar

Coursework 2 (30 marks)

This is an individual assignment.

Instructions for Submission

Compile all your work in PDF format (including theory, simulation data, results and appendix) and submit a single PDF file on MyDundee by 16th Dec, 10 pm. Delayed submission will be penalized according to the School policy.

There is a page limit of 15 including references and appendix.

The report should include Introduction (problem statement, brief literature review, project objectives, etc.), Research methodology (computational domain, choice of turbulence models, physical models, solution setup, etc.), Results (including validation with experimental/benchmark data widely available in the public domain) and Conclusion. Remember to include proper referencing. Marks will be deducted for plagiarism.

The report has to be concise.

You would not only be judged on the accuracy of your numerical results, but on the overall presentation and demonstration of the procedures taken to arrive at your final solution. Discuss your results based on two different turbulence closure schemes employed and make critical comparisons regarding the computational time and agreement with benchmark/experimental data. Sensible arbitrariness or estimation of geometry is permitted.

Project Titles

Using any two of the three turbulence closure schemes:

- Standard kε
- Reynolds Stress Model (RSM)
- Large Eddy Simulation (LES) – this is inherently unsteady (i.e. time dependent).

Solve one of the following 3D flow problems:

1. Smoke dispersion during a tunnel-fire
2. Turbulent flow around a building/cube (e.g. airflow and pollution dispersion)
3. Natural ventilation in public areas
4. Aerodynamics of a car
5. Turbulent mixing in a branched pipe
6. Any problem of interest (of similar complexity to the above)

Figure 5. Coursework 1 & 2 Briefs of Modified CAE Module

ME40001 – Computer Aided Engineering

UNIVERSITY OF DUNDEE

FSI Project 2nd Semester

50 marks

This is an individual assignment.

Instructions for Submission

Part 2 (Simulation work) is due on 6th March. (30 marks)

Part 1 (Comprehensive literature review) is due on 13th March. (20 marks)

You would not only be judged on the accuracy of your numerical results, but on the overall presentation and demonstration of the procedures taken to arrive at your final solution. Discuss your results in detail and make critical comparisons regarding the computational time and agreement with benchmark/experimental data. Sensible arbitrariness or estimation of geometry is permitted and this should be mentioned.

Part 1: Past, Present and Future of Fluid – Structure Interaction (20 marks)

A comprehensive 2000 – 5000 words literature review discussing the vast array of applications, challenges, developments and opportunities in Fluid – Structure Interaction (FSI). This should not be limited to the title you select for Part 2 and has to encompass a wide range.

Introduce what is FSI, the motivation of its use and how it ties in with CFD and FEA. Include views from industry (based on professional body publications and technical reports), academic research undertakings (published journal papers and conference presentation) and your own opinions (based on your observations and deductions of the reports you read, youtube videos you come across, etc). Consider using flow charts, illustrations and other visual aids.

The report will be judged on how you present (and 'sell') FSI. It should be supported by published work (Wikipedia and other online references don't count) and your appreciation of the applications, challenges and opportunities of FSI.

Part 2 (30 marks)

Using a suitable RANS model (i.e. not LES) and FEA in ANSYS solve any problem of interest where Fluid – Structure Interaction exists. Part of the exercise is your judgement on selecting an appropriate problem to solve taking into account the computation cost and available resources. (It is worth noting that Benchmark data might only exist for the 'CFD' part and not 'FSI', and hence use that to judge your likely accuracy).

The report should include Introduction (problem statement, brief literature review, project objectives, etc.) specific to your chosen problem (whereas Part 1 is a general report), Research methodology (computational domain, choice of turbulence models, physical models, solution setup, etc.), Results (including validation with experimental/benchmark data widely available in the public domain) and Conclusion. Remember to include proper referencing. Marks will be deducted for plagiarism.

The report has to be concise and preferably presented in a journal article format. For example see the article "Numerical Analysis of Fluid-Structure Interaction between Wind Flow and Trees" and "Numerical Simulation of the Aerodynamic Loads on Trees during Storms" in My Dundee.

Notes: Include your numerical results with the ANSYS FLUENT Time-stamp (the frame showing what model has been implemented, date of simulation, etc).

