

# CURRENT SCIENCE

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EDITORIAL

## Teaching Earth science – past experience and the way forward\*

Over the last 50 years, a period of which I have personal knowledge, Earth science teaching in both undergraduate and graduate levels has seen drastic changes keeping in line with new perceptions about the subject as such. It is time that we take a stock of the situation, assess carefully the lacunae and undertake course correction for the future. Gone are the days when we were learning about geology and geophysics as independent curricula, divorced from each other, as well as from the other phenomena that interacted with the solid Earth. Integration was neither planned nor executed. The divisions of subjects into ‘Honours’ and ‘pass’ or ‘major’ and ‘minor’ were arbitrary and damaging, as these clearly identified what we should learn seriously and what we should learn just as a requirement for course fulfilment. No wonder we produced many graduates who could not think in a holistic manner and many students were clueless about interlinking of natural processes. Earth science, being a natural science, must be curiosity-driven and nature does not discriminate between the artificial divisions we have imposed in the course curriculum. We should also introspect about the seriousness with which we have attempted to address the problems. A ballpark estimate of the number of brain-storming sessions discussing Earth science curricula versus those addressing research questions or research directions will be heavily biased towards the latter. This is despite our common sense that a well-taught graduate student would be better placed for a successful in research career.

The Earth science curriculum was drastically altered after 1970s, as the revolutionary paradigm of plate tectonics completely changed our perception of processes that govern most of the phenomena, driven by mantle convection and manifested in surface features of the Earth. The coupling of the interior of the Earth with processes that operate on its surface, including both the continents and ocean basins, and with the Earth’s atmosphere became apparent and due cognizance was taken in framing the curriculum. A changeover from a broadly descriptive approach to a process/mechanism-driven orientation took place. The palaeobiological world has similarly dramatically changed from its

earlier avatar. Subjects such as molecular palaeontology and genetic chronology have added a new edge in studies dealing with the origin of life, astrobiology and the convergence of fossil and evolutionary lineages based on genetic chronology. Topics of recent interest include fossil biomechanics and the role of gravity in the evolution of plants and animals.

Our concern for the environment and sustainability promoted further changes in the curriculum, as more emphasis was given to the interactions between the different spheres of the Earth, namely geosphere (solid Earth)–atmosphere–biosphere–hydrosphere–cryosphere in a holistic manner, and thus emerged the concept of Earth system science. The strong emergence of environmental sciences reflecting societal concerns was a turning point, as it overlapped considerably with Earth system science. I am not sure, however, that induction of environmental studies in schools, without proper scientific introduction of the interacting components that constitute the environment, was particularly helpful for the students. This must have increased awareness, but not with proper scientific justification. Thus, Earth system science is a borderless science requiring judicious application of physical, chemical, biological, mathematical/computational sciences. Hence the curriculum cannot relegate these subjects as ‘also taught’. Rapid improvement in computational facilities meant that Earth science could become more quantitative in approach. Simultaneously came some major downsides, such as field work or training that used to provide broad scientific questions in natural science, started getting neglected. Another example is related to the scale of observation and gleaning information from mesoscale to microscale study of natural specimens of rocks and minerals. The classical art of petrography has become ‘old-fashioned’ and students in many institutions are not properly trained. Quantification should ideally follow broad qualitative understanding of the entire gamut of interactive phenomena that constitute a scientific question.

Increased incorporation of other scientific disciplines in the Earth science curriculum allowed students to carry out some amount of forward modelling, deviating from the traditional inverse modelling adopted by geoscientists. The Earth science curriculum took another twist in the last

\*The views expressed herein are the author’s own and written from an Indian perspective.

few decades as the question of societal benefits of scientific teaching took centre stage. It was realized that the curriculum must address societal relevance and the need to emphasize why it should be taught mostly at the expense of taxpayers. Therefore, issues related to societal concern were added in the curriculum. Subjects like medical geology and forensic geology came into existence and have received fair response in some countries. India is yet to diversify in these directions on a large scale. Climate change and geohazards are obvious concerns of the society in general, and naturally have received huge attention in the curriculum. The repeated occurrences of hazards such as those at Kedarnath (2013) and Chamoli (2021), among many others in recent times, have emphasized the importance of paying serious attention.

Introduction of credit-based choice system (CBCS) and enlargement of its scope in the New Education Policy are helpful for students of Earth system science to get a holistic view. While such diversifications are welcome and have been successfully integrated in major teaching institutions, the same cannot be said about remotely located smaller institutions. I am aware of situations in small institutions, where it was difficult or even impossible to offer sufficient choices to the students because of infrastructural problems. My understanding is that we will need some more time to draw a balanced approach.

This brings us to face an uncomfortable question: were/are the educators, particularly those from the 'old school', competent to handle the conceptual change and train later generation of students? This was a huge challenge, especially in institutions which could not manage proper recruiting. These institutions faced considerable difficulties in enforcing CBCS curriculum because of infrastructural issues. For well-endowed institutions this was not acute as they have a dynamic recruitment policy and could entice well-trained personnel, both from India and abroad. Even at these places, there exists a tendency to teach the research problems of the respective teachers, ignoring the need for overall development of students, thus producing students with a narrow vision. Clearly some introspection is needed here.

Any policy on higher education must take into cognizance about the wide disparity in the available academic resources (including adequately trained manpower) and infrastructural facilities in a vast country like ours. Uniform implementation is an extremely difficult task. We often talk about the deteriorating standards of teaching in undergraduate colleges and state universities that produce bulk of the graduates, without trying to understand the reasons thereof. While the creation of elitist teaching institutions is always welcome, there is no reason to neglect existing facilities.

Highly deplorable conditions in many famous undergraduate and graduate institutions are a common knowledge. Many such institutions have suffered from lack of

facilities or maintenance of existing facilities, nepotism and inbreeding in appointments, and lack of administrative encouragement and support. The problem is acute for Earth science teaching as a moderate amount of sophisticated instruments, such as optical microscope, is necessary to impart even basic training. Financial support is necessary for field work, especially for needy students. Establishment of career-advancement schemes for teachers was a welcome move, but its implementation left much to be desired. Collectively, all these contributed to mediocre teaching and production of many graduates, who were clueless about the future. Nurturing such institutions should be a first-order priority, particularly in a populous country like ours. Needless to emphasize that recruitments in teaching institutions affect several generations of students, and, therefore, utmost care is called for. Since these institutions are autonomous bodies, they should themselves introspect and identify what went wrong. Teachers in such institutions need institutional motivation and everything should not be left to self-motivation.

We have already delayed much in introducing a proper Earth science curriculum in high schools, which should be top priority in our system. This would enable us to have a bunch of motivated school passouts, who are aware of the subject and will be in a position to consciously choose a higher education in Earth science. Given the strong influence Earth science has on the society in terms of energy, resources, climate change, environment and economy of the nation that decide its sustainability and growth, it certainly deserves a better treatment. Unfortunately, so far our endeavour has been restricted to a few invited lectures in programmes like INSPIRE, high-school student conclaves and popular exhibitions on important occasions or visits to laboratories by school students on designated days. While popularization of Earth sciences in young minds should remain on top of the agenda, perhaps a more serious look at the scientific aspects is overdue.

In summary, a dynamic course curriculum clearly bringing out the interactive and intricate relationships between different components of Earth system science with emphasis on training in physical, chemical and biological sciences, a right mixture of the traditional material and new challenges, support for the large number of less-endowed institutions and an early introduction of Earth science as a subject is the way forward. The importance of Earth system science cannot be underestimated if we want to achieve the United Nations mandated Sustainable Development Goals by 2030.

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