Integrating Concepts and Skills Through Design of Learning Activities

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Understanding physical geography involves graphicacy as well as cognitive skills and concepts from the domain of science and mathematics. Empirical data necessary for formulating teaching strategies that develop students' skills, or for developing appropriate instructional materials, is however inadequate. Moreover, pedagogic content knowledge of practicing teachers needs to be developed for facilitating effective learning of physical geography. A research approach involving an informed design of pedagogic innovations can provide the means for addressing these concurrent issues of practice. Hence, learning activities are designed for integrated development of graphicacy skills and transdisciplinary concepts; particularly involved in understanding the physical processes associated with rain. The design and planning of the learning activities has involved a synthesis of educational theory and pedagogic content knowledge of physical geography. This paper discusses the details of this prospective pedagogic design; evolving through reflective practice. Learning activities are found to provide the context for explicating the significant elements of student learning, with the corresponding teacher knowledge.

Perspective

The pedagogic content of physical geography draws upon concepts and skills in science and mathematics. Notably, understanding of geography involves graphicacy including map reading and visualization of diagrams; as well as graphical data interpretation. Yet, the content knowledge of social studies' teachers in Indian secondary schools needs to be developed substantially, to facilitate explanations that are meaningful, interesting and relevant to students' daily lives. Moreover, geography is one of the least liked subjects in secondary schools in India (Chunawala & Pradhan, 1993). Such limiting factors problematize the teaching and learning of physical geography. In general, the organization of conventional school education into separate disciplines like science, mathematics, social studies, etc., limits students from having an integrated perspective of knowledge. There is also inadequate pedagogic support for the essential development of students' skills (Downs & Liben, 1991).

The National Curriculum Framework (NCF 2005) suggests that Indian school education should move beyond high-stakes examinations based on information-loaded textbooks. Yet, most textbooks have informative treatments of geography (Warf, 1999) and therefore are insufficient for effective learning of physical geography. Hence, there is a need to develop and utilize good quality instructional materials (Dunn, 1992).

Empirical data necessary for underpinning practical decisions about instructional material development, and teaching strategies, is however inadequate. Downs (1994) has urged that to build an understanding of essential phenomena, and to have an impact on what goes on in classroom lessons, the approach to research in geography education has to be integral to the practice of geography teaching. Pedagogic inquiry needs to be conducted while analytically engaging with the conceptual content of the teaching (Shulman,1986).

Objectives

- Design of learning activities for integrated development of skills and concepts; in an exemplar case, for understanding the physical processes associated with rain

- Reflection by the researcher-teacher on the classroom interactions while con-ducting the learning activities

Nature of Study

Iterative design experimentation (Figure 1) is being conducted in the context of using purposeful learning activities designed for explanation of the physical processes associated with rain. The pedagogic framework of the learning activities has involved a synthesis of educational theory and content knowledge of physical geography, with careful planning. The design of learning activities is evolving through reflective teaching practice for integrated development of students' graphicacy skills and transdisciplinary concepts.

Learning Activities

This paper discusses the prospective design of the learning activities; the focal point of this study. The learning activities are designed in a context of physical geography, to facilitate student's cognitive involvement with the conceptual content through guided use of their developing skills.

Student Skills

Skills are involved in construing meaning of symbols used for conveying the conceptual content. These skills fall under broad categories namely literacy, numeracy and graphicacy. Literacy includes understanding terminology and explanations using words. Numeracy includes understanding mathematical notations for communication using numbers. Graphicacy refers to the educated skills of map reading, visualization of diagrams, etc. Balchin (1970) points out that graphicacy is the most distinctive geographical form of intellectual communication.

In this study, graphicacy is considered to include graphical data interpretation, as it is somewhat distinct from the numerical and verbal abilities and indeed depends on the *'visual-spatial ability of intelligence'* (Balchin, 1970). Students' inquisitiveness is promoted for student involvement in learning. Hands-on skills are included in the formative assessment of students' 'understanding in work'. Moreover, the learning activities also touch upon the important critical thinking skills of analysis and synthesis, whose neglect in school education is a serious lacuna. Broadly, there is a need to identify competencies and values for nurturing students at various stages in school education (NCF 2005).

Learning activities are designed, in this study, to involve students in 'learning through use' (Ainley et al., 2006) of a variety of skills, especially graphicacy. The teaching aims at developing students' skills, which are also requisite for understanding. The conceptual content for explanation of the physical processes associated with rain, provides the context.

