The Use of Study Guides to Improve Learning Outcomes in Engineering Fluid Mechanics and Hydraulics

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***Abstract**: Fluid Mechanics and Hydraulics is a second year core course within the Bachelor of Engineering program at Griffith University. A range of resources has been provided to students enrolled at the Griffith campus, which has included copies of lecture slides, a study guide plus a quick study guide. This paper describes the development of the two different study guides adopted in the course. An investigation into the efficacy of the study guides to improve student learning was undertaken. This included a survey of student perceptions of the study guide effectiveness at the end of the teaching semester. The survey showed that students felt that the study guide was clearly organised and that the study guides were effective in helping them to learn the material covered in the course. The study also shows that the study guides provide a means for supporting active learning strategies for students within the course.*

Introduction

The course Fluid Mechanics and Hydraulics is designed to introduce students to the fundamental engineering science concepts related to the mechanics of fluids. This includes fluid statics, fluid dynamics, fluid compressibility, fluid viscosity and turbulence, introduction to flow around submerged objects, open channel flow, flow in closed conduits, pumps and pumping. The aim of this course is to provide students with an understanding of the basic principles of fluid mechanics and of their application to civil, environmental and energy systems engineering problems. There is a strong focus on water in the course as taught at the Griffith campus, as this is one of the most important fluids for Civil Engineering practice. This is delivered as a core course within the second year of the Bachelor of Engineering (Civil) program at the Griffith campus, and there is a strong emphasis on helping students to develop their problem solving and problem communication skills.

As the first of the fundamental courses in water engineering, this course forms the basis for subsequent courses such as Hydrology, Introduction to Coastal Engineering and Water Resources Engineering. The course is designed to allow students to further develop the skills necessary for the analysis and design of hydraulic structures in civil, coastal and environmental engineering. Fluid Mechanics and Hydraulics has a strong emphasis on introducing students to the fundamental concepts of fluid statics and fluid flow, which underpins the curriculum.

The learning objectives specified for this course identify that after successfully completing this course, students should be able to:

- Demonstrate understanding of the basic principles of fluid mechanics including fluid statics, kinematics and dynamics;
- Demonstrate the knowledge of the basic methods in analysing various flow phenomena including the application of dimensional analysis;
- Apply analytical methods to the solution of typical hydraulic engineering problems such as flow in pipes and open channels;
- Follow appropriate procedures to carry out and report on laboratory activities.

The course is structured around the delivery of two weekly lecture sessions, an extended weekly tutorial session plus four laboratory sessions distributed throughout the semester. The total contact time allocated for the course was 72 hours delivered over the 13 week semester. 172 students enrolled in this course during semester 1 of 2010, with 71.3% of students successfully completing all of the assessment requirements. The course structure is designed to provide a balance between a formal teaching environment and an independent student learning environment. The formal teaching is delivered through more teacher centred lecture sessions, whilst the independent student learning centres on weekly exercise problems supported by formal tutorials and laboratory sessions.

To help students develop their own independent learning, this course has adopted the use of a Study Guide and a Quick Study Guide, which are linked to the weekly lecture sessions. This paper provides a description of the study guides that were implemented as part of the Fluid Mechanics and Hydraulics course taught at the Griffith campus of the Griffith School of Engineering. A student survey of the effectiveness of the study guides is also presented.

The Role of Study Guides

The teaching philosophy adopted in the delivery of the Fluid Mechanics and Hydraulics course at the Griffith School of Engineering is built on the presumption that learning is an active process within a supportive and nurturing environment. The role of the teacher is to facilitate learning through the development and implementation of a curriculum of study. This curriculum is built around a framework that focuses on the communication of ideas and concepts. Central to the development of this curriculum are the learning objectives which define the learning outcomes for students, and it is important that these objectives are clearly articulated in a language that the students understand. In this way the students are better able to become active with the learning experience. All of the learning resources must be designed to support the student in the development of this student-focussed learning environment. Study guides provide a key element in linking these resources so that students can focus on what is important to their learning.

