



Use of virtual research laboratory prototype in environmental education

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A problem of making education relevant to the workplace tasks is a key problem of higher education because old-school training programs are not keeping pace with the rapidly changing situation in the professional field of Earth system sciences. To meet this need educational process within the "Climate" system (<http://climate.scert.ru/>) is implemented in light of the new "research" educational paradigm, which is opposed to the traditional – "informative". Its essence lies in the shift from assimilation of thematic information to training of mental skills that allow resolving problems arising in the domain of Earth system sciences.

A joint group of specialists from Tomsk State University and Siberian center for Environmental Research and Training/IMCES SB RAS developed courses for students of "Climatology" and "Meteorology" specialties, which comprises theoretical knowledge from up-to-date climatic sciences with relevant computational tasks. The hands-on approach is realized through development of innovative trainings, containing practical tasks on climate modeling and climate changes assessment and analysis, which are performed using the information-computational web-GIS platform "Climate" (<http://climate.scert.ru/>). The platform is considered to be a prototype of virtual research and educational laboratory.

The approach is to combine a set of thematic courses of lectures with modern trainings which are developed by our team in accordance with up-to-date tendencies in Earth system sciences. Students have to make their computational tasks on climate modeling and climate changes analysis and assessment using typical tools of "Climate" system which are aimed at use by real-life practitioners performing such kind of research. Trainings are based on technologies and procedures which are typical for Earth system sciences. The courses are designed to permit students to conduct their own investigations of ongoing and future climate changes in a manner that is essentially identical to the techniques used by national and international climate research organizations , e.g. IPCC.

To organize the educational process we use an open-source course management system Moodle (www.moodle.org), so-called virtual learning environment which is used to create effective online learning courses.

The main theme of the developed course (<http://climate.scert.ru/resources/courses/>) is a comprehensive analysis of the climate change and its possible consequences. The topic is covered in the lectures "Monitoring and projecting of climate change" and the two computing trainings: "Analysis of regional climate change" and "Analysis of future climate". It also contains an information kit, which includes the usual list of recommended reading, enlarged by the files of many publications, the distribution of which is not limited by copyright law. Calculation exercises are designed to consolidate students' knowledge of discipline, to instill in them the skills to work independently with large amounts of geophysical data using modern processing and analysis tools of web-GIS system "Climate". The results obtained on laboratory work are presented as reports with the statement of the problem, the results of calculations and logically justified conclusion.

The developed courses have been used to prepare bachelors of meteorology and hydrology in Tomsk State University for two years now. The results received show that the proposed educational approach allows making students acquainted with the basics of actual climatic science and offers practical experience, increases students involvement, advances the use of modern information and communication tools. Thus it allows preparing the next generation of scientists to grapple with complex climate issues.

The approach is quite general and can be used in areas where the work with georeferenced environmental data is needed.