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ABSTRACT

This paper examines improving learning outcomes through redesigning information landscapes. The concept of information landscapes has been a constant theme in the development of interactive multimedia packages. For the user interface to this information to be effective and efficient, consideration must be given to the cognitive load placed on the user. The issues of redesigning learning outcomes are examined in the context of the development of a CD-ROM based interactive multimedia package, "Investigating Lake Iluka" (ILI). ILI is based around an ecology simulation and employs a number of different interface metaphors in presenting the materials to the user. The problem-solving nature of ILI lends itself to metacognitive support through the following features: cognitive self-management; provision of prompts; and experience of experts. The paper reviews evaluation of the learning outcomes from the initial use of the package. (Author/JLB)

Title:

Information Landscapes and Exploratory User Interfaces: Redesigning to Improve Learning Outcomes

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Abstract

The concept of information landscapes has been a constant theme in the development of interactive multimedia packages. For the user interface to this information to be effective and efficient consideration must be given to the cognitive load placed on the user. Improvement in learning outcomes can be supported by allowing students to focus on metacognitive processes as a component of performance support. The renewed interest in student-centred learning environments and recent constructivist approaches to learning place responsibility for learning firmly on the shoulders of the student, but this responsibility can only be taken on when appropriate support is available and the necessary skills can be developed with students. This paper examines these issues in the context of the development of a CD-ROM based interactive multimedia package, 'Investigating Lake Iluka', and reviews evaluation of the learning outcomes from initial use of the package.

Over the last decade there has been a significant shift in emphasis in curricula generally. Learning basic facts and definitions from textbooks has become less important than the application of knowledge in daily life and the development of higher order thinking skills such as problem-solving, critical thinking and decision making. In many countries this shift has been developing in parallel with national programs which are emphasising a move toward a more literate populus. The quality of the learning outcomes of a nation's education and training systems play a central role in determining the future levels of economic and social development. Many in-house industry training programs have realised that the focus should be on effective performance and problem solving rather the ability to remember facts and repeat theory without real understanding about its applicability

Recent curriculum documents in many western countries emphasise the skills of investigation, reflection and analysis to generate or refine knowledge. The appeal of cognitive process training to support this development is obvious, and it seems far more efficient to provide the student with general-purpose problem solving than instruction on specific solutions to specific problems. Metacognitive support provides a key to efficient higher order learning.

There has been considerable controversy, which will no doubt continue to simmer, over the clarification of constructivism as opposed to subjectivism. The constructivists argue that learning outcomes depend on:

- the learning environment.
- the prior knowledge of the learner.
- the learner's view of the purpose of the task.
- the motivation of the learner.

The process of learning involves the construction of meanings by the learner from what is said or demonstrated or experienced. The role of the teacher is one of facilitating the development of understanding by selecting appropriate experiences and then allowing students to reflect on these experiences.

To the learner, the constructivist learning experience may not look welcoming. It may seem daunting and complex to those who feel ill-prepared for such creative freedom and choice of direction. Often constructivist learning situations suddenly throw students on their own management resources and many fend poorly in the high cognitive complexity of the learning environment. Cognitive support tools and the explicit acknowledgment of the double agenda of metacognitive self-management and learning can help. The scaffolding and coaching of the cognitive apprenticeship model offer another solution.

Multimedia Design in a Contructivist Framework

A number of multimedia design models have been developed which illustrate the combination of complex learning environments and which also give students their own real control over their learning environment. Our model (Figure 1) is based on a more organic and iterative approach than traditional instructional systems design. Phase one takes the basic information derived from a needs assessment and converts it into a description of the Project space—the information which is to be included in the materials, how it is structured, what the target audience understands about the information and how it might be structured for the audience. A possible structuring device might a concept map of the ideas and links that are to be included in the project.

The second phase reviews the basic description and seeks to link the elements through an appropriate instructional or presentation strategy. It also seeks to identify metaphors which help both the design team and the final presentation of the information structure. The outcome of the second phase would be a formal description such as a design brief. The detail would enable the reader to understand the underlying knowledge structures and the ways it is proposed to link them conceptually and intuitively.