Conderman and Bresnahan (2010) note that *"study guides support students in learning their material, focus their attention on important topics and help them review for quizzes and tests"*. Study guides help students determine how important specific pieces of information are compared to other information provided in the course. So that study guides provide information in a way that helps students to undertake their own personal study (Conderman and Bresnahan, 2010). More importantly, Khogali *et al.* (2006) identify that study guides help students to *"manage their own learning"*. This is a key educational requirement when developing student-focussed learning environments. Study guides are also identified by Tincani (2004) as one of the ten strategies for increasing academic success of students with disabilities.

Khogali *et al.* (2006) identify that study guides can use a range of formats and that it is not possible to produce a rigid prescription for either the content or format of the material presented. However, it is identified by Holsgrove *et al.* (1998) that students may not even bother to read study guides which are unattractive or poorly compiled. Furthermore, study guides can be developed as either formative or summative, depending on whether they provide information on the concepts covered in the course or on the number and types of questions that will be assessed as part of the course assessment.

The Fluid Mechanics Study Guides

The Fluid Mechanics and Hydraulics course taught within the Bachelor of Engineering program in the Griffith School of Engineering has a strong focus on the application of mathematical theory to

engineering fluid problems. The relevant fluid mechanics and hydraulics theory is developed throughout the lecture sessions within the course to support this application. The lecture sessions also provide appropriate strategies to be adopted when applying this theory to the solution of engineering problems, as well as numerous example applications. The fluid mechanics and hydraulics theory is developed and applied in line with the information provided in the prescribed textbook for this course. Therefore, there is a need for students to combine information provided in the lecture sessions with that from the textbook and then synthesise this information to the solution of "real world" engineering problems. To help facilitate this process, two different styles of study guide have been developed and provided to students at the beginning of the semester of study.

The first style of study guide adopted in this course, defined here as the Study Guide, is divided into twelve modules, each of which matches the material covered in each of the formal lectures. The Study Guide was provided in a digital format on the Learning@Griffith web site for the course at the beginning of the semester. Each module includes the following:

- A descriptive introduction to the specific topic;
- A definition of the specific learning outcomes for the module of study, which are defined so that students should be able to explicitly measure their performance at the completion of the module;
- An identification of the important aspects covered in each module of study;
- Directions to the relevant chapter of the text; and
- A set of exercise problems, with numerical answer provided. A separate document with worked solutions to most of the problems was also provided at the beginning of the semester, in a digital format on the Learning@Griffith web site for the course.

