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AN EXPERIMENT ON FLUID MECHANICS IN A VIRTUAL-REALITY

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ABSTRACT: Physical sub-areas are mathematically studied in several disciplines of study to provide students the skills they need for professional optimization. This frequently results in a lack of awareness regarding the bodily relationships. Since significant quantities in the mathematical formulation cannot be seen in experiments (or can only be seen with much effort), practical experiments are frequently inappropriate for providing explanation. These amounts may be shown through numerical computations, but pupils are unable to perform them on their own. Thus, UNREAL ENGINE 4 is used to construct a virtual environment for fluid mechanics. This enables the students to influence the flow in order to experience and examine the basic physical effects. Hence by using this method self assessment and efficient result are shown.

KEYWORDS: Visualization Techniques, Virtual Reality, Virtual Laboratory, Fluid Mechanics, Fictitious Domain, Immersive Learning

I. INTRODUCTION

Fluid mechanics is the study of the behaviour of liquids and gases, and particularly the forces that they produce. Many scientific disciplines have an interest in fluid mechanics. For example, meteorologists try to predict the motion of the fluid atmosphere swirling around the planet so that they can forecast the weather. Physicists study the flow of extremely high temperature gases through magnetic fields in a search for an acceptable method of harnessing the energy of nuclear fusion reactions. Engineers are interested in fluid mechanics because of the forces that are produced by fluids and which can be used for practical purposes [1]. Some of the well-known examples are jet propulsion, aerofoil design, wind turbines and hydraulic brakes, but there are also applications which receive less attention such as the design of mechanical heart valves.

The purpose of this chapter is to teach you the fundamentals of engineering fluid mechanics in a very general manner so that you can understand the way that forces are produced and transmitted by fluids that are, first, essentially at rest and, second, in motion.

The fluid mechanics study involve many fields that have no clear boundaries between them. Researchers distinguish between orderly flow and chaotic flow as the laminar flow and the turbulent flow. The fluid mechanics can also be distinguish between a single phase flow and multiphase flow (flow made more than one phase or single distinguishable material) [2]. The last boundary (as all the boundaries in fluid mechanics) isn't sharp because fluid can go through a phase change (condensation or evaporation) in the middle or during the flow and switch from a single phase flow to a multi phase flow. Moreover, flow with two phases (or materials) can be treated as a single phase (for example, air with dust particle).

After it was made clear that the boundaries of fluid mechanics aren't sharp, the study must make arbitrary boundaries between fields. Then the dimensional analysis can be used explain why in certain cases one distinguish area/principle is more relevant than the other and some effects can be neglected. Or, when a general model is need because more parameters are effecting the situation. It is this author's personal experience that the knowledge and ability to know in what area the situation lay is one of the main problems.

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For example, engineers in software company) analyzed a flow of a complete still liquid assuming a complex turbulent flow model. Such absurd analysis are common among engineers who do not know which model can be applied. Thus, one of the main goals of this book is to explain what model should be applied. Before dealing with the boundaries, the simplified private cases must be explained [3].

There are two main approaches of presenting an introduction of fluid mechanics materials. The first approach introduces the fluid kinematic and then the basic governing equations, to be followed by stability, turbulence, boundary layer. The second approach deals with the Integral Analysis to be followed with Differential Analysis, and continue with Empirical Analysis. These two approaches pose a dilemma to anyone who writes an introductory book for the fluid mechanics. These two approaches have justifications and positive points [4]. This attempts to find a hybrid approach in which the kinematic is presented first (aside to standard initial four chapters) follow by Integral analysis and continued by Differential analysis. The ideal flow (frictionless flow) should be expanded compared to the regular treatment.

