*All Things Ignatian*

# Teaching Quantum Mechanics using Ignatian Pedagogy

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## The Big Idea

Although the Jesuit ideal of "magis" means in part that a Catholic and Jesuit education should be richer and fundamentally different than a secular education, it has proven difficult to apply the ideals of Ignatian education to science and mathematics courses which are content driven. However, the educational framework of problem/project-based learning (PBL) offers the potential to fully realize and utilize Ignatian pedagogy in the science classroom. This work describes the melding and fusing of PBL and Ignatian pedagogical approaches to truly bring the Jesuit ideal of education to physics courses at Creighton.

## Project-Based Learning

So what is Problem/Project-based Learning? Briefly, it is a systematic way to introduce active, student-centered learning to both large and small classes. The essential features of problem-based learning include:

1. Learning begins with a problem
2. Problems are complex and real-world
3. Not all information is given; students need to make assumptions and estimations
4. Students learn to search for outside information
5. Students work in groups
6. Student learning is active and connected
7. Faculty role is that of a guide and mentor

Problem/Project-based learning offers tremendous advantages to students as an example of a systematic, active engagement pedagogy which differs from more traditional, lecture-based strategies.

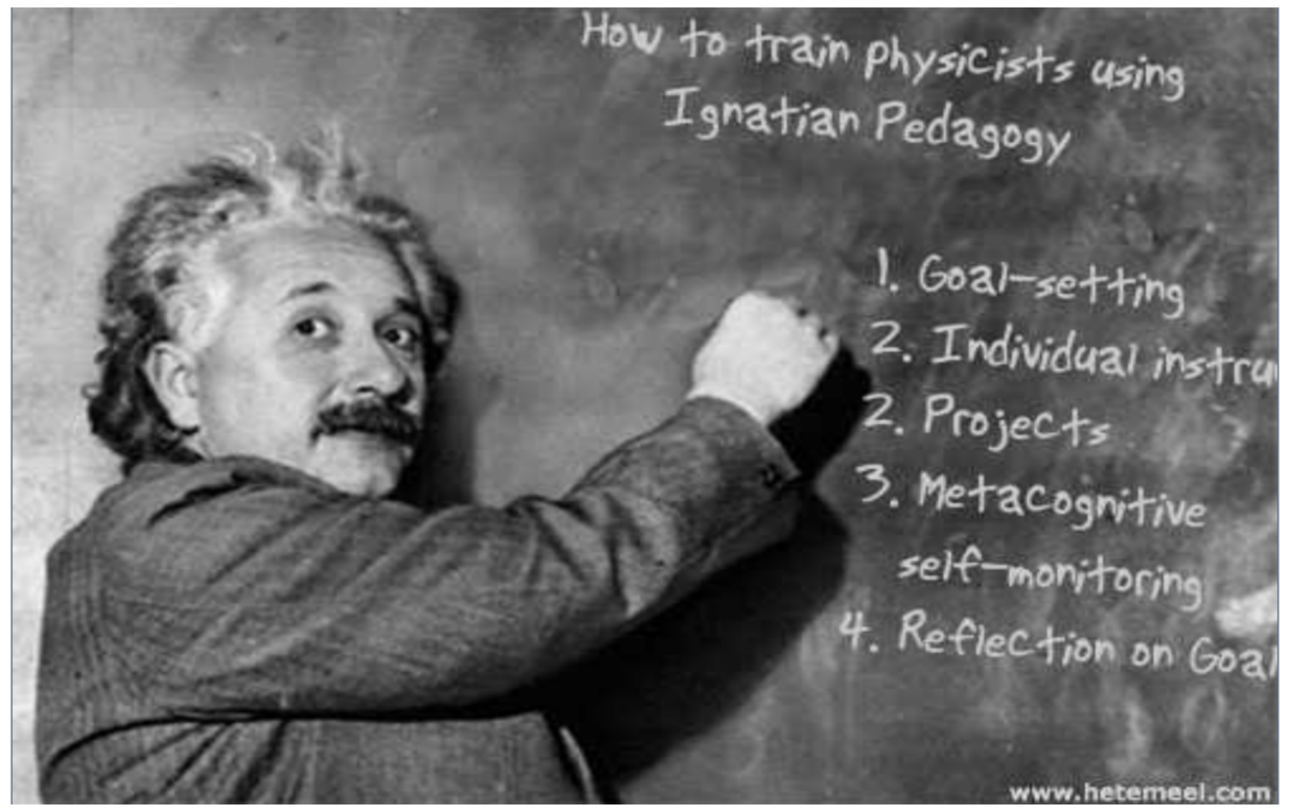


Figure 1: Several of the key elements of Ignatian Pedagogy as utilized in quantum mechanics.

## Ignatian Pedagogy

Ignatian education and pedagogy can be characterized best as a "constant interplay of experience, reflection and action". Ignatian education is a teaching style that grew out of the Jesuit Tradition and the spiritual exercises that emphasizes context, experience, reflection, and subsequent action. An Ignatian educational experience is exemplified by:

1. A set of experiences tailored to each student.
2. Students set goals and identity desires for learning.
3. Students are actively engaged.
4. Student reflection on learning is central.
5. Students build upon their reflections and take action based on knowledge gained, applying that knowledge to new problems and new situations.
6. An experience which emphasizes assessment and a growth in attitude and priorities.

## Can Science Education be Ignatian?

YES! Problem/Project-Based Learning shares several characteristics with the fundamental tenets of Ignatian Education and facilitates the use of Ignatian pedagogy.

