The use of crash courses to promote active engagement in large class sizes

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***Abstract**: Active engagement of students in large classes is imperative to ensure deep learning. This paper discusses the use of 'crash courses' as a teaching strategy for the Level I engineering course 'Engineering Mechanics: Statics' to facilitate student understanding. They have been developed as an integral part of the educational methodology of the author to promote active engagement and develop problem solving accuracy and efficiency. Examples of student and peer assessment are presented to indicate the impact of this teaching strategy on student understanding.*

Teaching Context

This paper presents a case study for the use of 'crash courses' as a teaching strategy by the author to improve student understanding for the Level I engineering course 'Engineering Mechanics: Statics' (hereafter denoted 'EMS'). The course is coordinated by the School of Civil, Environmental and Mining Engineering at the University of Adelaide.

EMS is presented to most Level I engineering degrees, which in 2009 exceeded 550 students. The course has an assumed knowledge of physics and mathematics and is based on Newtonian mechanics to analyse bodies under static equilibrium. It is a core civil engineering course and represents prerequisite material for several other courses. Therefore, a strong understanding is vital as it forms the building blocks of knowledge throughout the civil engineering degree. However, students study many different engineering disciplines, so some concepts in the syllabus may not be relevant later in their degrees. Hence, there is a need to develop the key graduate attributes of: (1) problem solving; (2) critical and independent thinking; and, (3) time management. In addition, teaching of large class sizes is often presented with the difficulties of: (1) engaging student interest; and, (2) facilitating interaction (e.g., AUTC, 2002; 2003; Iaria and Hubball, 2008).

As a result, the principles that form the basis of the teaching philosophy of the author are to improve student understanding and independence by:

1. Stimulating interest and increasing confidence in approaching challenging subject matter. This is achieved by promoting active participation, expressing analysis methods in simpler terms and highlighting links between topics; and,
2. Developing efficient problem solving skills to apply core principles to a range of problem types. This alleviates the desire to simply memorise solutions and develops a greater fundamental understanding of the course material and therefore engineering theory.

Teaching Strategy

Crash courses were developed as a teaching strategy by the author to: (1) develop the graduate attributes; (2) address the issues affecting large class sizes; and, (3) achieve the objectives of the teaching philosophy. This paper discusses the use and benefits of crash courses. Evidence of student and peer assessment of teaching is also provided to demonstrate the effectiveness of the teaching strategy in establishing student understanding.

What are crash courses?

Crash courses provide a concise explanation of the main theory at the start of the lecture, so that the more complicated theory can build on this later. They are delivered (e.g., using the document camera) before using the lecture slides to:

- promote active engagement in large class sizes;
- develop problem solving accuracy and efficiency (i.e., time management); and,
- improve student understanding.

Crash courses summarise and explain the key concepts of each lecture in a simplified manner to let students know what understanding they are working towards and why. Knowing the end point, the goal, of a lecture before the complex detail and discussion of a topic begins can preempt the sense of dislocation students can experience when introduced to unfamiliar concepts.

Most EMS topics are based on the assumed knowledge of previous topics. Hence, it is essential that students have a sound understanding of the initial theory before new material is presented. Therefore, crash courses re-establish the initial material that forms the building blocks of knowledge of the new material. Highlighting the links between topics and how they build on prior knowledge across the curriculum, allows students to envisage them as integral parts of a continuous learning process, not merely as isolated modules of theory. Crash courses stimulate interest by promoting active participation where students interact with questions. When delivered in conjunction with lecture slides (e.g., using the document camera) they vary the presentation style, which helps to focus attention and maintain concentration levels.

Crash courses consist of four main steps:

1. Highlight the goal of the topic and the main steps in the analysis, i.e., show the objective of a typical question using figures;
2. Where possible, indicate the links to previous topics (i.e., the building blocks of knowledge);
3. Summarise the new concepts used to solve problems; and,
4. Engage students in discussion through multiple choice questions and queries to encourage interaction and gauge understanding.

For example, a 50 minute lecture starts with a 5-10 minute discussion using the document camera to reiterate past content and summarise the new material to be presented. For the remainder of the lecture, the presentation screen alternates between the lecture slides and crash course. This clarifies the more complex concepts in the slides by comparing to their simpler representations in the crash course.

Crash course example

An example of a crash course is given as follows. Figure 1 (from a textbook) shows the typical slide used to start the lecture topic 'hydrostatics', while Figure 2 shows the simplified version used in a crash course to precede the introduction of Figure 1. Figure 1 shows a plate subjected to a water pressure, however it is complicated as it is in three dimensions, is submerged, and is oriented at an angle. As this represents a new concept to students, it will necessitate visualisation and interpretation of the complex figure, which may be difficult.

To remove this complexity, Figure 2 simplifies the theory by having a vertical plate shown in two dimensions, with a point of contact at the water level. The pressure distribution is now represented by a simpler shape (i.e., triangular, not trapezoidal). It also correlates to the previous topic of 'distributed loading', which establishes the building blocks of knowledge from the perspective of the student. Once the basic theory is established using the crash course, then the more complex example (Figure 1) can be discussed more easily.

