Enquiry based learning and application-driven teaching

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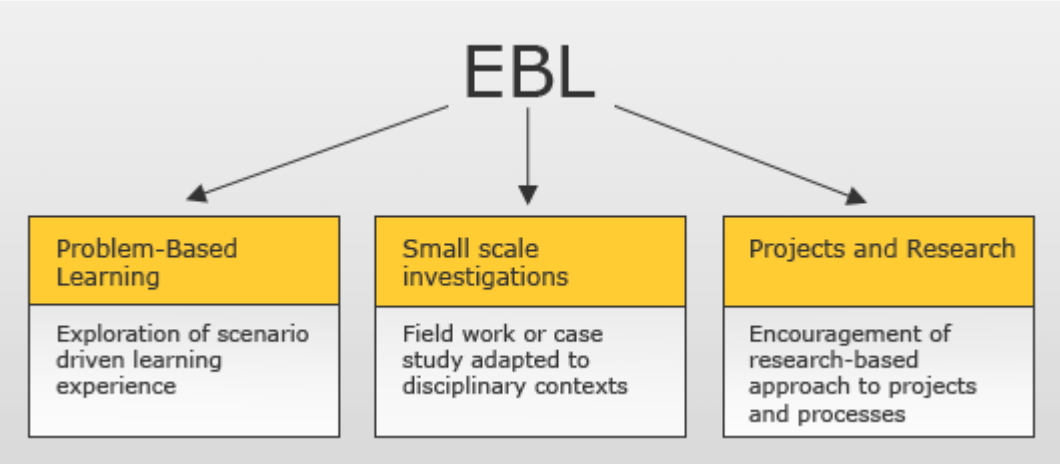
Outline

- **Enquiry based learning (EBL): definition**
- **Why EBL is needed in higher education?**
- **Materials Science and Engineering and links with other engineering disciplines**
- **Materials and Manufacturing Processes Module(s) for Mechanical, Motorsport and Automotive Engineering**
- **Challenges: very little time to cover too much information resulting in content to be too shallow, too dry, and less interesting and engaging**
- **Application of EBL at Coventry**
- **My role as the module leader**

Enquiry based learning (EBL)

Teaching and learning styles are changing, there has been move from lecture-based activities towards more student-centred activities.

Enquiry based learning (EBL): a *cluster of strongly student-centred approaches to learning and teaching that are driven by enquiry or research.*



Source: Centre for Excellence in Enquiry-Based Learning, The University of Manchester

Because EBL is often oriented around learning by doing, it often involves problem-based learning and project-based learning which is naturally suited for STEM disciplines.

Progression from teacher-led to learner-centred teaching

Curriculum element	Discipline and teacher-controlled approach	Enquiry and learner-centred approach
Teaching approach	Narrow, well-defined problems, lectures as central	Open, ill-defined problems, lectures as support
Knowledge	Disciplinary knowledge (KNOW-HOW)	Interdisciplinary knowledge (KNOW-WHY)
Academic staff	Teacher-controlled	Facilitator, guide, professional development support
Learning spaces	Traditional, formal lecture-tutorial spaces	Learning spaces for groupwork, both formal and informal
Assessment	Individual, summative	Group, formative

Progression through (Adapted from Guerra & Kolmos 2011, p. 5)

Can we have both approaches blended together?

