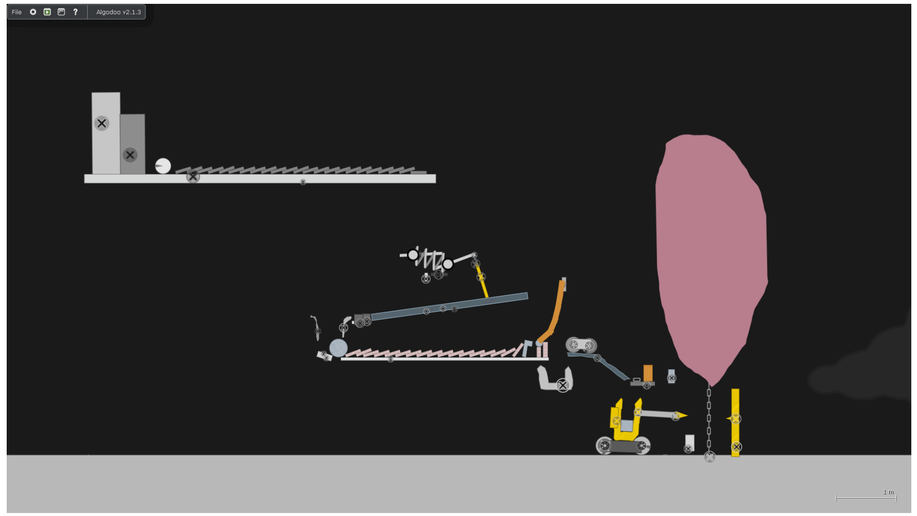
PRAYOGA™
Research to Transform Learning

Learning with Algodoo:

Simulation Building as a Pedagogical Tool



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Introduction

- The disruption to regular classes due to COVID-19 provided us with an opportunity to attempt something novel.
- We set out to investigate the effectiveness of teaching in an online setting using simulation building as a core pedagogical tool.
- High quality simulations have been argued to be effective educational tools in enhancing students' conceptual understanding of various science topics at school level as well as college level.
- Our work attempted using simulation building as part of an online instruction strategy.
- The principles of flipped learning pedagogy [1, 2] were utilized in our project.
- Students did the bulk of the work individually using the suggested reading material and videos and the facilitator interaction was limited to discussions of the work done and for clearing doubts.

[1] Kettle, M. Flipped physics. *Physics Education* (2013)
[2] Anand, S. Flipped pedagogy: Strategies and technologies in chemistry education. *Materials Today: Proceedings* (2021)