Many influences of fluid mechanics are found in daily life like a flying bird or a curled shot of a football. Students in many engineering fields have to learn the basics of physics of flowing media. Nevertheless, fluid mechanics is a quite complicated field of physics; therefore, it is also related to applied mathematics. For engineers, physical laws are treated mathematically in order to allow calculations for optimizations [5]. For an uncomplicated explanation of the physical background, schematic representations are used in textbooks or classic blackboard lectures. However, these depictions have the disadvantage of projecting reality onto a surface. The transition from three-dimensional to two-dimensional visualization inevitably increases the information density. This also inevitably reduces the accessibility and clarity of the problem considered. In addition, visualization of temporal changes ishardly feasible. It reveals the complexity of the depictions for the simple case of a flow around a moving cylinder from a typical textbook for engineers [6]. Ideally, at the beginning of their studies in fluid mechanics, students should get basic ideas about the behavior of flows. Thus, the mathematical treatment of flows in teaching does not fail due to representation-related physical imagination difficulties.

II. LITERATURE SURVEY

S. Xuejing, et.al [7] development and research of the test system has always been a significant aspect in the education reform. The online examination system is a hot project in recent years. Based on VB6.0 and Access Database, this article provides us a general description of the exam system for Thermodynamics, heat Transfer and fluid mechanics. A detailed elaboration on the main functions of the examination system has been given and the overall designing plan of the system has been proposed, and main modules and database of the system has been designed in details. The examination system provides an efficient means of evaluating the education and plays a significant role in promoting the socialization and modernization of education. The project of constructing the system, as proposed in the paper, can be widely applied to the online education too.

C. Zhu and Z. Hao,et.al [8] Based on the neural network method, a neural network model for comprehensive evaluation of teaching levels in fluid mechanics is built

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because the classic statistics method and static model can not meet the demand of precision to the nonlinear and uncertain system. The structure of the neural network model is described. The model is trained with fifty samples and tested with twenty samples. The test results agree well with the actual situation ,showing that the model is effective in evaluating the teaching levels.

L. Liu, J. Mynderse, R. Fletcher and A. Gerhart, et.al [9] Problem-based learning and entrepreneurially minded learning modules have been developed to include fluid power concepts into undergraduate Mechanical Engineering core courses Thermodynamics and Fluid Mechanics. Modules in Thermodynamics focus on pneumatics and modules in Fluid Mechanics focus on hydraulics. The purpose of this work is to assess the created modules for student awareness of fluid power, knowledge of fluid power concepts, and growth in the entrepreneurial mindset. Both direct and indirect methods were used for assessment. Assessment results indicate that students applied fluid power concepts that are traditionally not covered in these courses. Student surveys also indicate that students demonstrated sample behaviors associated with the entrepreneurial mindset, as defined by the Kern Entrepreneurial Engineering Network framework.

D. Budny, F. Kremm and J. Nolan-Kremm, et.al [10] fluid labs were built during a time period where universities had space for large facilities that included flumes, wind tunnels, pump stations, wet wells, etc. Today these labs are out dated and the need for lab space is forcing the closing of large scale labs. This same basic problem exists within the Engineering School at the University of Pittsburgh, thus over the past years we took on the task of removing all the old equipment and replacing it with small bench top scale experiments. This paper will describe the concepts behind the design of the experiments as a result of moving from a few large experiments to a large number of small scale experiments.

S. S. Ain Binti Fadhil, M. Fairuz Bin Abdul Jalal and N. B. Anuar, et.al [11] principle could be further understood by performing practical analysis. Laboratory courses provide the practical application of the principle taught in lecture. Previously, laboratory courses were conducted through instruction style but with the evolving learning method, new learning method which emphasize on in-depth learning is introduced. This paper studies the effectiveness of open-ended learning method over the traditional method. The effectiveness of the activity is made through response from questionnaire and observation of both learning methods. It was noted that the open-ended method improves the students' understanding on the course, promotes collaborative learning, encourages creativity and innovative skills, independent thought, and communication skill. The students prefer the open-ended learning method over the traditional learning method.