Although Figure 2 was drawn electronically for demonstrative purposes, the actual crash courses are drawn free hand in real time during lectures. For most students, their first experience of these concepts will be seeing them in the crash course and then being actively involved by copying it themselves. This allows concepts to be introduced more effectively rather than students passively looking at prepared slides. It also demonstrates to students how a free body diagram (i.e., an isolated depiction of an object, showing all the forces acting on it) is effectively formulated and used.

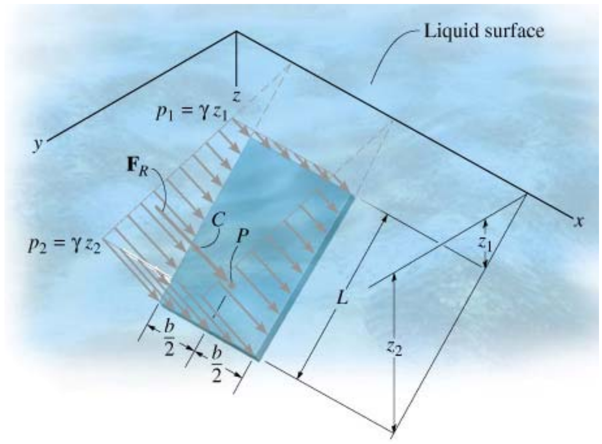
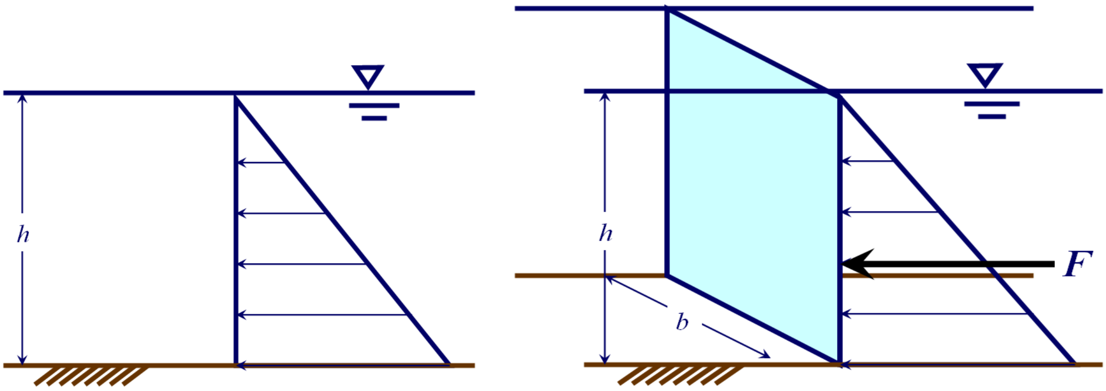


Figure 1: Initial hydrostatics slide from textbook (Hibbeler, 2007)



(a) (b)

Figure 2: Hydrostatics slides from crash course

For the above example, the details of the four main steps of the crash course are:

1. The determination of the magnitude and location of the hydrostatic force (i.e., created by the average water pressure acting over a surface area) forms the basis of the theory. This is shown diagrammatically in Figure 2a, where there is a linearly varying pressure distribution from the top water edge over the height, *h*. This pressure acts over a surface area measured into the page, given by the dimensions, height, *h*, and breadth, *b* (Figure 2b). The average pressure multiplied by the area creates a force, *F*, acting at the centroid of the pressure distribution.
2. Previous topics of distributed loading and centroids are essential in the development of the new material. The concepts that the magnitude and location of the resultant force are given by the area under the distributed loading diagram and the centroid, respectively, underpin the new topic.
3. The previous concept of distributed loading relates to a force per unit length, however for hydrostatics, the pressure is given as a force per unit area. This extra length dimension is given by the breadth, *b*, into the page. The other new concept is the calculation of the pressure, which is directly proportional to the height, *h*, and based on the fluid density.
4. Students ask questions to clarify the crash course before the lecture slides are presented. Multiple choice questions are included throughout the lecture slides to promote active engagement and survey student understanding. The short questions allow students to briefly discuss amongst themselves before answering by show of hands. This feedback is used to determine the level of detail concepts require for discussion in the lecture.

After the crash course is completed, the traditional lecture slides can be introduced. The more complex example (Figure 1) can then be discussed by relating it to the crash course, and key concepts can be reiterated throughout the lecture. Drawing these parallels between the presented materials can be very effective in establishing student understanding.

Why use crash courses?

