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Educational concept supporting a renewable energies traning school in africa

Hydrolink

EDUCATIONAL CONCEPT SUPPORTING A RENEWABLE ENERGIES TRAINING SCHOOL IN AFRICA

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A depictive teaching concept for hydraulics and hydraulic engineering has been developed at Technische Universität München (TUM). The concept's principle is the process of perception.Its final step is the application of the learnt subjects. In the framework of an initiative for international knowledge exchange founded at TUM the implementation of the gathered knowledge has been carried out in several hands-on projects in developing countries. There, universities and local people have been involved.

After briefly describing the educational concept and the university collaborations the design of a small hydro power plant for the power supply of a vocational training school for renewable energies is being presented.

Educational Concept

A discovery starts with an observation. The best proof for this thesis is the endlessly cited story of the apple falling down on Isaac Newton's head. Newton, it is said, started thinking of why such things happen, eventually deriving mechanics. Tracing the train of thought even further back it was Plato who deduced the anamnesis. He stated that the immortal soul already knows everything but forgets upon its birth. Humans have to recall their notion through external triggers – percipience. Indeed, without ever taking notice of the stars mankind would never have derived the heliocentric system and the orbits.

Hence, education in natural sciences should always start with the observation, or the sensing in general, of the phenomenon. Through the notion of what is going on one comprehends and deduces interrelated theory. The findings have to be thoroughly questioned and finally applied to certain problems (Rapp, 2012). This goes along with a permanent comparison of experiments and theory.

The approach has been implemented in hydraulics education at TUM. The following example stands for more than fifty simple hydraulic experiments developed for this teaching purpose. The fundamental deduction of the equations is not neglected.

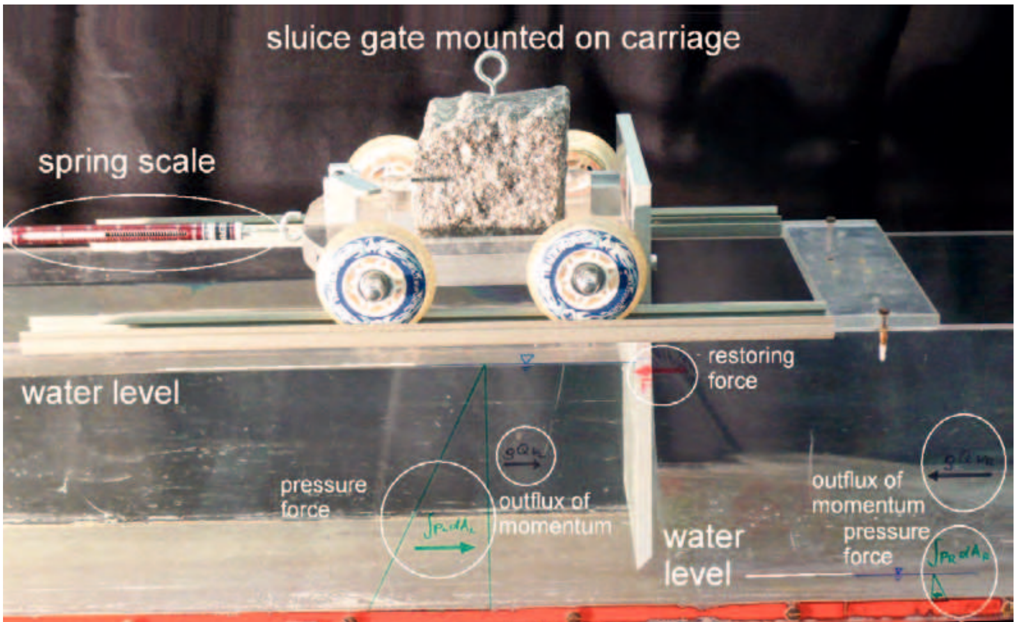

Figure 1 - A sluice gate is mounted onto a carriage with roller skates and placed onto a flume

Observe - A sluice gate is mounted onto a carriage with roller skates and placed onto a flume (see Figure 1). The carriage is fixed with a simple spring scale. When the water cycle of the flume is being started one can see that the carriage moves downstream as the flow rate and water level increase. While the sluice gate moves downstream the spring scale extends. However, at a steady state the sluice gate does not move any further. One can assume that the forces acting on the sluice gate are in balance with the reacting force.