N. S. Hageman, D. W. Shattuck, K. Narr and A. W. Toga *et al.*, [12] introduce a method for estimating regional connectivity in diffusion tensor magnetic resonance imaging (DT-MRI) based on a fluid mechanics model. We customize the Navier-Stokes equations to include information from the diffusion tensor and simulate an artificial fluid flow. The velocity vector field of this fluid construct is then used as a connectivity metric. We generate probable connection paths by maximizing the fluid velocity along a path between two regions of interest while constraining its bending energy. Our method is based on a second-order nonlinear Partial Differential Equation (PDE) and incorporates local anisotropy and similarity measurements into a viscosity term, which extends previous linear first-order methods. We tested our algorithm on a digital DTI phantom. Our method was able to correctly segment the structure of the phantom with various levels of noise, despite local distortion of the image pattern. We applied our method to DTI volumes from a normal human subject. Seed points were chosen along the corticospinal tracts, white matter regions with well-known connectivity. Our method produced paths that were consistent with both known anatomy and directionally encoded color (DEC) images of the DTI volumes. Applying our method to a digital phantom that simulates discrete white matter lesions, we also demonstrate that the fluid velocity field around areas of simulated localized white matter disruption becomes dampened and turbulent compared to the heat flow field from a first order PDE method. This provides a means for identifying lesion position from the fluid velocity field.

Xuehui Chen, Liang Wei, Jizhe Sui, Xiaoliang Zhang and Liancun Zheng, et.al [13] generalized differential transform method is implemented for solving several linear fractional partial differential equations arising in fluid mechanics. This method is based on the two-dimensional differential transform method (DTM) and generalized Taylor's formula. Numerical illustrations of the time-fractional diffusion equation and the time-fractional wave equation are investigated to demonstrate the effectiveness of this method. Results obtained by using the scheme presented here agree well with the analytical solutions and the numerical results presented elsewhere. The results reveal the method is feasible and convenient for handling approximate solutions of linear or nonlinear fractional partial differential equations.

M. K. Mitkova, A. R. Ansari and A. M. Siddiqui, et.al [14] Two-layer Couette flow of a third grade fluid is studied. Optimal Homotopy Asymptotic Method is used to find solutions of coupled nonlinear differential equations governing the motion of two immiscible layers of fluids with equal thickness. The solution expressions are used to model the flow and to illustrate the effect of variable material constants on the fluids' motion.

B. Lorendeau, Y. Fournier and A. Ribes, et.al [15] Numerical simulations using supercomputers are producing an increasingly larger volume of data to be visualized. In this context, Catalyst is a prototype In-Situ visualization library developed by Kitware to help reduce the data post-treatment overhead. On the other side, Code Saturne is a Computational Fluid Dynamics code used at Eléctricité de France (EDF), one of the biggest electricity producers in Europe, for its large scale numerical simulations. In this article we present a study case where Catalyst is integrated into Code Saturne. We evaluate the feasibility and performance of this integration by running two test cases in one of our corporate supercomputers.

III. METHODOLOGY

It takes a lot of equipment, including a perfused item, a pump, a flow medium, and a way to see the flow, to see flows. Simple findings, such a visual representation of the fluid flow, are only achievable in the absence of sophisticated measurement equipment. Tracers, often shell limestone or aluminum tinsel, can be added to liquids to improve vision. But since the tracer particles obscure one another, information on the motion of the visible particles can only be obtained on the uppermost surface of the tracer layer.

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Thus, the tracers' movement provides an impression of the streamlines and, consequently, the direction of the current flow. But an inexperienced observer, such as first-year students, would barely be able to identify the true flow behavior. As a result, the physical reasons for the flow behavior are still unclear. the water's movement via a sectoral leap. For visual aid, a rheoscopic liquid is used to mark the water.

The impact of the use of VR on teaching is also investigated for flow visualization. Many students have difficulties to differentiate between the three main visualization methods (pathline, streamline and streakline), because differences are only visible for instationary flows. This is hardly presentable in a book and also difficult to understand in a video, because a student cannot interact and change any configuration to check his understanding. To overcome these limitations, a cross-shaped flow domain with four openings is developed, as shown in Fig. 1. At any time the user can close each opening or set it to flow in or out. This results in possible combinations of flow fields, which can be reduced to one static flow field and elementary flow fields, from which all others can be obtained by rotation and mirroring. The user can insert particles individually (pathline) or permanently (streakline) at one spatial point, as well as viewing the corresponding velocity and pressure fields. This results in visualizations for pathlines, streamlines and streaklines. A change of the openings affects the lines differently and thereby reveals the differences between the three methods of flow visualization.

