Teaching Junior High School Physics: Personal Experiences and Observations

In my thirty years as a university science and engineering professor, I have always wondered about the apparent lack, among American-educated students, of a basic understanding of fundamental physical principles. Why doesn't the average student know the functions of simple everyday devices such as a light bulb, an electro motor, a transformer, a battery, or a resistor? Moreover, why do these students apparently lack the joy and excitement of discovering the laws and secrets of nature?

Part of the key to answering these questions undoubtedly must be sought at the lower educational levels. That is why I welcomed the opportunity to teach a "physics block" in a Waldorf school. In Waldorf schools, children are intensively exposed to a certain study area, such as chemistry, biology, history, or literature, for the first two hours of each school day, for three to four weeks. Waldorf schools also try, whenever possible, to combine various study areas. For example, teachers strive to intersperse physics with elements of philosophy, art, or history. My assignment was to introduce the 7th and 8th graders to the foundations of mechanics.

Our first endeavor was to explore the laws of pulleys and tackles. To do this, we hung a pulley from the ceiling, threaded a rope around the roller, and attached bricks of equal size and weight to each end. Quite naturally, and to nobody's surprise, the bricks held each other in balance unless someone pushed or pulled on one of them. Next, we fastened one end of a rope to the ceiling and threaded the other end through a movable pulley on which we hung a brick. The free end of the rope was then strung around a fixed pulley which was attached to the ceiling. This end of the rope was connected to only half a brick. Then came the question to the class: Why is it that half a brick can counterbalance a full brick? The question was not immediately answered by the pupils. Several incorrect suggestions were proposed, including magic or tricks. We took our time. After half an hour of experimentation, guessing, and steadily increasing excitement, I asked one student to hold one of the bricks in each hand and to move the hands up and down. Suddenly she exclaimed, "I have to move one hand a much greater distance than the other hand!!" Now everyone wanted to try it. This took another 15 minutes or so. Finally, everyone seemed to have shared the revelation that a movable pulley halves the necessary force while it doubles the travel distance. Philosophical remarks entailing how a weak person can double (or quadruple) his strength were discussed in order to bring this physical phenomenon into a larger, that is, human, context. At home, the pupils drew colorful pictures about the day's events in their own notebooks.

On another day, when studying the laws of an inclined plane, we wondered how the ancient Egyptians might have brought their heavy stones to the top of a pyramid. We discussed that the Egyptians might have piled up a ramp, consisting of mud from the Nile River, beside a pyramid on which they pulled their load. This ramp decreased the necessary force compared to a straight vertical lift. We studied the appertaining laws by experimenting with some simple devices, including a cart, an inclined plane, and some weights. The students eventually discovered for themselves that the smaller the slope, the less force is necessary for the lifting process.

On still another day, we investigated the laws of levers. First we constructed a seesaw from a 4 × 4 wooden beam and a wooden block. Then two approximately equal-sized children sat on the ends of the seesaw. After playing with this device for some time, I selected the heaviest boy and a small girl to sit on the opposing ends and we moved the fulcrum closer to the boy. You should have seen the excitement when the balance was eventually reached! Then we moved the fulcrum very close to one end of the beam. Over the shorter end we placed the crossbar between two legs of a table. At first, one child sat on the table and could easily be lifted by someone else pressing on the longer side of the lever. Then another child sat on the table, then another child, and so forth, until the pupils requested that even I had to sit on the table. Still, all of us could be lifted by only one child. We discussed how one person can move a large crowd. Then we talked about other types of levers. The children were allowed to go around the room and onto the school grounds to search for devices that function on the lever principle. It was interesting to observe how many levers they found, such as a nutcracker, a light switch, a clothes pin, etc.

The greatest excitement occurred on the day when we dropped bricks from various heights off a fire escape and measured their descent time. It came to most everyone's surprise that the bricks increased their velocity the longer distance they fell. We found the laws of free fall. We discussed how, hundreds of years ago, Leonardo da Vinci made similar experiments (supposedly involving the inclined tower of Pisa). Then we learned about other inventions and works of art created by Leonardo.

These experiments (and many others) that we performed were quite simple, inexpensive, and "transparent." In my view, there is no need to derive complicated equations in junior high school physics and to make the pupils solve mathematical-physical problems. This can largely wait until high school and college. Such problem-solving often bores the students and eventually drives them away from science or engineering. The main task in junior high schools is instead to bring an awareness of the laws of physics to the younger generation and to excite them.

Today, the children and I look back with a great deal of pleasure and pride when we browse through the class books prepared by each student as part of their homework assignment. No science textbooks were presented to the pupils. Their learning came through observations, experimentation, and by creating their own journals. It is hoped that this experience will plant a seed in these young souls which eventually might cause some of them to want to understand more of the mysteries of science.

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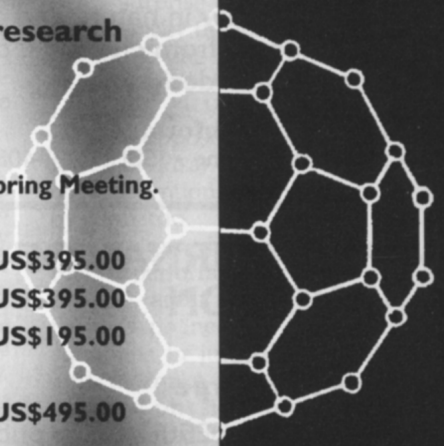

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