

DEVELOPMENT OF A CONCEPT INVENTORY FOR FLUID MECHANICS

Jay Martin¹, John Mitchell², and Ty Newell³

Abstract - Concept inventories are assessment tools designed to determine the degree to which students understand the concepts of a subject and to identify the misconceptions that students hold. The results of a concept inventory can be used to change the methods of instruction to overcome student misconceptions. A cooperative effort between Mechanical Engineering faculty at the Universities of Wisconsin-Madison and Illinois, Champaign-Urbana has been directed toward development of a Fluid Mechanics Concept Inventory (FMCI). Fluid mechanics typically follows thermodynamics in the sequence of courses in thermal sciences, involves both the mechanics and dynamics of fluids, and builds on basic physics and Newtonian mechanics. This paper describes the process used for development of the FMCI, the details of how we determined the content, and examples of actual content of the instrument itself.

Index Terms - Concept inventories, Fluid Mechanics, Assessment

INTRODUCTION

Fluid mechanics is studied in many different disciplines. For example, in basic physics taught to freshmen and sophomores, a fluid is described, and pressure and density are defined. Hydrostatics is developed by taking into account the force on a static fluid element under the influence of gravity, followed by consideration of manometers and barometers. Fluid dynamics as introduced in basic physics includes conservation of momentum or the equation of continuity, Bernoulli's equation and ideas such as lift and thrust[1]. This is followed in many disciplines in engineering, and many of the natural sciences, with additional study of fluid mechanics.

Following the example of Hestenes and the Force Concept Inventory (FCI) [2], a cooperative effort of faculty at the University of Illinois, Champaign-Urbana and the University of Wisconsin-Madison has been aimed at development of a concept inventory in fluid mechanics. The Fluid Mechanics Concept Inventory or FMCI described here is aimed for use in assessment of Mechanical Engineering students who have or will be taking a course in fluid mechanics in Mechanical Engineering.

To begin the development, the first step was identification of the fluid mechanics concepts that were considered to be essential knowledge by Mechanical

Engineering students having completed an undergraduate fluid mechanics course in Mechanical Engineering. The identification of concepts was initially done by experienced faculty and completed prior to writing individual questions. Once the concepts were identified, then multiple questions were written for each of the concepts, allowing for validation [3].

Following the lead of Kraus and other work on the development of a heat transfer concept inventory, students have been utilized in the development of the FMCI [4-5]. They were used in the identification of concepts and misconceptions, in the evaluation and development of questions used on the FMCI, and in the answers to the questions, assisting in the identification of key false positive answers (typically resulting from common misconceptions.)

IDENTIFICATION OF CONCEPTS

Identification of key concepts in fluid mechanics was, and is, considerably more difficult than would have been required for the Force Concept Inventory (FCI). Fluid mechanics, like other engineering subjects, does not have the same kind of readily identifiable model as the FCI, and is a combination of a large number of somewhat disparate concepts.

The list of concepts developed by the faculty is shown in Table I. Concepts identified begin with the basic concepts used in fluid mechanics, such as fluid properties and identification of boundaries and boundary effects. Concept identification places dimensional analysis and similarity in basic concepts. Fundamental fluid relations include conservation of mass and momentum. Specific terms in the equations defining conservation of mass and momentum were identified. Finally, there is a list of special topics that could be included in a FMCI depending on the discipline where the FMCI was used.

As shown in Table I, there are 3 principal areas that together comprise approximately 25 different concepts. This means that a concept inventory that had multiple questions on each of the concepts would be at least 50 questions, although it might be preferable to have 75 questions. An inventory of 75 questions is likely too long, and so it is possible that for any given application of the FMCI, a reduced set of questions will need to be used, or the number of concepts assessed will need to be reconsidered.

¹ Jay Martin, University of Wisconsin-Madison, Mechanical Engineering, 306 MBE 1513 University Ave., Madison, WI 53706 martin@engr.wisc.edu

² John Mitchell, University of Wisconsin-Madison, mitchell@engr.wisc.edu

³ Ty Newell, University of Illinois, Champaign-Urbana, t-newell@uiuc.edu

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