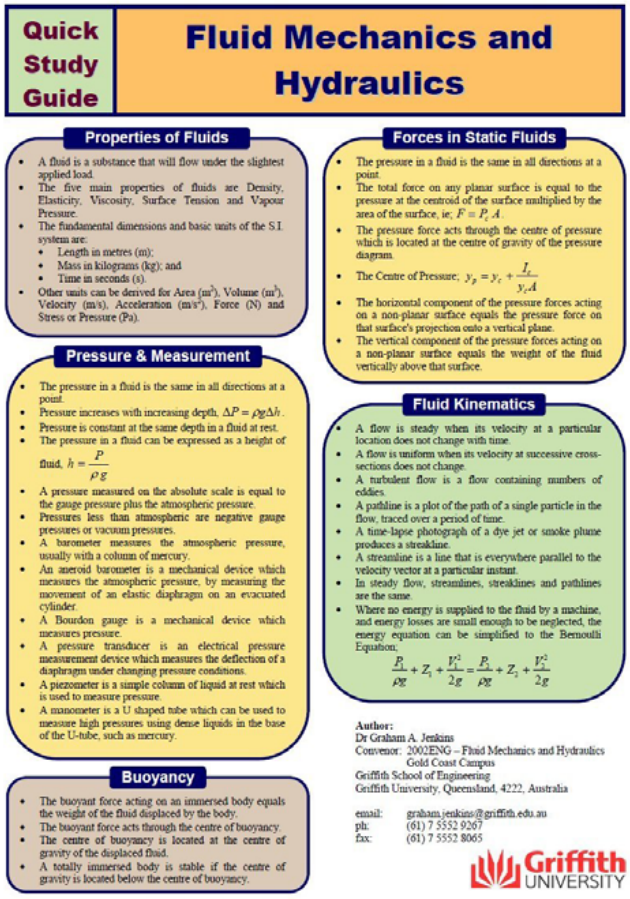

Figure 1: Layout of information on the Quick Study Guide

The second style of study guide is defined here as the Quick Study Guide, which was provided to students as a double-sided and folded A3 hard-copy colour sheet. The Quick Study Guide was handed out to students at the beginning of the semester of study during the first lecture session. A digital copy

of the Quick Study Guide was also provided for download from the Learning@Griffith web site for the course. The Quick Study Guide was arranged as a set of boxed topics, as shown in Figure 1, each of which provided a discussion of the important information relevant to each of the topics covered in the weekly teaching sessions. The information provided in the Quick Study Guide was taken directly from the important aspects provided in the Study Guide.

As noted by Holsgrove *et al.* (1998), the structure adopted for both the Study Guide and Quick Study Guide encourages students to prepare for the more formal teaching and learning sessions *"...by spending just a few minutes reading through the objectives and briefly revising the main points of previous learning..."*. Furthermore, the aim of the Study Guide is to provide a mixture of functions including "*provision of content information*", "*management of learning*" and "*student activities*", as described by Harden *et al.* (1999). This is facilitated by including the exercise problems within each module of the Study Guide. Students are encouraged to undertake these exercise problems as part of their independent learning in the course. These exercise problems then form the focus of the small class tutorial sessions. It is in these tutorials where students are more able to interact with the teaching staff to help them develop their knowledge of the basic principles of fluid mechanics and hydraulics, as well as develop their problem solving skills.

Student Perceptions of the Study Guides

An investigation of student perceptions of both the Study Guide and the Quick Study Guide was undertaken using a two page questionnaire. The survey was undertaken during the lecture session in the second last week of the semester of study. The first page of the questionnaire included questions regarding student perceptions of the Quick Study Guide, whilst the second page included questions on the Study Guide.

A front cover sheet to the survey document was also included so that all participants in the survey were fully informed about the nature and ethical conduct of the research being undertaken. The survey participants were asked to identify their response to eight (8) statements or questions relating to each of the Quick Study Guide and the Study Guide by selecting one of the check boxes adjacent to the statement or question. The statements or questions related to the layout of the guides, the organisation of the material, the presentation of the guides, whether or not the guides helped the student to learn the material in the course, whether or not the exercise problems helped the student to learn the material in the course, how often the student referred to each of the guides and the most important information presented in the guides.

Analysis of Student Reponses

The student responses to the surveys of both the Quick Study Guide and the Study Guide were collated and analysed to gauge the students' perceptions of the effectiveness of the study guides as teaching resources in the engineering fluid mechanics and hydraulics course. 101 valid responses were received for the Quick Study Guide survey form, whilst only 97 valid responses were received for the Study Guide survey form. The full set of questions/statements and student responses to each of the questionnaires are shown below in tables 1 and 2.

The results for the Quick Study Guide indicate that the majority of the students believed that the Quick Study Guide was easy to understand and was logically organised. The students also indicated that the different colours adopted in the Quick Study Guide made the information easy to follow, and the amount of information provided was acceptable. In contrast, only 59% of students believed that the Quick Study Guide helped them to learn the material covered in the course. This indicates that although the Quick Study Guide was well organised, with an appropriate amount of information, it was not particularly useful in helping students to learn the material covered.

Fifty-one percent (51%) of the students found the Quick Study Guide useful when undertaking more than one of the activities listed. However, it is of concern that 10% of the students surveyed did not find the Quick Study Guide useful for any of the activities. Although the Quick Study Guide was identified as being most helpful when undertaking assignments, many students also identified tutorials and tests. There was a relatively uniform distribution in the number of times students referred to the Quick Study Guide, with 96% of the students referring to it at some time during the course of their

study. A significantly large proportion of the students also identified "*Important Formulae*" as the most important information presented in the Quick Study Guide.

