The “Acheret” Center and the “Archimedes Fulcrum” Academy

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Background

The effectiveness of the conventional models of education has been a focus of research over the years (Chai & Tan 2009). Passive learning by students has motivated educators constantly to seek innovative ways to motivate students and improve learning outcomes (Marina 2009).

Many education reforms in the world that have been launched since the 1990s (Kim 2004), have been propelled by a strong demand from society that students should learn how to meet the challenges of a knowledge-based and fast-changing society. Students should learn not only subject matter knowledge but also general skills, such as critical thinking and collaborative skills. Moreover, in the past 50 years, major educational policy organizations have emphasized that students should learn by engaging in the thinking processes and activities of the scientists (Mullis et al. 2009). This approach has often been described as inquiry-based teaching and includes students drawing upon their scientific knowledge to ask scientifically oriented questions, collect and analyze evidence from scientific investigations, develop explanations of scientific phenomena, and communicate those explanations to teachers and peers (NRC 2001). Despite this emphasis, the efficacy of inquiry-based teaching has been continually challenged (Kirschner et al. 2006). Critics have argued that its minimally guided approach does not provide sufficient structure to help students learn the important concepts and procedures of science. They characterize the inquiry-oriented teacher as staying in the background while students engage in self-guided, hands-on activities of dubious value.

On the other side, Project- Based Learning (PBL) (Bell et al. 2010) is an innovative approach to learning that teaches a multitude of strategies critical for success in the 21st century. PBL is a student-driven, teacher-facilitated approach to learning. Leaners pursue knowledge by asking questions that have piqued their natural curiosity. The genesis of a project is an inquiry; students develop a question and are guided through research under the teacher's supervision. The student-centered, inquiry-based pedagogical approach of PBL, has been shown to be effective for facilitating knowledge acquisition and retention (Mergendoller et al. 2006; Cohn & Cohn Snir, 2019), supporting the development of important real-world skills such as solving complex problems, thinking critically, analyzing and evaluating information, working cooperatively and communicating effectively (Duch et al. 2001). Further studies have found PBL to engage students and help them learn how to learn (Newman et al. 1992).

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According to these findings and based on teachers' own experience, the Acheret Center ("Acheret" Center 2006) was founded in 2006 by Moshe Reich, a physics teacher and an educational entrepreneur, and is located on kibbutz Cabri (Israel). Acheret (the Hebrew acronym for Multi-Cultural Researchers Fellowship), is a regional center for physics research at HS (High School) level. It associates Jewish and Arab HSs and fosters authentic inquiry in physics in these schools. As part of their advanced physics learning all the 11^{th} and 12^{th} students in the associated schools, conduct a long-term research project (18 months) individually or in pairs. Students meet and work weekly with an advisor who is a physics teacher, an engineer, or a physicist. The advisors have an academic background in physics (at least a B.Sc. in physics or related engineering), but most are not professional researchers, some work also as "regular" physics teachers, and for some this is their first experience in research (Cohn & Cohn Snir, 2019).

Some of the PBL principles defined in the Acheret Center are:

- Both teachers and students conduct research projects in areas in which they do not know a priori all the answers.
- The subject of the investigation has to be related to physical natural phenomena we find in our everyday life.
- In each school laboratory, a library containing inquiry-based consulting books has to be established.
- A PBL website has to be built in order to provide support for teachers and students.

Background (continued)

A series of studies have analyzed the PBL environment. For example, Lam et al. (2010) claim that PBL will have a better chance to bring about the desired benefits for students if teachers have a strong motivation to experiment with it. Previous research has suggested a number of factors that may influence the degree to which teachers will persist in an educational innovation. These can be classified in two broad categories: (a) teacher personal factors and (b) school contextual factors (Abrami et al. 2004; Fullan & Hargreaves 1997).

Previous research showed also that relatedness is one of the most relevant factor to increase people's motivation. For example, Ishler et al. (1998) found that teachers' longterm implementation of cooperative learning was related to their involvement in collegial teaching teams and the support they received from colleagues.

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Taking into account these further findings and acknowledging that teachers, who knew all the answers in their traditional teaching, may now be confronted with a research where both teacher and student are 'stuck', we understood that we needed to build a supporting framework, so that teachers will be able to cope with such situations.

Then, in 2013, the "Archimedes Fulcrum" Academy was established, to train teachers, physicists and engineers so that they would be able to guide students in scientific creative studies, led by Dr. Amos Cohn, the Academic coordinator of Acheret (Arch of Sciences, 2015; Cohn & Cohn Snir, 2019). The Academy includes the following elements:

- **Mutual support** – we established a "guides' workshop": a forum that includes Technion professors, scientists from R&D institutions and retired scientists that were willing to help. They meet with the teachers every week or every two weeks and this cooperation is both successful and characterized by good will.
- **Cooperation between schools in the same region** – we established cooperation between teachers from different schools in the same region, facilitating sharing of laboratory equipment and shared acquisition of new equipment.

In the "Archimedes Fulcrum" Academy, a dialogue-based learning of physical and didactic dilemmas in the guidance of secondary students' projects is emphasized. Different projects that were guided by the Academy guides are analyzed. Teachers learn:

- Mathematical and computational methods
- Computer programs
- Advanced computer-based physics tools
- Didactic principles developed by the Academy teachers

In first year, the teachers are exposed to in-depth physics investigations and they get their first experience in the guidance of students' projects, while being assisted by an experienced Academy guide.

In second year, the teachers independently build an in-depth physics investigation, and they are asked to develop educational materials to be used by physics teachers and guides all over the country.

The present situation

The Archimedes Fulcrum Academy in the Acheret Center was recognized by the Ministry of Education as one of the two Israeli institutions whose students can take the most advanced physics exam for their Bachelor Certificate. The Technion Israel Institute of Technology, a world-known high-ranked higher education institution for science and engineering, more easily admits these students.

Moreover, several studies show encouraging results. For example, Kapon (2016) found that:

- All the students presented understanding of the conceptual, mathematical and empirical aspects of their inquiry.
- The students who formally studied physics at school presented high-level understanding of the experimental procedures involved in the project, and were able to explain the rationale behind the measurements, the detailed procedure and the interpretation.
- The ways in which students described their ongoing work suggests that hey not merely learned scientific content and skills but also internalized scientific habits of thought.
- The students who formally studied physics at school used scientific standards and norms to evaluate the quality of their explanation, claims and measurements.

- All the advisor’s former students expressed a growing interest and passion for science and physics, and a development of agency with regard to these subjects.
- All the students reported working on their project much more than they were required officially by the school.
- The students perceived their contribution to the project as rich, significant and multilevel, and they described the advisor and themselves as collaborators or partners in a joint scientific study.

A case study (Schvartzer & Kapon 2018) wrote that it “provides rich examples of particular authentic practices of doing science: generating testable hypotheses; valuing trustworthy documentation and reporting of measurements; and handling discrepancies between empirical results and the theoretical model”.

They added also, “the discussions between the student and the mentor reflect that both thought of the study as authentic joint research. The mentor was not acting; this was his study too… As the project progressed, the student gradually moved from peripheral to more central participation in the practice of scientific inquiry, adopting the values, practices, and discourse of the discipline”.

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