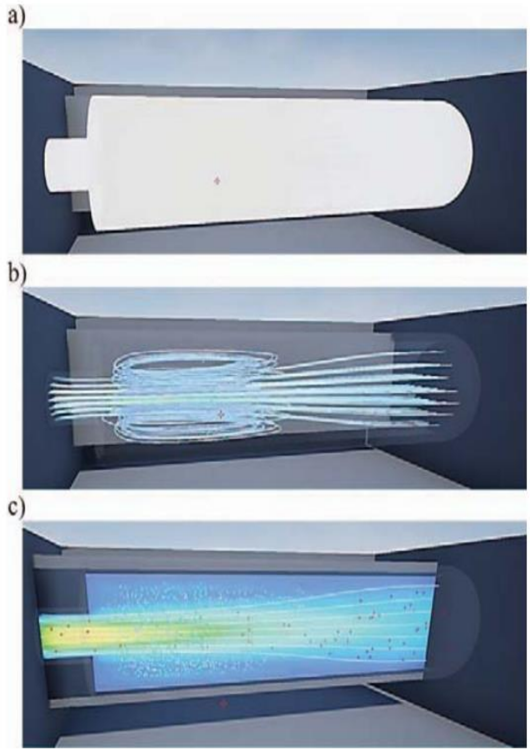

Fig.1: Flow through a pipe with a sectorial jump in virtual reality; a) geometry of the solid pipe b) streamlines and particles inside the pipe c) velocity field inside the pipe.

IV. RESULT ANALYSIS

In this result analysis fluid mechanics is observed in this section.

Table.1: Performance Analysis

Parameters	VR	SIMPLEC
Self-Assessment	81	90
Accurate	95	87

In Fig.2 self-Assessment comparision graph is observed between VR and SIMPLEC.

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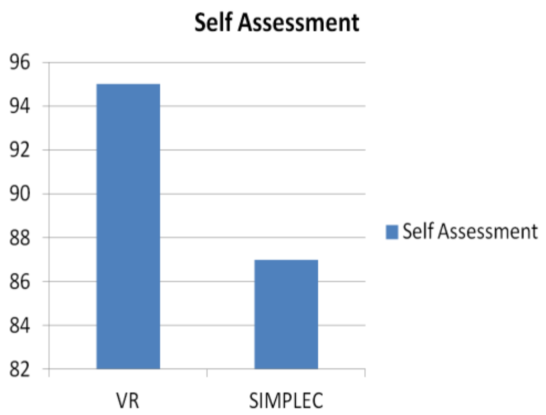

Fig.2: Self-Assessment Comparison Graph

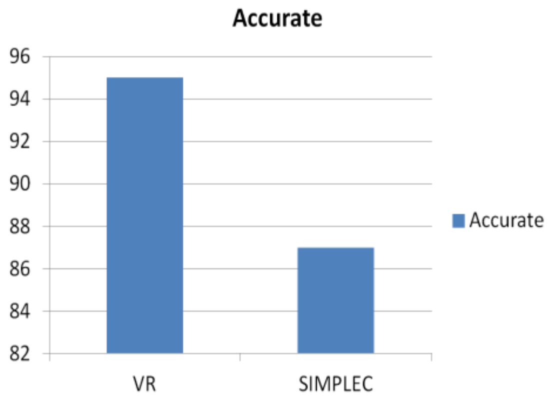

Fig.3: Accurate Comparison Graph

In Fig.3 accurate comparison graph is observed between VR and SIMPLEC.

V. CONCLUSION

This made a virtual world where the player's individual activities may affect the flow of the environment. As a result, in addition to the motion of particles inside a flow, velocity fields, pressure fields, and visualization forms like streamlines may also be shown. Different influence possibilities were created: The flow can be influenced by a variation of the pressure gradient and by choosing the functionality of a section between wall, inlet, and outlet. The differential balancing of the forces can be carried out at any point of the flow. Using the environment in the exercise leads to a significant increase in the learning effect, which is further enhanced, if the students use the environment by themselves in the tutorials. Hence, by using this method self-assessment and efficient results are achieved.

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