Pedagogic Content

Lesson units have been planned for teaching each of these processes, in the following sequence.

1. Evaporation: Misconception studies (Henriques, 2000) reveal that evaporation is conceptually vulnerable. Hence, clarifying questions are framed for a comprehensive explanation of the conception of evaporation. For example, does evaporation occur at night? In what ways does evaporation depend on insolation (i.e. solar radiation on the earth's surface)? Pedagogic interactions are interspersed with a student activity involving calculation of the percentage composition of air, given the number of molecules of important constituents, including moisture/water vapour (see Figure 3a).

2. Saturation: Students are familiarised with the saturation of humidity in the atmosphere, as they plot a graph of maximum absolute humidity corresponding to various temperatures. Students are also given appropriate feedback for developing their graph plotting skills.

3. Convection: Convection is explained in terms of buoyancy of warm moist air. The saturation humidity graph that students have plotted is used as a resource for applying the concept of percentage to calculate relative humidity (RH) at a few temperatures. This is followed by discussion of how the increase in RH with decrease in temperature leads to the saturation of humidity with

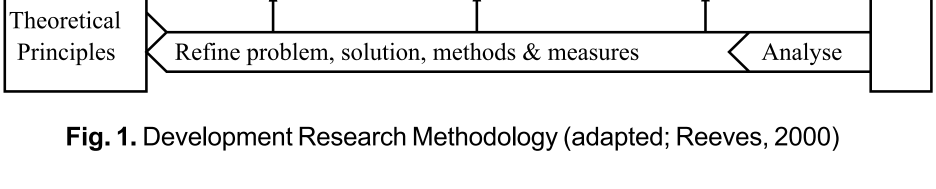


Fig. 1. Development Research Methodology (adapted; Reeves, 2000)

the convection of air up the troposphere.

4. Condensation: Pedagogic interactions happen in the context of a demonstration of the condensation of mist, when air is exhaled on a cold mirror. Students are guided to relate the process of condensation with the saturation of moisture in the air. Students can verify the saturation of water vapour in the exhaled air, at the temperature of the cold mirror, by comparing the percentage composition of the exhaled air with their saturation humidity graph. These observations are related to cloud formation, in further discussion.

5. Precipitation: Students are guided to observe that the mist on the cold mirror surface aggregates and trickles down as water droplets. Further, students are guided in visualizing the cyclical transformations of atmospheric H_2O through the processes of evaporation, convection, saturation, condensation and precipitation. Orogenic precipitation (caused due to mountain slopes) is studied with the help of a diagram, while treating wind flow up the mountain as a case of forced convection.

6. Rainfall distribution: Students construct the relief model of India by synthesis of the information from their textbook, given in the form of a relief map of the Indian subcontinent specifying the elevations at various areas, and a diagram representing a schematic cross-section of the major feature – the Deccan plateau.

7. Students are involved in the analysis of maps of India showing the spatial distribution of rainfall. They have to relate this distribution to the process of orogenic precipitation with respect to the relief model. Students also study the temporal rainfall variation, in say Mumbai, by plotting a rainfall histogram (Figure 3b).

Pedagogic Framework

There are involved temporal and spatial relationships among the physical processes that are to be studied. However, in this pedagogic design, the above learning sequence has been useful. The subject matter to be learnt has been embedded in learning activities, with purpose and utility for the students (Ainley et al., 2006).

The details of the lesson plans given above reveal the coherence and continuity of the learning activities (Brophy, 1999). For example, the saturation graph plotted by students is further used for visualizing condensation with decrease in temperature.

Students are given opportunities to learn and apply concepts and skills in a meaningful progression (Vosniadou, 2001). For example, the revision of the concept of percentage as ratio is followed by its application in the calculation of relative humidity.

In the emerging paradigm, the characteristic curriculum elements are as follows.

1. Syllabus: purposeful activities with integrated content

   The learning activities are considered as dynamic entities; always adaptable to the local context with formative and reflective evaluation.

2. Pedagogy: conducting meaningful pedagogic interactions that are responsive and facilitative to student learning activities.

   The pedagogy uses content knowledge and elicits local knowledge for explaining and questioning, and guides students in the practice of developing skills.