1. Problems are real-world: students confront purposeful, open-ended, and ill-defined problems.
2. Student learning is active and students are encouraged to reflect on learning.
3. Students and teachers are equal co-investigators, with the faculty member serving not as an expert and sole source of knowledge, but a companion in the educational journey who guides and advises.

| Quantum Mechanics Topic | Student Deliverable |
|---|---|
| One-Dimensional Potential Wells | Uranium Decay and Quantum Tunneling: 4-5 page journal-style article |
| Time Dependence | Particle Physics Application: 10 page review article |
| Spin | Rabi Paper: Journal Club Presentation |
| 3D Quantum Mechanics and the Simple Harmonic Oscillator | HCl molecule: Poster Presentation |

Table 1: Student projects and deliverables for the course. The focus of projects was on real-world applications and the communication of those results.

## Student Reflection

Finite Well Tutorial Self-Assessment

Please rate yourself on the learning objectives of the tutorial using the scale provided. Be honest and identify areas in which you are still struggling!

| Objective (Students will be able ...) | Did not Meet Objective | Need more help to meet objective | Met Objective |
|---|---|---|---|
| 1. To solve the 1D time independent Schrodinger Equation for the finite square well potential in all regions. | | | |
| 2. To demonstrate in another context how energy quantization arises as a result of boundary conditions. | | | |
| 3. To find allowed energies through graphical solutions of transcendental equations. | | | |
| 4. To explore and calculate the number of bound states that a given finite well can support. | | | |
| 5. To discover and quantify the role of symmetry in 1D potential problems in quantum mechanics. | | | |

After completing the tutorial, where are you still struggling? What are you still confused about and what questions do you have?

Figure 2: Students reflected frequently on their own learning in the course. In addition to self-assessments after each in-class tutorial, students completed written reflections after each project, and set goals for themselves for the semester.

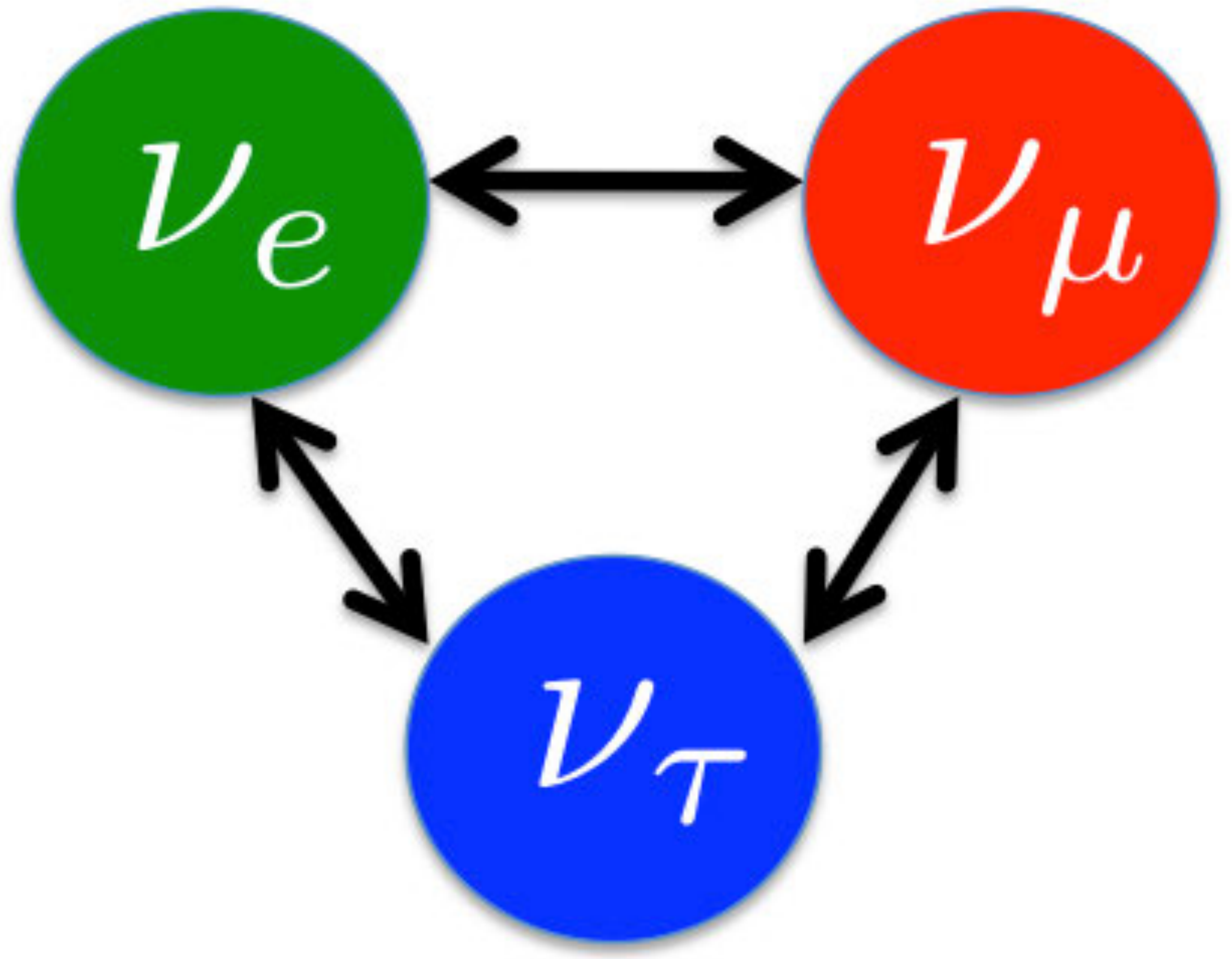


Figure 3: Students explored neutrino oscillations, a real-world phenomena, for their second project.

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