Comprehend - Why has the carriage got to be held? The flow must apply a horizontal force onto the gate and the spring reacts with a restoring force in the opposite direction. Ideally, the force resulting from hydrostatic pressure has been explained before through various examples like in (Rapp, 2012) so that everyone is aware that the hydrostatic pressure increases linearly with depth. The outflux of momentum can be experienced by the students holding their hands in the flume upstream and downstream from the sluice gate. While doing

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so one can even distinguish between sub- and supercritical flow by watching the waves propagating.

Deduce - In theory the forces acting on a structure can be determined with the momentum equation (1), of which Ludwig Prandtl said (Prandtl, 1944):
"The value of these momentum equations is that they reveal conditions at the boundaries only, so that one can reason phenomena that are not comprehended in detail."
A volume fixed in space is being cut free and all forces acting onto that volume to keep it in place and in shape are being marked on the flume's wall. The volume has to be held against gravity for instance or the flow has to be deflected somehow. The forces can be derived through the Cauchy equation.

Question - In the present example the flume has got a width $b = 0.200\ \mathbf{m}$, an upstream flow depth $y_L = 0.176\ \mathbf{m}$ and a downstream flow depth $y_R = 0.020\ \mathbf{m}$. With a discharge $Q = 5.7 \times 10^{-3}\ \frac{\mathbf{m}^3}{\mathbf{s}}$ the spring force results $F = 22.8\ \mathbf{N}$.

$$F = \int p_L dA_L + \rho Q v_L - \int p_R dA_R - \rho Q v_R = 30.4 + 0.9 - 0.4 - 8.1 = 22.8\ \mathbf{N}$$
(2)

The spring scale shows a value of approx. 22 N, which complies in a reasonable manner with the calculated restoring force; however, the question of the discrepancy pops up. The answer can be found in the experiment itself again. The carriage is not placed on the flume friction free and also, in a lesser manner, the friction losses of the flow have to be mentioned as well.
The questioning of the deduction should be continued with appropriate examples, e. g. the restoring force of a nozzle exposed to a flow.

Apply - The application of the findings to new problems is an essential part of the learning process.
Apart from the application to certain assignments the practice of the comprehensive knowledge within a concrete project is mandatory. To do so several hands on student projects have been done at TUM in collaboration with institutions in developing countries. One of these projects is being elaborated in the following.

Knowledge exchange – hydro power project

Developing countries face the challenge to provide rural areas with electricity. According to official sources the rural electrification rate in Sub-Saharan Africa is only 18.3% which implies almost 600 million people without access to electricity in total plus approximately the same number in Developing Asia; in Latin America there are still 24 million people without power (IEA, 2013). Since energy is the precondition for socio-economic progress as it forms the basis of education, basic social and health services as well as economic growth, this fact heavily reduces chances of local development. On the other hand the above mentioned regions have an enormous potential for small hydro power plants. In Western and Middle Africa the installation/potential ratio is 11% and 23% respectively, whereas Western Europe reaches 87% (Liu, et al., 2013).

One of the integrated projects that were followed in the framework of the initiative is the design of the electricity supply for a vocational training school for renewable energies at the northern foothill of Foumban, Cameroon (Rapp, et al., 2012a). The project's scope is diverse. Firstly, the generated electricity shall supply the school and its workshops with electricity. Secondly, people living close to the planned plant who do not have access to the power grid shall be connected to satisfy their basic needs. Thirdly, a curriculum for renewable power generation with theoretical and practical lessons shall be created for the vocational school. And finally the plant is meant to serve as an example for the course. For these reasons an easy but depictive layout is aimed for. The overall paradigm is an ecofriendly design. The feasibility of various renewable energy systems has been assessed during a field trip. The high regional hydro power potential which is a consequence of the reliable and extensive rainfall and the topography, the relatively low costs and the ecological friendliness have made it first choice.

Such projects can only succeed if future associates, residents and local authorities are involved from the beginning on. The people have to identify themselves with the proposition and they have to be involved. Moreover, decisive concerns are legal and administrative issues and yet knowledge of place. Additionally, the mutual exchange implies benefits and precious experiences for both sides.
Collaboration has been set up with ADEID, a Bafoussam based non-profit organization.
The proposed site is located in the proximity of the school plot where a small weir (max height approx. 1.5 m) already exists (see Figure 2). In the concept a 100 m long penstock with a gross head of 8.5 m will feed a crossflow

Prince Sultan Bin Abdulaziz International Prize for Water

Recognizing Innovation

Winners for the 6th Award (2014)

Creativity Prize: The prize is awarded to the team of Dr. Eric F. Wood and Dr. Justin Sheffield (Princeton University, USA) for their development of a state-of-the-art system for accurately monitoring, modeling, and forecasting drought on regional, continental and global scales.