3. Assessment: timely feedback to students through formative assessment of understanding in work

The chosen convenient sample of about 50 students is a grade 9 classroom from an Ashram school (Residential school for tribal students) located in the Sahayadri mountain ranges of the state of Maharashtra, meant for providing educational opportunities to socio-economically underprivileged children. The data for this paper is taken from the initial 6 sessions totaling approximately 10 hours. The classroom interactions are characteristic of the learning ecology, as depicted in Figure. 2, which is viewed as a paradigm case of learning activities. Figure 2 reveals the potential symbiosis in the learning ecology. The participating elements are depicted in terms of dynamic entities which are measured. An arrow depicts the influence of one element on the other. A solid arrow depicts the measurement of the influential element through the element to which it points.

Evaluation

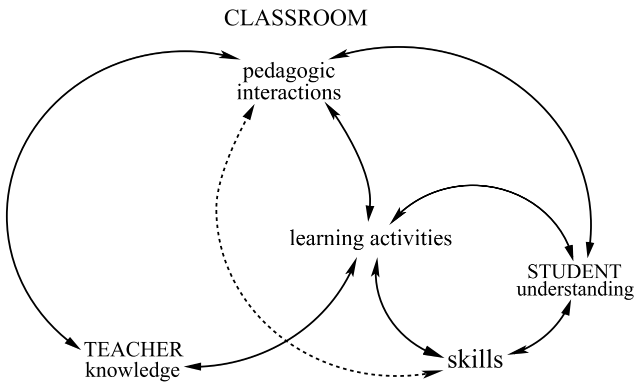
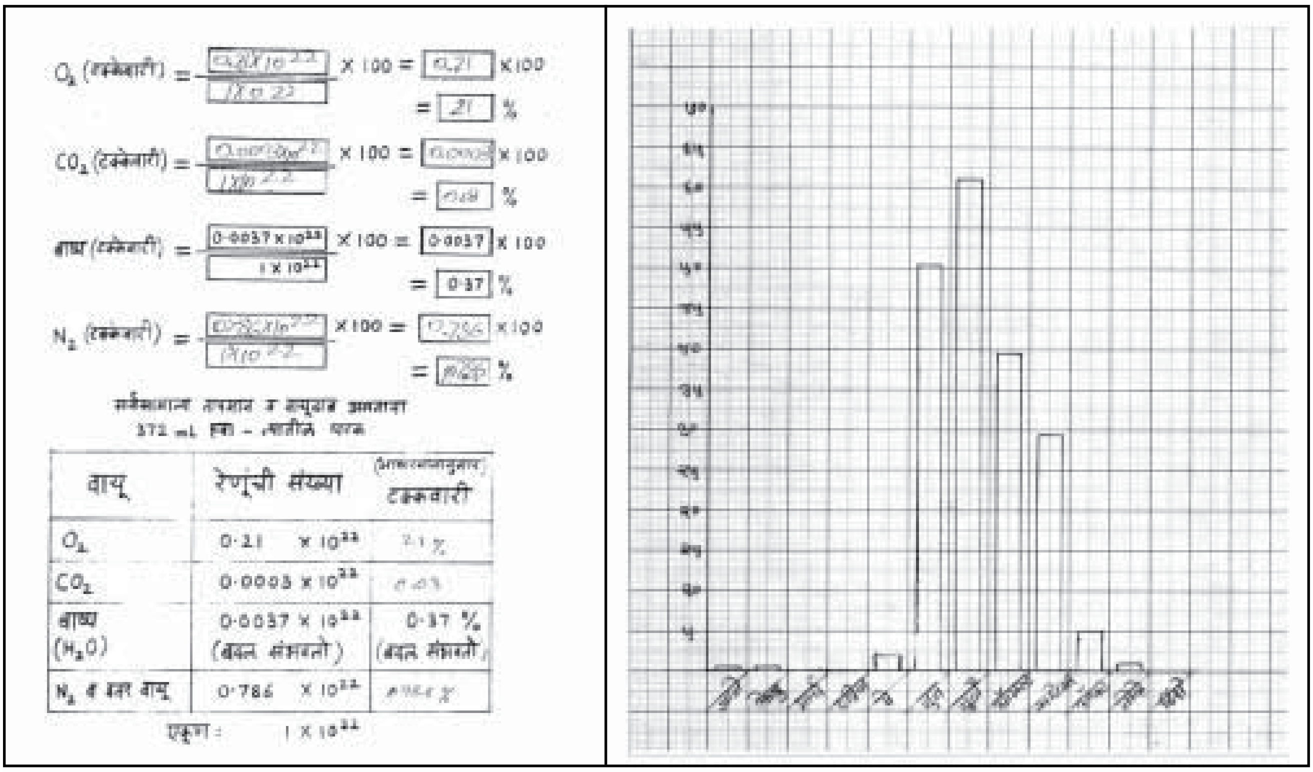