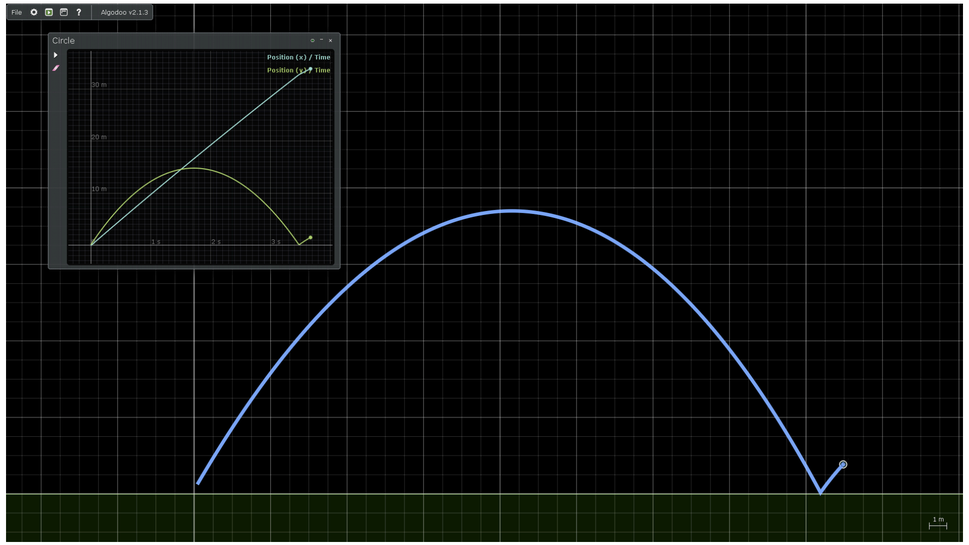
Methodology & Implementation

- Students form certain alternate conceptions in a bid to explain their observations of the world.
- An effective instructional strategy has to address these preconceptions by creating a cognitive conflict such that they are forced to re-evaluate, paving way for conceptual change [3].
- The main thrust of the project was for students to explore hitherto unknown physical phenomena and try to gain insights through simulations that they build through Algodoo [4].
- The project was implemented in an alternative school in Bengaluru, India during the pandemic enforced lockdown in 2020.
- The project had two stages - an initial introductory stage of three weeks when students familiarized themselves with Algodoo, and the latter stage of five weeks when the physical phenomena (2-dimensional projectile motion and total internal reflection) were studied.
- A weekly interaction session with the 16 students of ages 12-14 was held via Zoom (60-90 minutes per session).
- Students did the bulk of the work individually using the suggested reading material and videos and the facilitator interaction was limited to discussions of the work done and for clearing doubts.

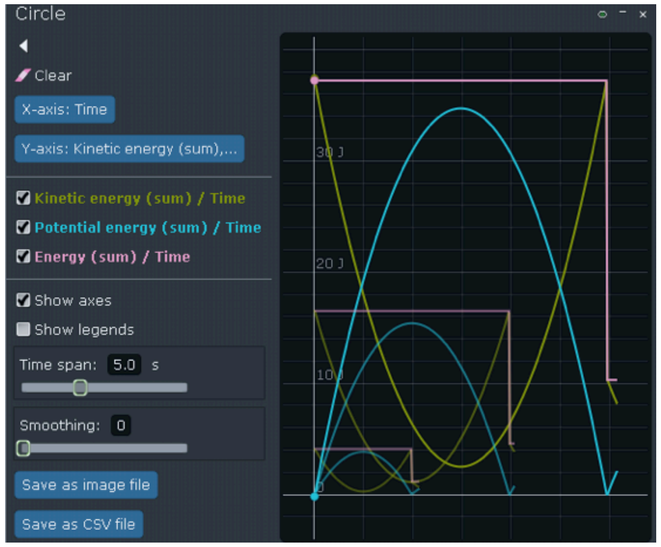
[3] Posner, G., Strike, K., Hewson, P., & Gertzog, W. Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education* (1982)
[4] Gregorcic, B. Never far from shore: productive patterns in physics 8 students' use of the digital learning environment Algodoo. *Physics Education* (2012)

2-dimensional Projectile Motion

- To qualitatively study the relationship between different physical quantities in a 2dPM 4 scenario such as the angle of projection, velocity, maximum height, range etc.
- Students were expected to create a simulation of 2dPM, collect the necessary data (by employing the plotting tool in Algodoo) and then analyse this data.
- Most students (8/9) were able to collect the relevant data, but a considerable fraction (5/9) submitted poor or no analysis of the data.
- Students were able to identify how the energy changes occurred by studying the kinetic energy and potential energy plots and correlate it with the projectile motion.
- Given that students had only studied motion in 1d, and had no prior formal knowledge of 2dPM, this was a very challenging assignment that required higher order thinking skills.



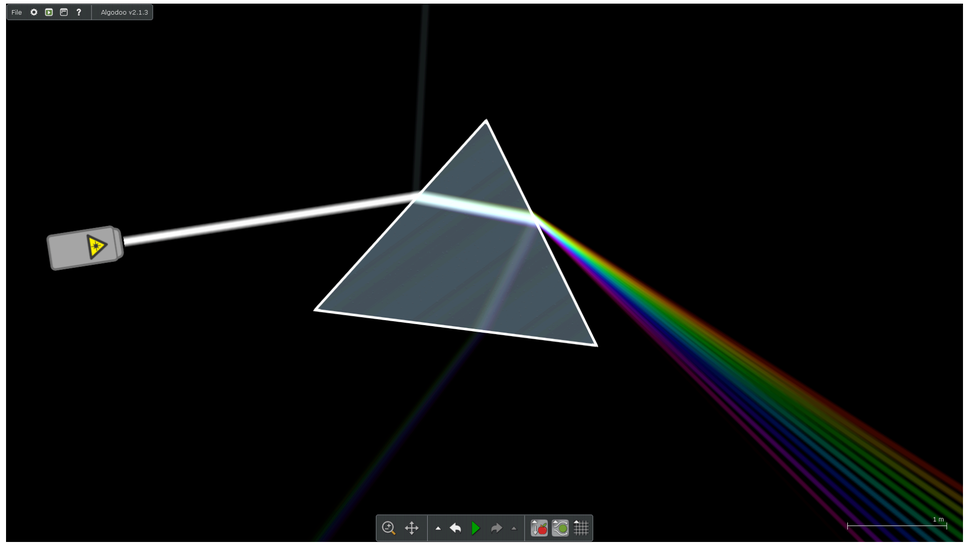
The figure above shows an example 2dPM simulation submitted by students.



