
Introducing particle physics through story

For many people physics inspires awe, wonder and the 'Eureka' feeling. For too many others it provokes dislike, fear and a tendency to flee. Can we halt this exodus? Can we reach out to interest and attract non-science students and ordinary people? I would like to share a route that seems to work for some, using the age-old technique of story-telling—a natural teaching format in non-science disciplines like history and literature. Narratives and story-formats present, explain and facilitate learning of scientific concepts and facts, and build metaphors and analogies into the story-environment. I have used story-telling successfully (with large increases in enrollment and retention) to attract and interest many non-science undergraduate students, including women, minorities and working adults.

Can such story-formats also retain and teach the physics-fearful along with attracting and interesting them? Does this use of narrative and story-format advance pedagogy? Does this approach, along with its integrated use of analogies and metaphors, help the

student to comprehend? Does it help the student to retain and recall the subject content? Again, personal experience indicates a 'yes' to all of these.

The story-format advances pedagogy by presenting facts and concepts through dynamic, action-oriented situations, using analogies and metaphors as integral components. Again, the use of analogies and metaphors in descriptive, explanatory contexts in traditional science pedagogy is common. For example, we invoke the '*balloon surface*' analogy to explain space-time curvature and the expansion of the universe; we use the term '*electron cloud*' to describe '*indeterminacy*' of a bound quantum state and '*water waves*' to visualize light waves moving through a vacuum. We even try to explain QCD forces between quarks and gluons by the concept of '*colour charge*'. (We then try to clarify, instantly, that it is actually nothing like colour or charge as we generally perceive them!)

The use of analogies and metaphors in action and event-oriented settings, woven into story elements, en-

Quarks

Excerpt from *Muonic Rhapsody and Other Encounters*. The story element uses a ‘*deep inelastic scattering event*’ by a muon (or electron) to introduce quarks, confinement and strong interactions:

... What happened was a violent head-on collision. It was so violent, I impacted right into what I hit. I seem to have plunged into a dense crowd.

All around me float strange creatures. They seem to be free to move as long as they remain within the crowd and its confines.

“Who are you?”

Their question indicates they are as curious about me as I am about them.

“How did you get in?” quips another.

“I’m not sure”, I reply. “I was jettisoned in, accidental collision. I am sorry.”

“Do not be”, they say. “A casual observer outside would see only the apparently lifeless object you hit. But deep within we run around and thrive on motion.”

“I seem to be quite welcome. They appear to be friendly folk.”

“We don’t see much of the outside world.”

They sound wistful. “We are free to do whatever we like as long as we do not try to escape.”

“Why is that?” I am intrigued.

“Oh it is the law. We carry fractional charge and this is something the outside world is not allowed to see. Nobody is watching us now. But if we try to run away, the others immediately become on guard and pull us back. We are quarks and held together

by glue; this glue becomes stronger and cements us as we approach the outskirts.”

The sudden collision jolts me. I have run straight into a quark. The others run helter-skelter as they try to see what we do.

The quark and I exchange only a quick photon and a virtual one at that . . . but even that is embarrassing before so many peeping quarks and gluons!

The act over, I head for an exit . . .

Factual way: Matter as we know it is made up of neutrons and protons, and neutrons and protons are made up of quarks that interact through ‘strong interactions.’ At the quark level these hold the nucleus together by exchange of gluons.

Quarks and gluons carry ‘colour charge’, which is a property like charge or mass. We could say that at its elemental level, the strong interaction is mediated by gluons interacting with quarks and with each other through their colour charge. The force operating is the ‘colour force’ and the theory is called quantum chromodynamics (QCD), which requires quarks to be permanently confined within hadrons. Quarks also carry electric charge, but they carry fractional charge. Their fractional charges are not visible as quarks and are always confined within hadrons.

riches their effectiveness and adds an additional dimension to science pedagogy. The portrayal of facts through such dynamic and eventful situations serves to (i) **interest** and **motivate** students, (ii) **connect** their science experience to **life situations** and facilitate science-learning by aiding **comprehension, retention** and **recollection** of the subject content.

The use of narrative **does not** preclude or diminish the role of factual presentation and other standard science pedagogy, including technology and hands-on labs. Rather, it opens yet another road for those initially reluctant to tread the others. Usually, once the relaxing story atmosphere dispels their fear, they are eager to try other routes as well, for a more complete learning experience. In particular, it appeals to liberal arts students who are used to narratives and are wary of science. Once, I had some humanities majors happily building neutrons and protons from fractionally charged quarks towards the end of the course. One of them re-

marked that if I had tried that at the start of the semester, before the stories had made them comfortable and relaxed, they would have fled the class!

One of the most effective ways to use narratives is to (i) read the story, (ii) test comprehension with questions from the story, (iii) supplement this with factual presentation so the students learn the scientific terminology. The learning experience can be further enhanced by real, virtual or simulation labs, activities and discussions. Informal research indicates that the creative use of narrative and characterization, used in combination with supporting factual sections, questions, tests, activities and hands-on labs, can be a successful teaching technique for liberal arts students of all ages and backgrounds. The stories also serve as starting points for group discussions that feed from the factual support sections and internet research. The analogies and ‘life-settings’ generate interactive views. I recall one instance, when a student told me he could

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not remember what beta decay was, but he thought about the relevant part from the story and was able to answer his question. I was also rewarded to learn from a colleague that one of his students in high school had found my book in a bookstore and brought it into class. She wanted to share it with her teacher and classmates because it appealed to her so much.

I had some initial reservations as to whether the ‘anthropomorphic’ characterization of particles would confuse the students but found they had no problems sifting the fact from the fiction. Nevertheless, my book does carry a warning: ‘Subatomic particles do not think, feel or talk the way we do. They do however lead exciting, interactive lives interspersed with events, including birth, decay and annihilation. Fundamental interactions, laws of probability and conservation prin-

ciples determine their actions. The metaphoric romances in the story serve as dressing for electrical forces and electromagnetic bound states.’

Colleagues may find my books useful for trying the narrative format and I would be happy to share more detailed experiences and teaching tools. The box shows some quotes from my book *Muonic Rhapsody and Other Encounters* published by Roli Books, India (ISBN 81 7436 010 7). Excerpts from my other book *The Exotic Lifestyles of Subatomic Particles*, published by Kendall/Hunt (ISBN 0 7872 7396 1), are available in the online version of this article.

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