Fig. 2. Learning ecology model



a. Percentage calculation

b. Rainfall histogram

Fig. 3. Two examples of student worksheets

The pedagogic assessment of the learning activities constitutes "adequately documenting the learning ecology" (Cobb et al., 2003). The effectiveness of the learning activities and pedagogic interactions is measured in terms of questions, explanations, individual or chorus responses and performance of skills. Data sources include experimenter-teacher log, audio and video recordings of classroom interactions, lesson plans and student worksheets. Qualitative data analysis is coordinated at multiple levels, viz., student involvement, student learning and practical, dynamic teacher knowledge.

Field Experiences

Here we look at some empirical insights emerging from preliminary data obtained during the ongoing development research.

Scientific terminology can become a constraint for meaningful explanation. It is found that a word like 'cross-section' in the context of a diagram, meaningful to the teacher, may not be appropriately understood by students. Hence, an explanation in which such terminology is repeatedly used is not meaningful to some students. It was formed similarly that the use of the word 'ratio' did not necessarily clarify students' understanding of the concept of percentage.

While teaching the process of evaporation, a practical contingency emerged while guiding the student activity involving calculation of percentage composition of air (Figure 3a). Quite some time had to be devoted for explaining the concept of the decimal point, to enable students to correctly perform the multiplication of decimal fractions by 100. However, this discussion depended on the teacher's knowledge of the requisite mathematical terminology, especially in the language of instruction, Marathi which is the official language of the state of Maharashtra in India.

Teacher knowledge of the details of what students are to do in an activity, e.g., the steps for plotting a particular graph, is necessary for defining appropriate sub-goals for students. The pedagogic issues involved in teaching graph plotting are being explicated in this study.

Graph Plotting Pedagogy

Plotting line or bar graphs involves some decision making. Given tabulated data of numerical values for two variables, the students have to decide the (dependent) variable, which they will plot, say, on the Y-axis. The students have to decide appropriate numerical scales for an efficient data plot. Plotting a data point involves suitable approximation of the numerical value, e.g., 26.7 may have to be approximated to 26.75 or 26.6 depending on the chosen scale. The teacher must understand such numerical nuances to be able to guide different work. Moreover, it has been found that the teacher should have arithmetic expertise for flexibly moving from one explanation based on a numerical scale with a least count of 0.2 to another student's doubt based on a different scale whose least count the teacher needs to quickly gauge. The teacher also has to be attentive to decide when (s)he can provide a common explanation to the class and when to give individual explanations to different students. In this context, individual attention is experienced to be vital; large class size turns out to be an unwarranted constraint.

Teacher knowledge of appropriate performance strategies for a learning activity is also required for guiding different work. For example, the teacher needs to know why and when to ask students to reconsider their choice of the numerical scale while plotting a graph. To gradually develop this skill, graphs involving one nominal variable, e.g., months of the year, have been found as good starting points for facilitating students to focus on numerical issues along a single dimension. For example, a rainfall histogram shown in the school geography textbook (Maharashtra Textbook p.34, 2007) can be redrawn by students (Figure 3b). The graph plotting activity is found useful for developing students' appreciation for visualization of patterns in numerical data required for meaningful interpretation of graphs.

Concluding Remarks

Educational theory does provide insights about learning conditions that can be productive, but these are not commonly practiced. This study provides an exemplar of an evidence based practice of reflective teaching in an integrated learning context that is essentially activity-based.

The thematic learning activities developed during this research study will serve as an exemplar to enrich and improve the teaching of physical geography in secondary schools. A teaching strategy is evolving, which develops students' skills and facilitates active cognitive engagement of students in understanding explanations involving the integrated content. The theory driven design of innovations thus enables us to create opportune learning conditions, so as to conduct empirical educational research for understanding how, when and why they are effective.

Learning activities, in this study, provide the context for explicating and addressing the needs of student and teacher learning. "Such findings provide insights into the complexity involved in developing knowledge and skills, and they help us understand the role that teachers play in capitalizing on the affordances of learning materials, but they could easily have gone unnoticed had the research focussed solely on the summative effects of the intervention." (The Design-Based Research Collective, 2003)

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