4-13-2020

Teaching and Learning of Fluid Mechanics

Ashwin Vaidya

fluids

Editorial

Teaching and Learning of Fluid Mechanics

Ashwin Vaidya

Department of Mathematics, Montclair State University, Montclair, NJ 07043, USA; vaidyaa@mail.montclair.edu

Received: 8 April 2020; Accepted: 10 April 2020; Published: 13 April 2020

Fluid mechanics is arguably one of the oldest branches of physics, and the literature on this subject is vast and complex. However, this subject has not sufficiently captured the interest of STEM educators like in other subjects such as quantum mechanics [1,2]. The objective of this collection, while not necessarily intended to generate education research, aims at bringing together various ways of teaching and learning about different topics in fluid mechanics.

Fluid mechanics occupies a privileged position in the sciences; it is taught in various science departments including physics, mathematics, environmental sciences and mechanical, chemical and civil engineering, with each highlighting a different aspect or interpretation of the foundation and applications of fluids. While scholarship in fluid mechanics is vast, expanding into the areas of experimental, theoretical and computational, there is little discussion among scientists about the different possible ways of teaching this subject or wide awareness of the how fluid mechanics plays a role in different disciplines. We believe there is much to be learned from an interdisciplinary dialogue about fluids for teachers and students alike.

The terms 'interdisciplinary', 'multidisciplinary' and 'transdisciplinary' have become common parlance in academia, but have been misunderstood and used without distinction [3]. Multidisciplinary teaching refers to diverse parallel viewpoints, with different goals and objectives being presented in the same setting while interdisciplinary or transdiscplinary refer to instances where goals overlap or unify completely [4]. In the context of education, inter- or transdisciplinary instruction allows students get to see the commonalities between different disciplines, thereby allowing students to make new meanings out of old ideas [5]. The education theorist, William Doll [5], articulates this idea very well: "Order emerges from interactions having just the 'right amount' of tension or difference or imbalance among the elements interacting." In a recent paper on education, my co-authors and I have argued that the synergy between different disciplines can result in the emergence of order, which we argue is nothing but creativity [6]. Doll's fluid analogy [5] for this idea is especially relevant to this issue:

"Emergence of creativity from complex flow of knowledge—example of Benard convection pattern as an analogy—dissipation or dispersal of knowledge (complex knowledge) results in emergent structures, i.e., creativity which in the context of education should be thought of as a unique way to arrange information so as to make new meaning of old ideas."

With this philosophy in mind, we have included all kinds of articles in this issue, including research on the pedagogical aspects of fluid mechanics, case studies or lesson plans at the undergraduate or graduate levels, articles on historical aspects of fluids, and novel and interesting experiments or theoretical calculations that can convey complex ideas in creative ways. The current volume includes 14 papers and showcases the work of scientists from different disciplines ranging from mathematics and physics to mechanical, environmental and chemical engineering. It truly is a wonderful collection and provides ideas on theoretical computational and experimental aspects of fluid mechanics that be implemented in a course in fluids in any department. The suitability of these papers ranges from early undergraduate to graduate level.

Overall, this issue contains papers in various, somewhat distinct categories. The articles [7–11] add and *reconsider fundamental ideas in fluid mechanics*. The paper by Brkić and Praks [7] is devoted to the solution of Colebrook's friction equation. This basic equation is used to introduce interesting and sophisticated mathematical tools, such as the fixed point method and Padé approximation, among others. The article by Kariotoglou and Psillos [8] is a synthesis of previous research upon high school and undergraduate students on the teaching of concepts such as pressure in fluids. The two papers by Pal [9,10] are focused on fundamental ideas in thermomechanics; the papers discuss the ways in which important thermodynamic ideas can be introduced and elucidated in a fluid dynamics course through examples such as flow in pipes and flow through packed beds. Vianna et al. [11] take up the concept of *permeability* in porous media flow and discusses new computational concepts that can help convey such complex concepts.

Several collections in this issue deal with the *development of computational tools* to resolve important problems in fluid mechanics [12–14]. Addair and Jaeger [12] consider efficient and effective strategies to convey fundamental concepts in Computational Fluids Dynamics (CFD) to undergraduate students, such as the implementation of the finite volume method to solve Navier–Stokes equations. The paper by Battista [13] provides an open repository of several useful two-dimensional solvers written in MATLAB and Python 3. The contribution by Pawar and San [14] is about CFD Julia, a programming module that teaches the foundations of computational fluid dynamics (CFD). This piece is written for an upper-level undergraduate and early undergraduate course in fluid mechanics and uses the inviscid Burger's equation and the two-dimensional Poisson equation as examples.

Articles [10,15] treat *classical topics in fluid mechanics* in a very thorough and innovative manner and serve to guide the development of lectures on these topics in undergraduate and graduate courses. Medved, Davis and Vasquez [15] deal with the classical problem of a particle motion in a fluid. Pal's contribution [10] cited earlier regarding melding fluid mechanics and thermodynamics in the context of pipeline flow is yet another example of such a contribution.