Table 1: Student responses to the Quick Study Guide survey questions

Question/Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. The layout is easy to understand.	1%	2%	10%	56%	31%
2. The information provided is logically organised.	2%	1%	15%	53%	29%
3. The different colours adopted make the information easy to follow.	1%	6%	21%	45%	28%
4. The information provided helped me to learn the material covered.	3%	8%	30%	39%	20%
5. The Quick Study Guide provides too much information.	11%	62%	18%	8%	1%
	Tutorials	Assignments	Tests & Exams	Nil	
6. The Quick Study Guide helped me when undertaking:	50%	71%	48%	10%	
	> 13 Times	> 9 Times	> 6 Times	> 3 Times	Never
7. How many times did you refer to the Quick Study Guide during the semester?	19%	22%	29%	27%	4%
	Important Formulae	Diagrams	Application of Theory	Description of Theory	Other
8. The most important information presented is:	83%	29%	33%	39%	0%

Table 2: Student responses to the Study Guide survey questions

Question/Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
1. The layout is easy to understand.	0%	2%	14%	59%	25%		
2. The information in each of the modules is logically organised.	0%	1%	13%	55%	31%		
3. The information provided helped me to learn the material.	0%	4%	18%	48%	30%		
4. The exercise problems helped me to learn the material covered.	1%	3%	14%	37%	44%		
5. The Learning Outcomes made it clear what I needed to learn.	1%	5%	22%	46%	26%		
	Tutorials	Assignments	Tests & Exams	Nil			
6. The Study Guide helped me when undertaking:	69%	74%	78%	3%			
	> 13 Times	> 9 Times	> 6 Times	> 3 Times	Never		
7. How many times did you refer to the Study Guide during the semester?	40%	26%	23%	10%	1%		
	Important Formulae	Diagrams	Application of Theory	Description of Theory	Learning Outcomes	Exercise Problems	Other
8. The most important information presented is:	72%	53%	55%	40%	32%	79%	1%

The results for the Study Guide indicate that the majority of the students believed that the Study Guide was easy to understand and was logically organised. Seventy-eight percent (78%) of students believed that the information provided in each of the modules in the Study Guide helped them to learn the material covered in the course. A similar proportion of students surveyed also identified that the exercise problems helped them to learn the material covered. This indicates that students value appropriately selected exercise problems as a way of developing their understanding of such a mathematically oriented course. However, it may be that students are conditioned to expect this type of learning environment through the traditional engineering education system. However, the answer to this question is beyond the scope of this current study.

Seventy-nine percent (79%) of the students found the Quick Study Guide useful when undertaking more than one of the activities listed. However, in comparison with the Quick Study Guide, only 4% of the students surveyed did not find the Study Guide useful for any of the activities listed. It also appears that the Study Guide was helpful to a significant proportion of students when undertaking tests, assignments, as well as tutorials. Unlike the results for the Quick Study Guide, 40% of the students surveyed referred to the Study Guide at least once each week during the semester, with 99% of the students referring to the Study Guide at some time during the course of their study during the semester. A significantly large proportion of the students also identified "*Exercise Problems*" as the most important information presented in the Study Guide. It is also important to note that 79% believed that the important information in the Study Guide included more than one of the items identified in the questionnaire.

