# Discovery Cycle as Strategy of Science Teaching

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**Abstract**. The *Discovery Cycle* is a strategy for reaching the scientific knowledge trough discovery. We are applying this strategy with physics students of Mechanics Laboratory of first year of university. The cycle is focus on research the dynamical behaviors of mechanical systems modeled with Newton's Laws. It consists of seven stages: exploration, experimentation, empirical modelling, theoretical modelling, numerical modelling, model results *versus* experiment and prediction. Students carry out this strategy in a specific context of a mechanics system. Here, we analyze the motion of a disc, sliding on a tilted plane as an example of application of this cycle.

## 1 Background

In the physics career at Science Faculty of the National Autonomous University of Mexico, our students take their first laboratory course in the second semester of the first year. This is a mechanics laboratory, where in addition of teaching the Newtonian mechanics, we must also teach the experimental technics. The experimental teaching in previous educational cycles is usually not very good. Traditional teaching is not enough for students, to achieve a deep learning in mechanics concepts and their experimental applications at the University. For this reason, we developed the Discovery Cycle, which had showed to be an efficient learning strategy.

## 2 Discovery Cycle.

Discovery Cycle is a sequence of seven stages of learning: exploration, experimentation, empirical modelling, theoretical modelling, numerical modelling, model results versus experimentation and prediction. These stages are divided into two methodological branches: the inductive methods (exploration, experimentation, empirical modelling) and the deductive methods (theoretical modelling, numerical modelling, model results versus experimentation and prediction). In Figure 1, we show in a conceptual map the connections between the different stages of the cycle.

In the mechanics laboratory, motion phenomena are studied, so, they are the starting point of the Discovery Cycle, as it can be seen in the conceptual map. In agreement with the map, students and teacher must select a motion phenomenon to be studied with the application of Newton's laws.

Teacher detonate the Discovery Cycle, with a research question or a questionnaire. In most cases, students have some ideas about the behaviors of the phenomenon, but during the exploration stage they usually examine different motions that represent the phenomenon under study; in this way they acquaint with it and may develop concrete ideas to explain tentatively the observed behaviors. These ideas are used as the hypothesis to be confronted experimentally.

In the next stage of the cycle, students choose a specific motion of the phenomenon to make experiments carefully, taking and analyzing data with tables y graphs, and if it possible to get empirical equation. All of this, following the techniques advice in the experimental methods.

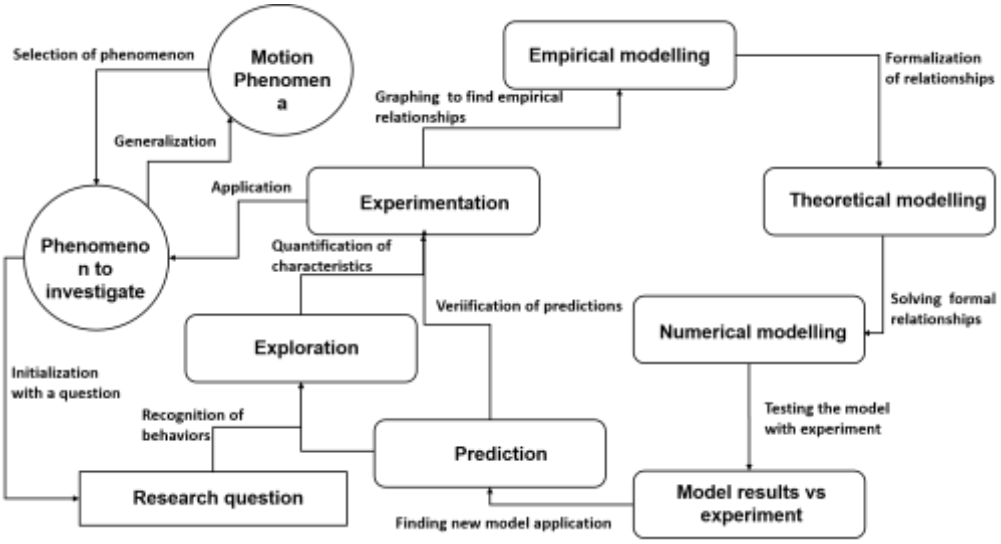

Fig. 1 Discovery Cycle conceptual map

The next two stages are dedicated to modelling. First, the theoretical modelling, where students and teacher arrive to the motion equation with the support of the conceptual frame of physics, and second, the numerical modelling, where students solve the motion equation with numerical methods (analytical methods are no used in this stage, because students in their first year of physics career do not know how to solve differential equations).

Confrontation between model results *versus* experimental data is the next stage. Numerical solution is tested against experimental data and if all is well, the entire process is almost finished.

As the numerical solution is carried out in a spreadsheet, parameters, variables, graphs, comparisons with experiment, etc., are all at the same place. Thus, students make predictions of new behaviors of the phenomenon by changing parameter values and see how the changes occur graphically. This is the last stage of the cycle, if students cannot check the confirmation of the prediction by experimentation for lack of time.

### *2.1 Application*

The discovery cycle was carried out by students in the study of the movement of a disc on a tilted plane that is under the action of the force of gravity and the dry friction between the disc and the plane. The students explored different trajectories[1] of this motion and selected one of them; they made an experiment to find the coefficient of friction, took a video of the trajectory of the selected movement to collect and analyze data. Then, they found the motion equation, solved the equation numerically, compared numerical results with data experiment, and finally, they done predictions to draw their own conclusions.

## 3 Conclusion

Discovery Cycle is a successful strategy of learning physics, because it involves students in a scientific environment of discoveries, through the tracking of this cycle, students discover new concepts, knowledges, techniques, methods and applications, developing high thinking skills and transforming them in creative and independent human beings.

## References

[1] S. Wang. Trajectory of a projectile on a frictional inclined plane. Am. J. Phys. 82, (2014) 764 – 768.