Figure 6. Coursework 3 Brief of Modified CAE Module

Coursework A was designed to be a guided 'warm up' based on easily accessible scientific validation studies from www.cfd-online.com. The proceeding Coursework B was open-ended and required students to source external research/technical articles to compare against. They also had the opportunity to propose their own topics. Once the students had developed their confidence in running CFD simulations, the 2nd semester challenged them to combine fluid dynamics with structural analysis (FSI) and this was even more open-ended based on real-life applications (see Figure 6 for the project brief).

CONCLUSIONS

The design and delivery of the CFD (later CAE) module evolved in response to students' feedback, industrial needs, latest state-of-the-art software developments, and evaluation of class performance. Emphasis shifted from theory (lecture delivery) to engineering application through experiential learning (project-based coursework). The cohort the changes first impacted welcomed the new approach. Extract from module review in 2015:

"Majority of the survey indicated students enjoyed the lectures, particularly the 'engaging teaching style' and 'encouragement for discussions.' They also found that the delivery provided 'good explanation', 'applications', 'practical knowledge', 'and interesting examples' of relevance and career adding value."

The faculty staff who took over the module as the author left for a new job in 2019 nicely sums the impact of the enhancements introduced over the years:

"The existing module materials were of a very high level with numerous influences from real engineering and work that [the author] had previously been involved with, including his own publications relating to this field…. The inherent form of this module also works with hybrid or online teaching…"

"I believe [the author's] plan for assessment strategies proved very effective in motivating the students to develop and apply their CFD techniques…and to act as real engineers in a way that would be sought by future employers…Students benefited from clear and coherent guidance."

"He advised on constructive feedback on report submissions to enhance future work, and to invite students to discuss their concerns. A detailed report template was made available by as a guide, along with examples of good (anonymous) reports…which provided direct guidance for me to support the students, and for the students to guide themselves."

FINANCIAL SUPPORT ACKNOWLEDGEMENTS

The author received no financial support for this work.

REFERENCES

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn* (Vol. 11): Washington, DC: National academy press.

Deakin, M. (2006). Research led teaching: a review of two initiatives in valuing the link between teaching and research. *Journal for Education in the Built Environment, 1*(1), 73-93.

Eberlein, T., Kampmeier, J., Minderhout, V., Moog, R. S., Platt, T., Varma-Nelson, P., & White, H. B. (2008). Pedagogies of engagement in science: A comparison of PBL, POGIL, and PLTL*. *Biochemistry and molecular biology education : a bimonthly publication of the International Union of Biochemistry and Molecular Biology, 36*(4), 262-273. doi:10.1002/bmb.20204

Edward F. Crawley, J. M., Sören Östlund, Doris R. Brodeur, Kristina Edström. (2007). *Rethinking Engineering Education*: Springer US.

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*: FT press.

Richardson, J. T. E. (2015). Coursework versus examinations in end-of-module assessment: a literature review. *Assessment & Evaluation in Higher Education, 40*(3), 439-455. doi:10.1080/02602938.2014.919628

Taras, M. (2002). Using Assessment for Learning and Learning from Assessment. *Assessment & Evaluation in Higher Education, 27*(6), 501-510. doi:10.1080/0260293022000020273

Tittagala, R., Hadidimoud, S., & Liang, B. (2016). Addressing the UK-SPEC competence levels: challenges in programme design and delivery in a diversifying engineering HE sector. In: ISEE.

BIOGRAPHICAL INFORMATION

Salim Mohamed Salim is an Associate Professor and Director of International Partnership at Faculty of Science and Engineering, Swansea University. He is a Visiting Professor at Taylor's University, Malaysia and Adjunct Faculty at Saveetha University, India. Dr Salim is also a Chartered Engineer (CEng) and Senior Fellow of the Higher Education Academy (SFHEA). His pedagogical interests include student-centred, research-led, and active learning, with an emphasis on the real-life applications of engineering skills and knowledge. He also engages and develops global academic and research collaborations including opportunities for student and staff exchange.

Corresponding author

Salim Mohamed Salim
Swansea University
Faculty of Science and Engineering
Bay Campus, Swansea SA1 8EN
United Kingdom
s.m.salim@swansea.ac.uk