Materials Science and Engineering

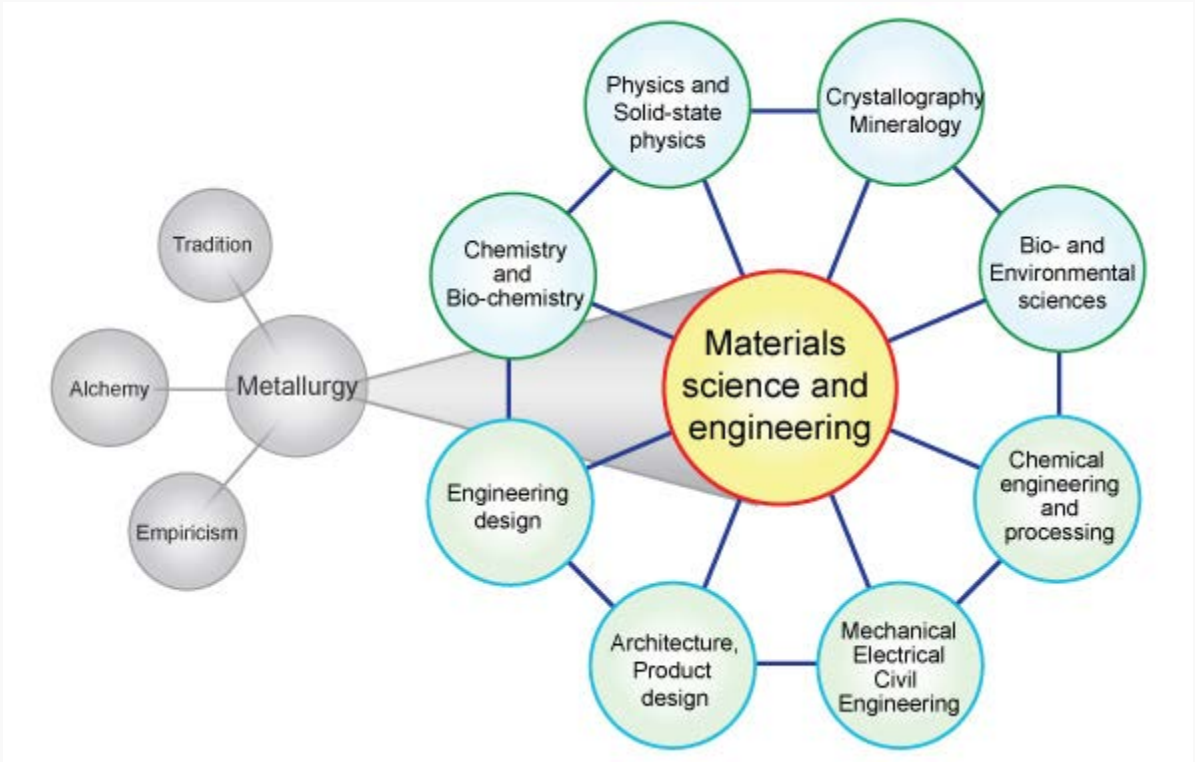
It involves study of 4 broad categories of eng. materials (metals and alloys, ceramics, polymers or plastics and composites)

It involves systematic study of materials and can be further classed into:

- Processing of materials
- Structure and composition of materials
- Making different materials
- Testing and evaluating the performance and application of materials

This is to design and to produce materials with novel properties that will meet the requirements of people for various applications.

Origins of Materials Science



Source: 2nd North American Materials Education Symposium, 2011, Worcester Polytechnic Institute, Worcester, MA, March 24-25, 2011

Example: Manufacturing Technology and Materials 20 credits module

This module is designed to provide an integrated introduction to engineering materials and manufacturing processes

Intended Module Learning Outcomes

1. Employ a range of methods for identifying the mechanical, physical, electrical and environmental properties of polymers, metals, ceramics and composites.
2. Employ the principles of solidification, diffusion and solid state deformation to the relevant manufacturing process.
3. Develop a broad knowledge base of the various types of manufacturing processes (e.g. casting technology, forming and shaping processes, material removing processes and joining processes).
4. Employ property enhancing and surface treatment operations to metals.
5. Evaluate manufacturing processes on the basis of cost, accuracy and lead time to form judgments about their applicability to given manufacturing situations, including considerations of environmental and end of life costs of products.
6. Evaluate common engineering materials on the basis of mechanical and physical properties, cost and manufacturing properties, and form judgments about their applicability to given product functional requirements.

Institution of Mechanical Engineers [IMechE]