Creativity Prize: The prize is awarded to the GPS Reflections Group led by Dr. Kristine M. Larson (University of Colorado, Boulder), and including Dr. Eric E. Small (University of Colorado), Dr. Valery U. Zavorotny (NOAA) and Dr. John J. Braun (UCAR), for their discovery that standard geodetic GPS instruments are sensitive to hydrological influences and their subsequent development of a new, unexpected, and cost-effective technique, GPS Interferometric Reflectometry (GPS-IR), to measure soil moisture, snow depth, and vegetation water content.

Surface Water Prize: The prize is awarded to Dr. Larry W. Mays (Arizona State University, USA) for his comprehensive work in surface water hydrology and water resources engineering, culminating in three leading and innovative textbooks in the field, and for his applying this extensive knowledge base to develop optimization models in practical hydrology for current problems, including real-time optimal dam release during flood conditions and watershed development in urban areas.

Groundwater Prize: The prize is awarded to Dr. Jesús Carrera Ramirez (Institute for Environmental Assessment and Water Research (IDAEA), CSIC, Barcelona, Spain) for contributing decisively to the development of mathematical hydrogeology and transport modelling in groundwater systems. As a result, he has helped in the quantitative identification of the mechanisms and possible solutions for the globally critical problem of seawater intrusion and water salinisation in arid regions, as well as making advancements in the reliable prediction of the long-term fate of pollutants in environmental systems.

Alternative Water Resources Prize: The prize is awarded to Dr. Polycarpos Falaras (National Center for Scientific Research "Demokritos", Athens, Greece), coordinator of the European Union's CLEANWATER Project, for developing a novel water detoxification technology by taking advantage of solar light and advanced titania photocatalysts combined with ceramic and composite membranes.

Water Management and Protection Prize: The prize is awarded to Dr. William W-G. Yeh (University of California, Los Angeles, USA) for pioneering the development of optimization models to plan, manage and operate large-scale water resources systems throughout the world. His methodology, and the algorithms he developed for the real-time operation of complex, multiple-purpose, multiple-reservoir systems, have been adopted in a large number of countries, including the United States, Brazil, Korea, Taiwan and the People's Republic of China.

Nominations are open for the 7th Award. Nominations can be made online until 31 December 2015.

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Figure 2 - View onto the existing weir from downstream and overhaul measures

turbine to generate about 15 kW (approx.. 120.000 kWh/a). A hydrological approach has been developed to cope with the scarce data available.

Turbine - Various reasons have contributed to the distinct decision for a crossflow turbine. They are robust, relatively unsophisticated, easy to maintain locally and, most importantly, they are designed and optimized for these site parameters. Furthermore, crossflow turbines deal with comparatively low velocities wherefore they are not prone to sediment-induced abrasion and cavitation.

Constructional tasks - The weir capturing approx. 10.000 m³ leaks at several spots (see Fig. 2) what makes an entire overhaul mandatory. An intake structure, the penstock on the left embankment and a small power house will be erected.

Ecological and social impacts of the plant - Special emphasis has been placed on the ecological and social impact and an improvement of the current situation. The dimensions of the weir will stay untouched to exclude negative effects on flora, fauna and flood security. Endemic fish species like cyprinids and catfish will be prevented from entering the penstock and the turbine by a fine rack at the intake structure.
What electricity means to people living in rural Africa can best be examined in William Kamkwamba's book (Kamkwamba & Mealer, 2009). The Malawi uneducated brilliant engineer has brought electricity to his village by means of a self-designed wind turbine made from scrap. Electrical power is the foundation of development and therefore the hydro power plant for the supply of a vocational training center on renewable energies is being regarded as a local lighthouse project.

Conclusion

In this contribution an educational concept for an international knowledge exchange project has been presented. The application of theory through a concrete hydro power project for the benefit of the local population has been shown. Unfortunately, administrative decision for the hydro power plant has not been approved yet. Mutual support, knowledge exchange and collaboration are the keywords of the Association's projects conducted for instance in Jordan, Ecuador (see Fig. 3 and 4), Mozambique and Tanzania. For more information see: www.knowledgExchange.org

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Figure 4 - Tibi, Ecuadorian Indigena carrying a showcase model of a water wheel that illustrates the functional principle of hydropower


Figure 3 - German and Cameroonian student surveying the site