Understanding of structural behaviour

How can academics make the learning and teaching of structural behaviour more effective? What is the role of academics in better preparing graduates to meet industry expectations?

Taking into considerations the limited resources available and the timelines required to implement substantial changes into curricula, this resource sheet looks at ways to improve existing programmes and focuses on 1 aspect of understanding structural behaviour: **Using real structures**

1. Learning outcomes	**Year 1**: Apply basic statics theory to analyse simple structural systems and elements. **Year 2**: Identify and understand the underlying structural concepts within real framed structures. **Year 3**: Develop the ability to appreciate and critique the uncertainties and complexities of real structures. **Year 4**: Use critical awareness of current and innovative solutions to deploy original structural solutions.
	Real structures should be used at each level to demonstrate clear principles. For example: **Year 1**: Students should relate line drawings (used to produce BM, SF, and deflection diagrams) to real structures, developing a sense of the proportion of members. **Year 2/3**: Students should be able to create their own line diagrams, which can then be used for structural analysis, incorporating support conditions, joint types, and applied loading.
	Students should also: Sketch load paths for a wide variety of structures. Visualise and draw different structures (e.g., bridges, tower blocks). Understand construction technologies, from domestic to high-rise buildings, including heritage forms and material lifecycle impacts on stability.
2. Assessment and feedback	**Quantitative Assessments**: Utilize diagrams (e.g., BM/SF/deflection) to analyse real structures and compare to simplified models. Encourage students to use calculations to validate structural behaviour.
	Qualitative Assessments: Implement oral presentations and reports where students explain structural behaviour, providing feedback on both performance and conceptual understanding.
	Group Projects: These should allow students to explore more complex structures and work collaboratively, encouraging peer-to-peer feedback.
	Formative Assessments: Use scaling techniques or group models to assess understanding, with feedback provided both from peers and instructors.
	Assessments should prioritise engagement and relevance by connecting theory to real structures, utilising tools such as FEA models to compare with students' hand calculations.
3. Teaching methods: examples of best practice	**Site Visits**: A must for understanding structural behaviour. Real structures such as bridges (e.g., Exchange House or Cannon

	Street Station in London) offer great examples for students to observe and analyse.
	Group Projects: Combine site visits with group projects to deepen understanding through collaborative exploration.
	Use of Models: Small-scale models or virtual representations of real structures can complement tutorials, lectures, and YouTube videos to enhance learning.
	Guest Lecturers: Industry professionals can provide practical insights and bring real-world experience into the classroom.
	Encourage Sketching: Structural engineering students should maintain sketchbooks (digital or hand-drawn), similar to architecture students, to document and explore real structures.
	Non-Destructive Testing: Use forensic case studies and non-destructive testing methods to further inform students about real structural behaviour.
4. Opportunities and challenges	**Opportunities**: **Real-Life Engagement**: Use real structures to make theoretical knowledge more tangible. Physical models or MOLA kits can allow students to “play” with the models, reinforcing core principles. **3D Printing**: This technology can be used to create models of real structures for classroom experiments. **University Resources**: Investigate local resources such as exposed bracing at UWE to use for teaching, integrating these into the curriculum. **Collaborative Projects**: Consider field courses or group projects based around ongoing construction sites, engaging students in practical learning. **Challenges**: **Access to Buildings**: Securing access to real structures for educational purposes may require building relationships with industry partners. **Industry Involvement**: Engaging lecturers with significant industry experience can be challenging but is essential for bridging the gap between theory and practice. **Time and Resources**: Real structures require time for students to analyse fully, as well as resources (labs, IT) to model and test concepts.
5. Strategies for implementation throughout existing curricula	**Progressive Learning**: Real structures should be introduced early (Year 1) and revisited throughout the curriculum, with increasing complexity and relevance to taught structural theory. **Industry Links**: Collaborate with industry to provide insights and real-life problem-solving experiences. This may require changes to the curriculum to reflect industry needs and practices. **Site Visits**: Integrate site visits into modules, ensuring they complement lectures and tutorials. These could be followed up by group work components for deeper analysis.

	Field Courses: Organize structural field courses around ongoing construction projects and completed buildings, allowing students to explore the interfaces between various components. **Consistent Approach**: Ensure the use of real structures is consistent across all modules, from structural analysis to design, to reinforce learning outcomes. By incorporating real structures into the curriculum, students can better understand the complexity of structural systems and develop the skills needed to succeed in the industry.
6. Post-meeting notes and additional resources	***Post-workshop thoughts from organisers:*** Different type of site visitis may be organised for the students including: - live construction - completed projects - conservation and refurbishment A related talk and group discussion would also complement the site visits. For example, Year 1 students at the University of Surrey visit a local building under construction (e.g Birch House Residential Complex and Royal Surrey Hospital Cancer Treatment Centre). Also, attend a talk about the construction of three different types of buildings on campus (i.e student accommodation, academic building and sports centre) followed by visiting the buildings. They finally visit a conservation project (e.g Clandon Park) or an on going refurbishment project on campus. Each visit requires a half day timetabled session, so the attendance is compulsory. A potential challenge is the size of cohort and site limitations for number of visitors, so the students may be divided into groups to repeat the visits as appropriate. 

International visits also would provide great opportunities for the students and Turing Scheme (https://www.turing-scheme.org.uk/) may provide financial support. The picture shows a group of Surrey students visiting a conservation project at Guadalajara, Mexico in 2022.

Also, visiting specific type of structures could help students understanding the construction details and stability during assembly. The picture shows Surrey students visiting membrane structures before practicing the assembly of such structures in the lab.

3D printing can be used for visualisation of complex geometries such as spatial structures. The following picture shows 3D printed configurations by groups of Year 1 Surrey students for their assignment.

	A1
A2
A3
A4
A5
A6
A7
A8
A9
B1
B3
B5
B6
B7