https://cumoodle.coventry.ac.uk/my/

Assessment

Coursework 100%

•Assignment 1- (20%) assesses learning outcomes 1,6

- Mechanical Testing short report based on analysis of mechanical testing data

•Assignment 2 - (45%), assesses learning outcomes 2,3,5,6

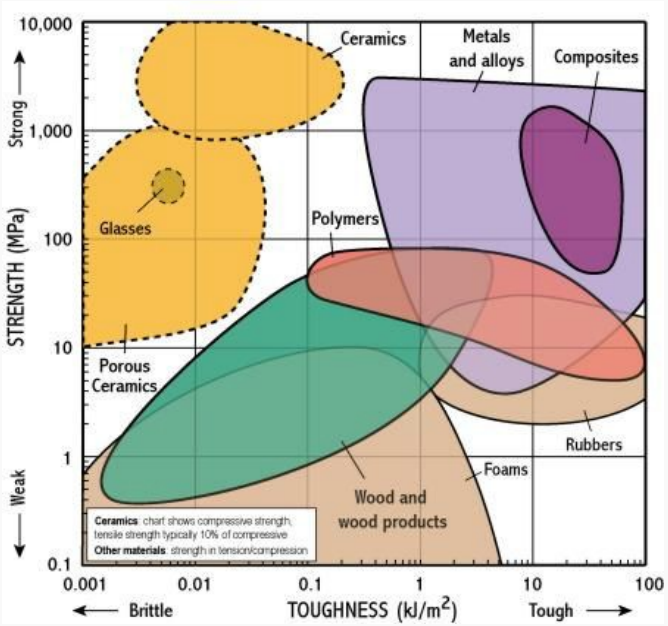
- Materials and Manufacturing Report to demonstrate materials and process selection capability and use of CES software

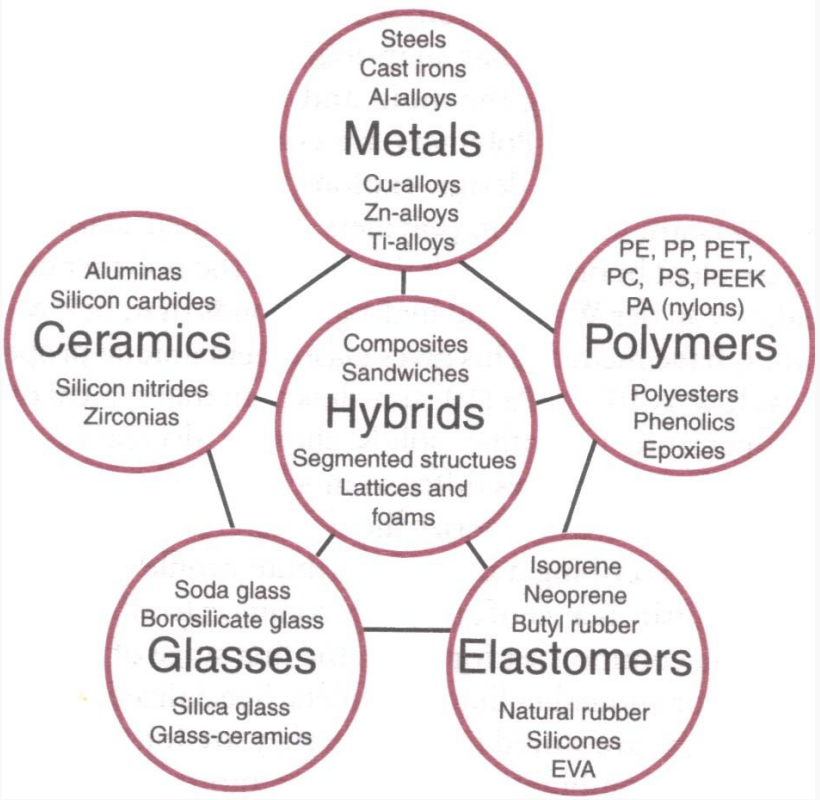
•Assignment 3 –(35%) assesses learning outcomes 3,4,5,6

- A 20 to 30-minute In-class PC-Based Test. A mixture of multiple choice and short calculation questions to demonstrate knowledge of course subjects.

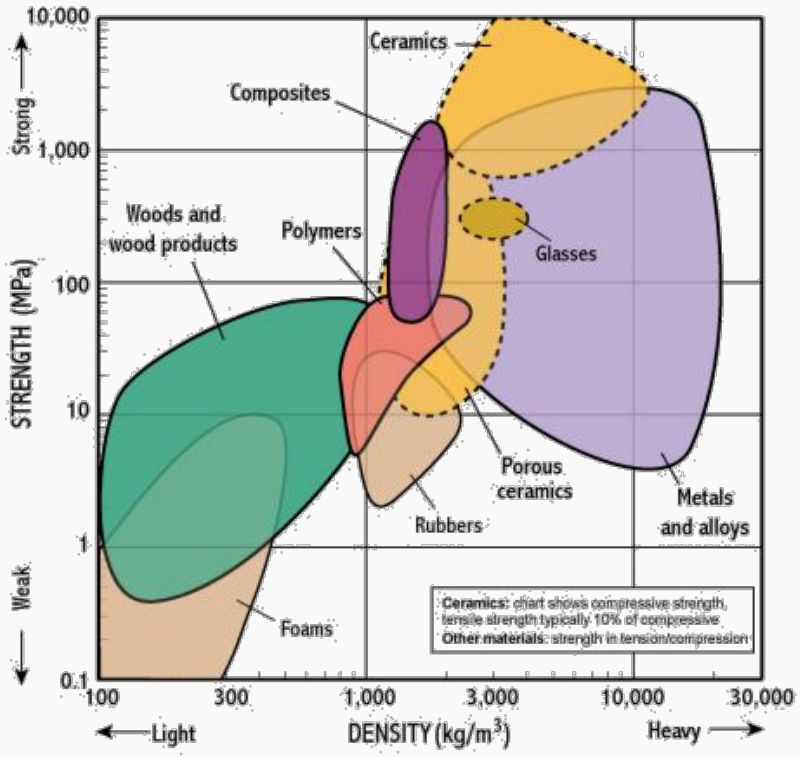
Individual Task
Group work assessment
Phase test assessment