The main benefits of using crash courses include:

1. Promotion of active engagement. Students interact and participate through multiple choice questions that monitor student understanding. Having students actively copy new material (e.g., using the document camera), reduces the passive nature of amending prepared copies of the lecture notes. In addition, the mix of media (e.g., document camera and slides) varies the presentation style to focus attention. This is important for large class sizes where strong engagement is essential to ensure successful learning.
2. Development of problem solving skills. The key objective of the academic is to develop students into engineers. Essentially, the core attribute of the engineer is problem solving, hence it is imperative to encourage this behaviour throughout the degree, especially from Level I. This promotes critical thinking and discourages rote learning. Each crash course highlights the goal of the topic and the tools available to solve the problem. More importantly, it demonstrates how to develop a plan for an effective solution, as the order in which equations are used can affect its efficiency. This is done with the objective of performing a self-check where possible.
3. Inclusive of all student backgrounds. Crash courses discuss general engineering concepts rather than technical details. By introducing concepts in simpler terms and avoiding technical 'jargon', the material becomes less dependent of the students' level of competence in physics or mathematics. This can be crucial for some students with English as their second language, so they can understand the background knowledge before applying it to numerical examples. This can also alleviate transition concerns for some students. The issue of transition difficulties for Level I students is discussed elsewhere (e.g., Falkner and Munro, 2009). To expedite learning, the formulation of crash courses should always consider the subject matter from the students' perspective, rather than an experienced academic.

Impact on learning

Student feedback

Representative examples of student testimonials supporting the use of crash courses include:

- *The crash courses in various Statics topics in our lectures lately have been very useful in understanding the concepts. Hearing a clearer version and briefly learning the topic again has helped me understand how to answer the questions. Thanks.*
- *Your crash courses both during new material and recapping old material were extremely helpful. Your revision of key points on 3D moments was very understandable and helpful. Thank you.*
- *Please keep up the crash courses; they are extremely helpful, and while in most cases so far I've understood how to get to the end result, and usually the correct answer, your crash courses help greatly in learning the correct paradigms for solving these problems. Learning the specific questions and tips/tricks, produces for me at least, a result that allows me to understand and complete the exam-type questions in a much more complete fashion, and in the end it also helps understand the overall content with decent worked examples. Thanks.*
- *Just a quick note to say that your crash courses have helped me a lot. I find your crash courses very useful and it has helped me understand many of the previous ideas. Thanks.*

Positive student evaluation on the teaching of the author has also been received via Student Experience of Learning and Teaching (SELT) surveys. Each SELT survey consists of seven quantitative questions to determine the level of agreement students have with statements describing attributes of the teacher. The results for the author are summarised in Table 1 and compared against the aggregate of the School average for all student levels for 2008. The difference between the results for the author and the School average are also indicated.

Questions 4 to 7 most closely relate to the crash course objectives of promoting active engagement and improving student understanding. In 2008, all results for the author were generally in excess of 90% broad agreement, despite the very large class size, which typically obtains lower SELT results. The results also compare extremely well to the School average for 2008. For all seven responses, the values of broad agreement for the author were 7 to 26% higher (this was further improved in 2009).

The highest difference was for 'clear explanations' where the School average was 70% broad agreement, while for the author it was 96%. The number of responses were 354 (2008) and 465 (2009), which varied greatly due to the rapid increase in class size. This gave a response rate for each survey (conducted at the end of the course) of approximately 80-85%, demonstrating high attendance and student retention.

Table 1: Summary of SELT results (% broad agreement)

	EMS (2009)	EMS (2008)	School Average (2008)	Difference (2008)
1	99	96	73	23
2	99	96	84	12
3	94	82	75	7
4	96	90	75	15
5	85	87	70	17
6	92	86	64	22
7	98	96	70	26

SELT Questions

1. All things considered, how would you rate the effectiveness of this person as a university teacher?
2. This person is well organised.
3. This person shows concern for students.
4. This person shows enthusiasm for encouraging student learning.
5. This person encourages student participation.
6. This person stimulates my interest in the course.
7. This person gives clear explanations.

The qualitative component of the teaching SELT results in 2008 and 2009 most frequently commented that the 'best aspect of the teaching' was the use of crash courses, indicating their effectiveness in developing a strong understanding of the course material. Other teaching aspects highlighted by students which further support the benefits of crash courses include:

- *good interaction and student participation;*
- *explanation of concepts in a logical, clear and concise manner;*
- *identification and reiteration of key difficult areas;*
- *connection of concepts between topics; and,*
- *encouragement of student understanding.*

Peer feedback

In 2009, an academic colleague attended a lecture for EMS to provide peer evaluation of teaching. The comments highlight the key objectives of crash courses as follows:

- *level of engagement was excellent;*
- *clear descriptions;*
- *good practice reminders (stress the need and way to make checks);*
- *tied in this topic with previous ones;*
- *maintained good control; and,*
- *working through an example shows the method very clearly.*

Summary

This paper discusses the use of crash courses as a teaching strategy to develop a greater fundamental understanding by students. The main benefits include: (1) promotion of active engagement; (2) development of problem solving skills; and, (3) inclusive of all student backgrounds. The main steps include: (1) highlight the goal of the topic; (2) show the links to previous topics (where possible); (3) summarise the new concepts used to solve problems, and, (4) engage students in discussion through multiple choice questions and queries. Positive student and peer feedback strongly supports the use of this teaching strategy. For the case study reported in this paper, the use of crash courses has been applied to a numerically based case. However, it is proposed that this teaching strategy has general applicability and could be extended to other course types.

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Acknowledgements

The author gratefully acknowledges the guidance of Dr. Katrina Falkner, and the financial support of the School of Civil, Environmental and Mining Engineering. The conclusions and opinions expressed in this paper are those of the author and not necessarily those of the School of Civil, Environmental and Mining Engineering.