Articles [16,17] provide *novel and creative new ways of introducing fluid mechanics* to students. They make rich connections between several disciplines and are guaranteed to capture the imagination of students. The paper by Mayer [16] discusses the seemingly simple example of an experiment on the flow of a fluid through a bottle. This seemingly mundane topic is a classic example of the richness and complexity of fluid mechanics, but also its ubiquity. Nita and Ramanathan [17] make a creative connection between fluids and music in their discussion of the physics of the Pan's flute. These are both truly exciting examples that can be introduced in undergraduate or graduate courses on fluids.

Articles [18–20] are more *pedagogically focused*. Huilier's contribution [18] is unique and provides a rich personal history of teaching fluid mechanics for over forty years at the University of Strasbourg. While the subject of fluid mechanics has evolved much in the last several decades, this reflective piece is a guide to all young instructors about how to adapt and evolve one's teaching and pedagogy. The paper by Potter and Wolff [19] discusses the experience and observations of interventions in a second-year fluid mechanics module, and provides insights into the teaching of fluid mechanics at their institution. A second goal of this paper is to conceptualize the use of Legitimation Code Theory (LCT) dimensions towards teaching strategies intended to facilitate improved learning outcomes. The LCT provides educators with a very useful tool to guide their curriculum planning and pedagogy. The article [20] by Valyrakis et al. focuses on the importance of lab-based fluid mechanics instruction. The authors demonstrate the value of using physical models ("floodopoly") to demonstrate complex geophysical processes such as sediment transport and flooding. A survey instrument is used to assess and demonstrate student understanding and perception of the subject.

References

1. Carr, L.D.; McKagan, S.B. Graduate quantum mechanics reform. *Am. J. Phys.* **2009**, *77*, 308–319. [CrossRef]
2. Singh, C. Student understanding of quantum mechanics at the beginning of graduate instruction. *Am. J. Phys.* **2008**, *76*, 277–287. [CrossRef]
3. Lawrence, R.J. Deciphering interdisciplinary and transdisciplinary contributions. *Transdiscipl. J. Eng. Sci.* **2010**, *1*, 125–130. [CrossRef] [PubMed]

4. Park, J.-Y.; Son, J.-B. Transitioning toward transdisciplinary learning in a multidisciplinary environment. *Int. J. Pedagog. Learn.* **2010**, *6*, 82–93. [CrossRef]
5. Doll, W.E., Jr. *A Post-Modern Perspective on Curriculum*; Teachers College Press: New York, NY, USA, 2015.
6. Monahan, C.; Munakata, M.; Vaidya, A. Creativity as an Emergent Property of Complex Educational System. *Northeast J. Complex Syst. (NEJCS)* **2019**, *1*, 4. [CrossRef]
7. Brkić, D.; Praks, P. What Can Students Learn While Solving Colebrook's Flow Friction Equation? *Fluids* **2019**, *4*, 114. [CrossRef]
8. Kariotoglou, P.; Psillos, D. Teaching and Learning Pressure and Fluids. *Fluids* **2019**, *4*, 194. [CrossRef]
9. Pal, R. Teach Second Law of Thermodynamics via Analysis of Flow through Packed Beds and Consolidated Porous Media. *Fluids* **2019**, *4*, 116. [CrossRef]
10. Pal, R. Teaching Fluid Mechanics and Thermodynamics Simultaneously through Pipeline Flow Experiments. *Fluids* **2019**, *4*, 103. [CrossRef]
11. Vianna, R.S.; Cunha, A.M.; Azeredo, R.B.V.; Leiderman, R.; Pereira, A. Computing Effective Permeability of Porous Media with FEM and Micro-CT: An Educational Approach. *Fluids* **2020**, *5*, 16. [CrossRef]
12. Adair, D.; Jaeger, M. An Efficient Strategy to Deliver Understanding of Both Numerical and Practical Aspects When Using Navier-Stokes Equations to Solve Fluid Mechanics Problems. *Fluids* **2019**, *4*, 178. [CrossRef]
13. Battista, N.A. Suite-CFD: An Array of Fluid Solvers Written in MATLAB and Python. *Fluids* **2020**, *5*, 28. [CrossRef]
14. Pawar, S.; San, O. CFD Julia: A Learning Module Structuring an Introductory Course on Computational Fluid Dynamics. *Fluids* **2019**, *4*, 159. [CrossRef]
15. Medved, A.; Davis, R.; Vasquez, P.A. Understanding Fluid Dynamics from Langevin and Fokker–Planck Equations. *Fluids* **2020**, *5*, 40. [CrossRef]
16. Mayer, H.C. Bottle Emptying: A Fluid Mechanics and Measurements Exercise for Engineering Undergraduate Students. *Fluids* **2019**, *4*, 183. [CrossRef]
17. Nita, B.G.; Ramanathan, S. Fluids in Music: The Mathematics of Pan's Flutes. *Fluids* **2019**, *4*, 181. [CrossRef]
18. Huilier, D.G.F. Forty Years' Experience in Teaching Fluid Mechanics at Strasbourg University. *Fluids* **2019**, *4*, 199. [CrossRef]
19. Pott, R.W.M.; Wolff, K. Using Legitimation Code Theory to Conceptualize Learning Opportunities in Fluid Mechanics. *Fluids* **2019**, *4*, 203. [CrossRef]
20. Valyrakis, M.; Latessa, G.; Koursari, E.; Cheng, M. Floodopoly: Enhancing the Learning Experience of Students in Water Engineering Courses. *Fluids* **2020**, *5*, 21. [CrossRef]