Classes of Engineering Materials

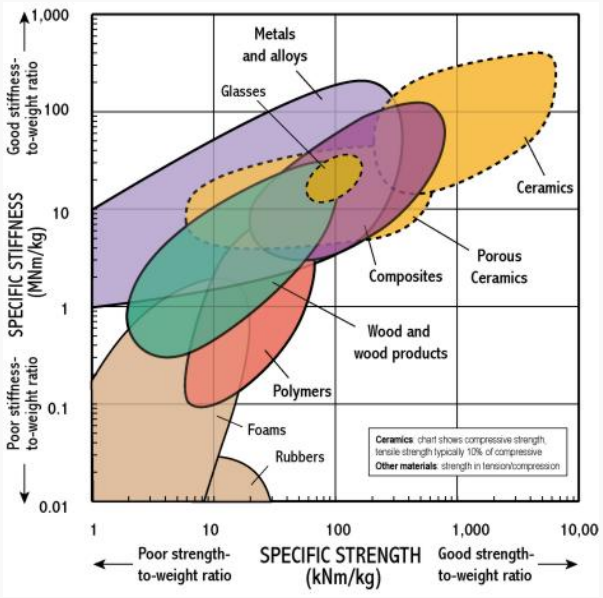




Light weighting/ conflicting objectives

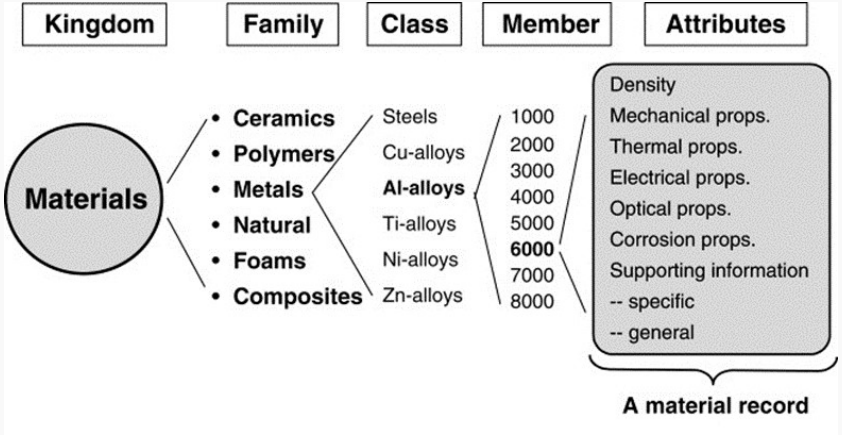


Most engineering structures and components especially in transportation now pose a different kind of challenge, requiring **strength** and at the same time **light-weight** (conflicting objectives).



http://www-materials.eng.cam.ac.uk/mpsite/interactive_charts/strength-density/basic.html

Classes of Engineering Materials- *CES: Cambridge Engineering Selector*



Each family of materials is divided in to classes

In the case of metals, these are the different alloys based on individual metallic elements e.g. Al alloys, Ti alloys, Steels (Fe based)

Wrought Al alloys are sub-divided in to 8 sub-classes (1000 - 8000 series)

Within each sub-class there are a large range of individual alloys, available in different conditions

Main Assessment based on a case study

Task and Mark distribution:

You have the option to choose from non-ferrous alloys (e.g. light alloys), ferrous alloys and composite materials to design and manufacture a given component, a connecting rod. You are asked to choose a material from these materials for a connecting rod to be used in an engine of a commercial passenger car to be made later this year, or early next year. Figure 1 shows a sketch of a typical connecting rod. Figure 2 provides an example of size specification for a connecting rod used in an internal combustion engine.

