

5 Summary and Discussion

As first step in this study, Scientific Computation Literacy was conceptualised and developed as a means of achieving - in a meaningful, purposeful and comfortable manner, and primarily from a learner’s perspective - specific Scientific Literacy and Computer Literacy objectives. The scientifically-oriented characteristics and computer-based resources of the System Dynamics methodology were suggested to provide the mechanisms by which our notion of Scientific Computation Literacy may feasibly be promoted.

A preliminary requirement that needed to be met was the establishment of the significance of scientific computation in the curriculum, i.e., the domain and processes encompassing Scientific Computation Literacy, the educational issues inherent in the learning of the scientific content and the computational features underlying our notion of scientific computation, and the role of System Dynamics within such mechanism. The following diagrams - Fig 5.1 and Fig 5.2 - define our domain of Scientific Computation Literacy and illustrate the structural features of how the mechanisms of System Dynamics were conceptualised and developed to achieve the objectives of Scientific Computation Literacy, respectively.

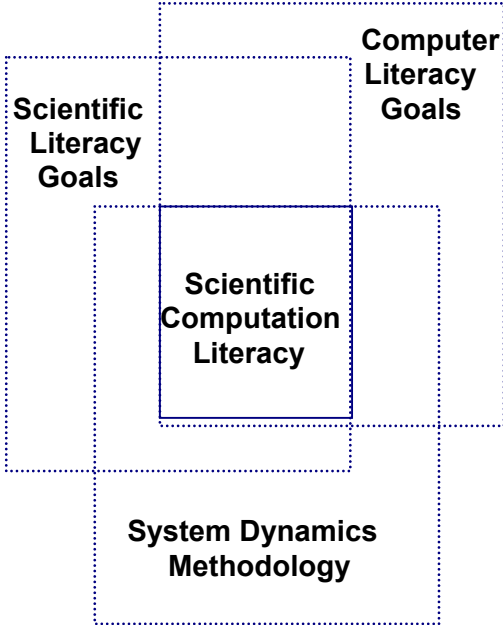


Fig. 5.1 The Domain Of Scientific Computation Literacy

In **Fig. 5.2**, 1 outlined the operating domain within which traditional Scientific Literacy and Computer Literacy objectives - pitched at our

particular (pre-university) level - may be defined, and which was to be modified to include the notion of Scientific Computation, the interaction with System Dynamics and the development of Scientific Computation Literacy. The appreciation and/or promotion of scientific reasoning and algorithmic thinking skills are considered desirable goals within Scientific Computation Literacy. 2 designates the path taken by the "Glass-Box" approach hypothesised and adopted in this study in contrast to 3 - the path considered to be taken by the "Black-Box" approach and underlying systems such as STELLA, MODUS and others. A particular learning environment envisaged in terms of the objectivistic-to-constructivistic inclinations of science learners was conceptualised to assess the degree of receptivity of System Dynamics in science learning. These particular features of the study characterised the content of CHAPTER 1.

In CHAPTER 2, the parallels between the scientific component of System Dynamics and aspects of scientific method were explored in an intuitive and tacit basis. Scientific problem-solving was shown to be promoted through the development of constructive and intuitive intellectual strategies and on the organisation of information that are inherent in System Dynamics. The framework for such organisation, drawing on elements of systems thinking - in contrast to reductionism that characterises much of current science education - and upon structuring principles derived from elementary Cybernetic science metaphors and techniques, was observed to provide the process and the interlocking concepts as well as a solid support for diversity.

The development of an educational value-base was considered in the light that any innovation in science education, seeking to provide learners with intellectual abilities and social values relevant to the scientific world of the future, encourages respect for nature and society and precludes the pursuit of ideas that could possibly be dangerous in their wider context. As such is suggested a scientific methodology that looks at the whole as well as the parts, and at qualities as well as quantities, and one that cultivates the intuitive as well as the analytical way of pursuing knowledge.

