Spoken Tutorials: A Tool for Enhancing Multi-representation Skills in Physics Classroom

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Abstract. In recent decades, ICT has advanced rapidly, significantly impacting education. The indispensable role of computers in higher educational institutions for teaching and learning is evident. However, students often encounter challenges in understanding questions with multiple representations, leading to misconceptions and learning gaps. Leveraging ICT tools, like spreadsheets facilitate better conceptual development. Himachal Pradesh University, India has incorporated Computational Physics course into its undergraduate curriculum, complemented by spoken tutorials and a computational laboratory. This paper focuses on a case study of B.Sc. students, illustrating how integrating and embracing Free Open Source Software ensures accessibility and benefits students from all societal backgrounds.

Introduction

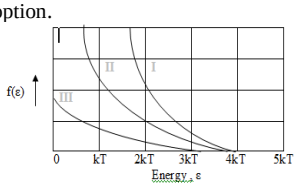
In recent decades, researchers have been dedicated to integrating new theories of learning and teaching into the fields of science, engineering, and technology. Their goal is twofold: to enhance students' comprehension and conceptual grasp of subject matter, and to shift the focus of education from teacher-centered to learner-centered approaches. Studies have shown that students often struggle with questions that require interpretation of graphs, particularly when confronted with multiple representations of information [1]. To overcome the challenge of interpreting multiple representations in physics problems, utilizing powerful charting and analysis tools such as Microsoft excel or Libre office Calc can be immensely beneficial**.** The spoken tutorial project [2] of the 'Talk to a Teacher' activity launched by the Ministry of Human Resources and Development, Government of India is one such initiative which can help learner learn the requisite tool through reusable objects in the form of spoken tutorials leaving ample opportunity to the user to learn the tools on their own and use them for doing physics problems.

Understanding Statistical Distribution Functions: A Case Study Using MS Excel/Calc

The author has developed a concept inventory focused on statistical mechanics [1], featuring a range of items that employ various representations. This inventory was administered to diverse groups, including 97 undergraduate students, 37 postgraduate students, and 55 teachers, revealing a fundamental misunderstanding of key concepts across all groups. This case study seeks to outline a methodology for designing a supplementary spreadsheet for the theory course, particularly aimed at enhancing the understanding of graphical representations.

One of the question items involved in the concept inventory of statistical physics leading to the development of spreadsheets is shown in Figure1. A very low percentage of correct answers given by undergraduate and post graduate students and as well as teachers indicate that they fail in relating with multiple representation questions, especially visualization through graphs[3].

Q In the figure given below the curves of three distribution functions M-B $f_{MB}(\varepsilon)=1/\{e^{\alpha}e^{\varepsilon/kT}\}$, B-E, $f_{BE}(\varepsilon)=1/\{e^{\alpha}e^{\varepsilon/kT}-1\}$ and F-D $f_{FD}(\varepsilon)=1/\{e^{\alpha}e^{\varepsilon/kT}+1\}$ with $\alpha=-1$,is shown. Label the curves I, II, III according to the distribution functions and tick the correct option.



(a) I is M-B, II is B-E, III is F-D (b) I is B-E, II is M-B, III is F-D
(c) I is M-B, II is F-D, III is B-E (d) I is B-E, II is F-D, III is B-E

Figure1: Question item

Statistical Distribution Functions

Statistical Mechanics determines the most probable way of distribution of certain amount of energy among N number of system of particles in thermal equilibrium at the absolute temperature. The spreadsheet has been designed to show the comparison of the three (Maxwell Boltzmann, Bose Einstein and Fermi Dirac) statistical distribution functions. Figure 2 shows the comparison of the three distribution function for $\alpha=-1$. With the help of this spreadsheet one can clearly clear the underlying concept.

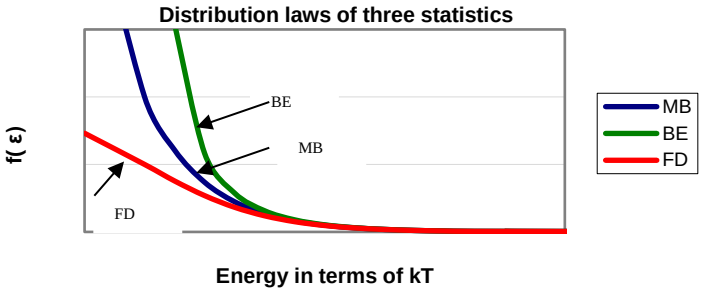


Figure 2: Graphs for the MB, BE and FD distribution functions

Conclusion

This case study underscores the difficulties students encounter, especially in comprehending graphical concepts, prompting the need for targeted instructional interventions such as computer simulations, visualization tools, and tutorials. In response to these challenges, interactive spreadsheets were created to concentrate on statistical distribution functions. These spreadsheets empower students to interactively explore the content, facilitating a more profound grasp of graph interpretation and the fundamental principles of physics [4].

References

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[3] S. Sharma and P. K. Ahluwalia, Diagnosing Alternative Conceptions of Fermi energy among Undergraduate Students, *Eur. J. Phys*. **33** (2012) 883-895.

[4] M. I. Ageel, *Spreadsheets as a Simulation Tool for Solving Probability Problems*, 2002.