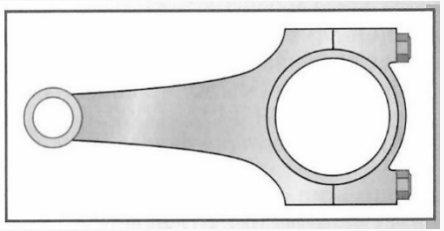


Figure 1. Sketch of a connecting rod

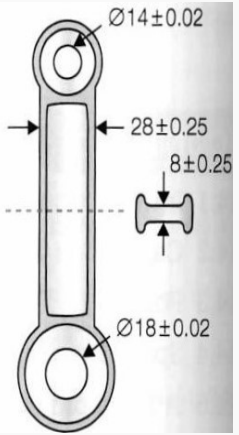


Figure 2: Example of dimensions of a small connecting rod in an internal combustion engine.

Marking rubric

GRADE	ANSWER RELEVANCE	ARGUMENT & COHERENCE	EVIDENCE	SUMMARY
First **≥70**	Innovative response, answers the question fully, addressing the learning objectives of the assessment task. Evidence of critical analysis, synthesis and evaluation.	A clear, consistent in-depth critical and evaluative argument, displaying the ability to develop original ideas from a range of sources. Engagement with theoretical and conceptual analysis.	Wide range of appropriately supporting evidence provided, going beyond the recommended texts. Correctly referenced.	An outstanding, well-structured and appropriately referenced answer, demonstrating a high degree of understanding and critical analytic skills.
Upper Second **60-69**	A very good attempt to address the objectives of the assessment task with an emphasis on those elements requiring critical review.	A generally clear line of critical and evaluative argument is presented. Relationships between statements and sections are easy to follow, and there is a sound, coherent structure.	A very good range of relevant sources is used in a largely consistent way as supporting evidence. There is use of some sources beyond recommended texts. Correctly referenced in the main.	The answer demonstrates a very good understanding of theories, concepts and issues, with evidence of reading beyond the recommended minimum. Well organised and clearly written.
Lower Second **50-59**	Competently addresses objectives, but may contain errors or omissions and critical discussion of issues may be superficial or limited in places.	Some critical discussion, but the argument is not always convincing, and the work is descriptive in places, with over-reliance on the work of others.	A range of relevant sources is used, but the critical evaluation aspect is not fully presented. There is limited use of sources beyond the standard recommended materials. Referencing is not always correctly presented.	The answer demonstrates a good understanding of some relevant theories, concepts and issues, but there are some errors and irrelevant material included. The structure lacks clarity.
Third **40-49**	Addresses most objectives of the assessment task, with some notable omissions. The structure is unclear in parts, and there is limited analysis.	The work is descriptive with minimal critical discussion and limited theoretical engagement.	A limited range of relevant sources used without appropriate presentation as supporting or conflicting evidence coupled with very limited critical analysis. Referencing has some errors.	Some understanding is demonstrated but is incomplete, and there is evidence of limited research on the topic. Poor structure and presentation, with few and/or poorly presented references.
Fail **<40**	Some deviation from the objectives of the assessment task. May not consistently address the assignment brief. At the lower end fails to answer the question set or address the learning outcomes. There is minimal evidence of analysis or evaluation.	Descriptive with no evidence of theoretical engagement, critical discussion or theoretical engagement. At the lower end displays a minimal level of understanding.	Very limited use and application of relevant sources as supporting evidence. At the lower end demonstrates a lack of real understanding. Poor presentation of references.	Whilst some relevant material is present, the level of understanding is poor with limited evidence of wider reading. Poor structure and poor presentation, including referencing. At the lower end there is evidence of a lack of comprehension, resulting in an assignment that is well below the required standard.
Late submission	0	0	0	0

Summary and Future work

- There are few different methods what could be used under Enquiry Based Learning, e.g. problem solving, project based or use of case study.

- Enquiry Based Learning should be implemented when teaching Materials Science and Engineering to other engineering students. This is to enhance their engagements and therefore learning experiences. This is currently used partially in our module, mostly on assessments and some tutorials. However, the lectures content should be adjusted to reflect this method.

- It is thought as a community we could share our experiences to identify most effective methods when teaching Materials Science in current environment.