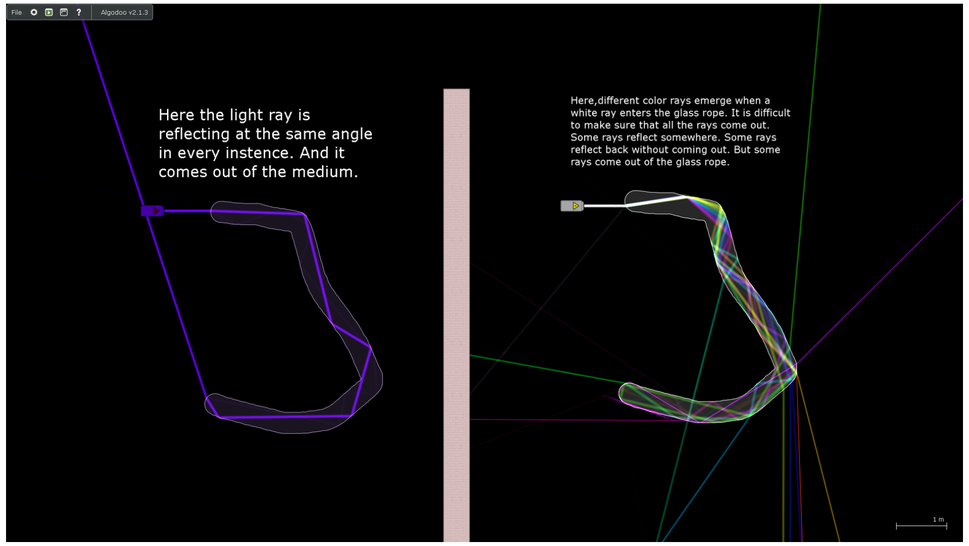
Some students were able to study the energy change during the 2dPM. They were also able to correlate the total energy with the changes in kinetic and potential energies. Figure to the left is an example.

Total Internal Reflection

- First task was for students to simulate dispersion through a prism. Second task was about discovering the phenomenon of total internal reflection. Both tasks were accompanied by questions that the students had to answer by using the respective simulations.
- These tasks were possible in Algodoo as it enables the manipulation of refractive index of any object created.
- Almost all students (6/7) succeeded in simulating dispersion of light by a prism. But when they were posed the question of why this phenomenon occurred, the students were not able to come to the right explanation even though they were able to make the observation that different coloured lights refracted differently.
- Only very few students (2/7) were able to observe TIR in the second task. A possible explanation for this could be students' impatience and tendency to jump to conclusions given that they were working in a virtual medium and on their own.



The figure above shows an example of the dispersion simulation.
The figure below shows an optical fibre simulation which demonstrates TIR.



Conclusions

- In this project, we attempted to elicit conceptual change in students regarding the topics of 2-dimensional projectile motion and total internal reflection through simulation building in Algodoo.
- The challenge in trying to instigate a conceptual change became even more so due to the fact that we were in a non-traditional, online instructional strategy and the results were admittedly mixed.
- Some of the major challenges during the implementation were in terms of keeping the students engaged and maintaining high levels of motivation.
- Based on student feedback, it was clear that students found it difficult to maintain engagement in the virtual space and that their motivation waned.
- On the flipside, simulation building could become very effective as a pedagogical tool in an experiential classroom for situations difficult to recreate physically in labs (such as manipulation of air friction, gravitation etc).