The resources provided by the "LIMITS TO GROWTH" and "BEYOND THE LIMITS" reports - based on information acquired through application of System Dynamics - were seen as appropriate and significant in this respect. Scientific reasoning skills are, consequently, regarded to have significant potential for development through the learning and adoption of an alternative approach, and further research to assess the magnitude of such potential may be of particular interest.

In CHAPTER 3, computational skills have the potential to be acquired through the model-verification, debugging and model-validation procedures that form the rudiments of the computer simulation procedure. The role of the computer as a tool and as a synthetic laboratory, the

activity of programming and the domain over which the programming language DYNAMO operates is clearly defined. In contrast to PASCAL and LOGO, DYNAMO - being a special-purpose, functional-programming language - provides an environment which offers a good chance of exposing the algorithmic and the computational sequences - and, thereby, narrowing down the problem-solving task - and which is created through the employment of a communication system which is simple to learn, easy to use and designed for the task. The underlying algorithms and their formulations are tried out through concrete examples from Biology, Chemistry and Physics. Here again, a scientific computation culture, in which algorithmic thinking processes can be promoted through the conjunction of programming activity and manipulating and visualising scientific data - in distinct contrast to the shifting of the focus of the computer culture from programming to the manipulation of simulations - characterises the computing environment; further research as to the extent to which this can be realised could also provide valuable information.

In the attempt to assess the degree to which involvement with the mechanisms of System Dynamics - presented as an adjunct to a regular scientific studies program - can influence pre-university science learners' personal attitudes towards computer-oriented science learning and their epistemological commitments, the empirical surveys in CHAPTER 4 indicate that no distinct visions could be gleaned. There were, however, clear indications to suggest that:

- amongst learners harbouring a negative or unhappy association with conventional science education, System Dynamics has strong potential to revitalise their involvement with science learning and to modify their attitudes towards science in a particularly positive manner;
- particularly amongst academically-oriented learners, specific scientific literacy notions - scientific method and scientific problem-solving through modelling in particular - and computer literacy objectives - such as the appreciation of computer as a tool and the significance of the computational process - were made significantly more visible and/or, respectively, more appreciative as a result of interaction with System Dynamics; some clearly acknowledged the role of computers in making inductive solutions possible or easier.
- academically- and scientifically-oriented learners - in particular those subscribing to an objectivistic epistemology - consider the intrusion of System Dynamics as a potentially powerful influence and a significantly positive development in their scientific studies.

We regard that the principal contribution of the studies in chapters 2, 3 and 4 has been to demonstrate the potential and role of System Dynamics in providing the learner/instructor of Scientific Computation with a skeleton/structure which can be fleshed out for acquiring deeper insight into rudiments of scientific method and of the significance of the process of computation in the application of scientific reasoning. We also regard the potential of System Dynamics to be productively integrated into any scientific studies program at a pre-university level as high. Finally, a further contribution of this thesis has been to highlight the non-changing role of a specific aspect of computer literacy but the continued modification of some scientific literacy objectives.

Computer-oriented prospects and, therefore, the further development of such a mode of the computational activity with respect to other relevant aspects of upper secondary school/tertiary level science learning, are being considered to remain one of the key features within the realm of the Laboratory Work Station 2005 – see **Fig. 5.3** below – which is envisaged to be forming the bases of a digitally-relevant science curriculum for the foreseeable future. Amongst the future trends with respect to Information Technology integration towards the potential enhancement of science learning, the following educational resource facilities and technical developments are immediately recognisable:

- Hardware and software becoming more sophisticated and powerful.
- The availability of Data-logging and Sensing capabilities.
- The versatility of laptops and palmtops.
- The dimension of Virtual Science Laboratories and Dry Laboratories.
- Networks as the normal in institutions.
- The Internet.

The impact and the outcomes of these on the cognitive, socio-cultural and scientifically-oriented development of the science learner and upon her/his scientific and computer literacy need to be further investigated if applications of Information Technology are to be constructively and resourcefully integrated within a digitally relevant and meaningful science curriculum.