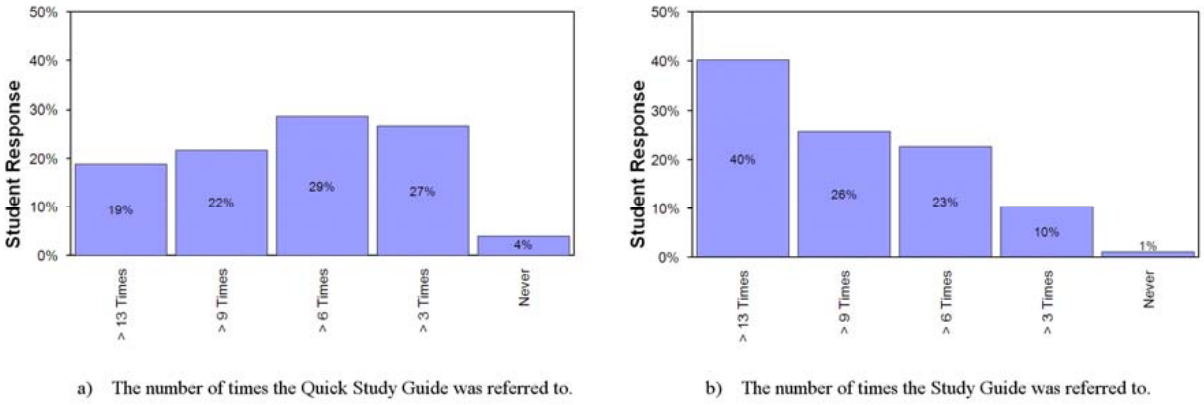

Figure 2: Student usage of the different study guides

Although the majority of students surveyed believed that the Quick Study Guide helped them to learn the material covered in the course, this belief was not universal with more than 40% being either neutral or did not believe that this was the case. In contrast, only 22% of the students surveyed believed that the Study Guide did not help them to learn the material covered in the course. It appears that students mostly referred to the Quick Study Guide to help them remember important formulae that they needed when undertaking the assignments. The five (5) assignments were spaced approximately every second week, which explains why there was a relatively diverse response relating to how often students referred to the Quick Study Guide, with a slight maximum at approximately every second week, as shown in Figure 2. It appears that students referred to the Study Guide as part of their weekly study practice, which is to be expected as the Study Guide included exercise problems that were covered in each of the weekly tutorial sessions. In this case, 81% of the students surveyed identified that the exercise problems helped them to learn the material covered in the course.

The results of the student survey indicate that summative assessment is an important driver for many students in the management of their learning. The Study Guide appears to be an ideal resource for students when undertaking this summative assessment. However, the only assessment within the Fluid Mechanics and Hydraulics course at the Griffith School of Engineering is summative. The

tutorial sessions held each week are designed to provide formative assessment to the students, but this is not formalised in any way, with participation in these tutorials being voluntary.

There appears to be a strong need for the inclusion of a more formal approach to the provision of formative assessment within the Study Guide format. It is also felt by the authors that any formative assessment must be structured in such a way that encourages students to take ownership of their own learning, rather than relying purely on a teacher focussed process. Therefore, future versions of the Study Guide will include a self assessment component within each of the modules of study. This will include a set of either single answer or multiple choice problems with answers provided through the Learning@Griffith web site for the course. Students will be encouraged to undertake the self assessment as part of their regular independent study for the course. The answers provided on the Learning@Griffith web site will also include guidance for students to assess their level of achievement against the defined learning outcomes for each module of study.

Conclusions

The course Fluid Mechanics and Hydraulics is designed to introduce students to the fundamental engineering science concepts related to the mechanics of fluids. The aim of this course is to provide students with an understanding of the basic principles of fluid mechanics and of their application to civil, environmental and energy systems engineering problems. This is delivered as a core course within the second year of the Bachelor of Engineering (Civil) program at the Griffith campus.

To help students develop their own independent learning, this course has adopted the use of a Study Guide and a Quick Study Guide, which are linked to the weekly lecture sessions. This paper provides a description of the study guides that were implemented as part of the Fluid Mechanics and Hydraulics course taught at the Griffith campus of the Griffith School of Engineering. A student survey of the effectiveness of the study guides is also presented. The results of the student survey indicate that summative assessment is an important driver for many students in the management of their learning. The Study Guide appears to be an ideal resource for students when undertaking this summative assessment. However, there appears to be a strong need for the inclusion of a more formal approach to the provision of formative assessment within the Study Guide using a self assessment component within each of the modules of study.

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