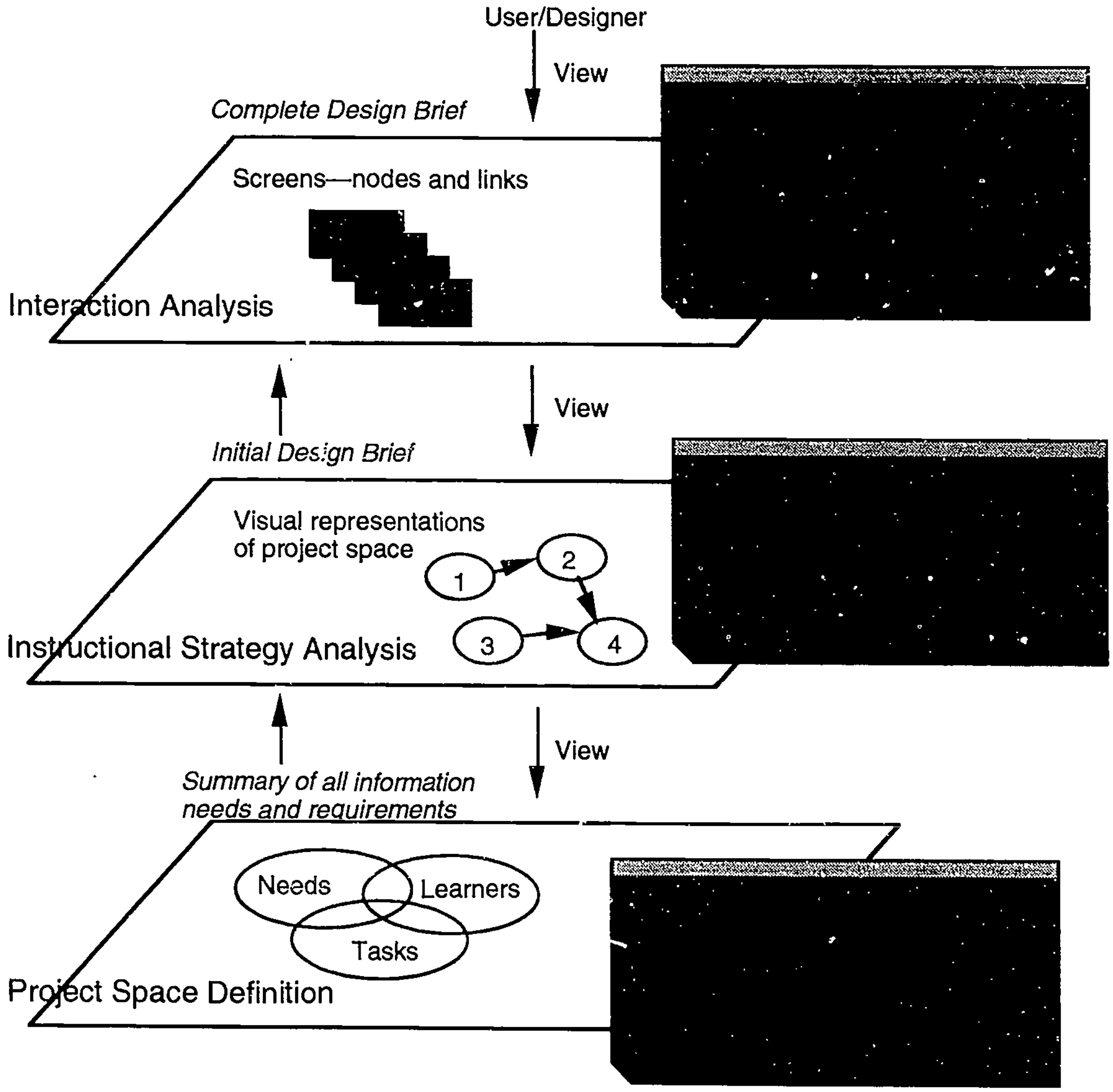

Figure 1: The design process used for this interactive multimedia package.

The third phase is a third pass at the same material, this time with the express goal of linking the design ideas into a potential interaction structure. One output of this phase would be an interactive mock-up of the interactive materials using such tools as HyperCard or Toolbook to illustrate not only static display of information but also the graphical and visual metaphors used to create understandable links. The information included in this prototype may include visual, motion, static graphics, sound and data landscapes as appropriate to the concept under development.

Each interaction consists of a node point which forms the basis of the interaction, a set of options which provide links to other nodes or additional information attached to the current node. One of the links must relate to earlier travelled or preferred paths through the materials, and each choice must inform the user about what is likely to occur as a result of a choice. These can translate into the traditional concept of results (correct or incorrect) or information feedback choice, but should also include simple feedback elements such as confirmation of choice (feedback that a button has been selected) or performance support enhancement such as suggested hints, or revision of the underlying concept/principle which might be employed to make the choice. Depending on the instructional strategy chosen another element might include the concept of duration, either time or the limit of options based upon previous choices or paths taken. What constitutes each of these functions and what they create in terms of cognitive skill development for the user are determined by their physical manifestation in terms of navigation options.

The complex integration now possible with a variety of hardware and software combinations raises problems for the user in that multiple paths are possible to the same or different end–points. Learners are faced with the need to understand what learning possibilities might be available from where they are in a multimedia learning environment. When a student can branch down multiple paths and rapidly change the direction and focus of the learning sequence, there is possible interference with effective learning through the inappropriate application of information by the learner to their internal schemas. Other concerns include disorientation with location, cognitive overload when following several trails or trying to remain oriented on their goal, flagging commitment and a poor presentation rhetoric or metaphor.

The potential of both the technology and learning strategies to incorporate the recent initiatives in science education have lead to the development, production and evaluation of a particular interactive multimedia CD-ROM based package called Investigating Lake Iluka. The package has been designed to facilitate access to the information landscape through the learner's choices by:

- supplying accessible and useable tools to allow access to the scope of supporting interactive multimedia resources (eg. video and graphic representations of concepts)
- providing an adaptive navigation system and coherent information metaphor which requires little or no explanation.

Investigating Lake Iluka has been based around an ecology simulation and employs a number of different interface metaphors in presenting the materials to the user. The package is based on the concept of an information landscape that incorporates the biological, chemical and physical components of a range of ecosystems that make up a coastal lake environment. The user is given some problem solving strategies to investigate this information in a variety of ways using the range of physical tools provided. They can collect biological, physical or chemical data as well as media information and 'construct' their own understanding of the basic ecology concepts embedded in the package. This facility has the potential to increase student understanding and control of their learning through control of their learning environment. Inquiry and problem-solving techniques have been embedded in the package through case studies of ecological scenarios presented to the user via media reports of problems posed directly to the user. Each scenario can be investigated using the package tools. It is expected that users will develop a broad array of scientific investigation skills using this realistic simulation. One of the unique features of this package is the facility for users to generate their own customised report which can be refined and presented independently of the package.

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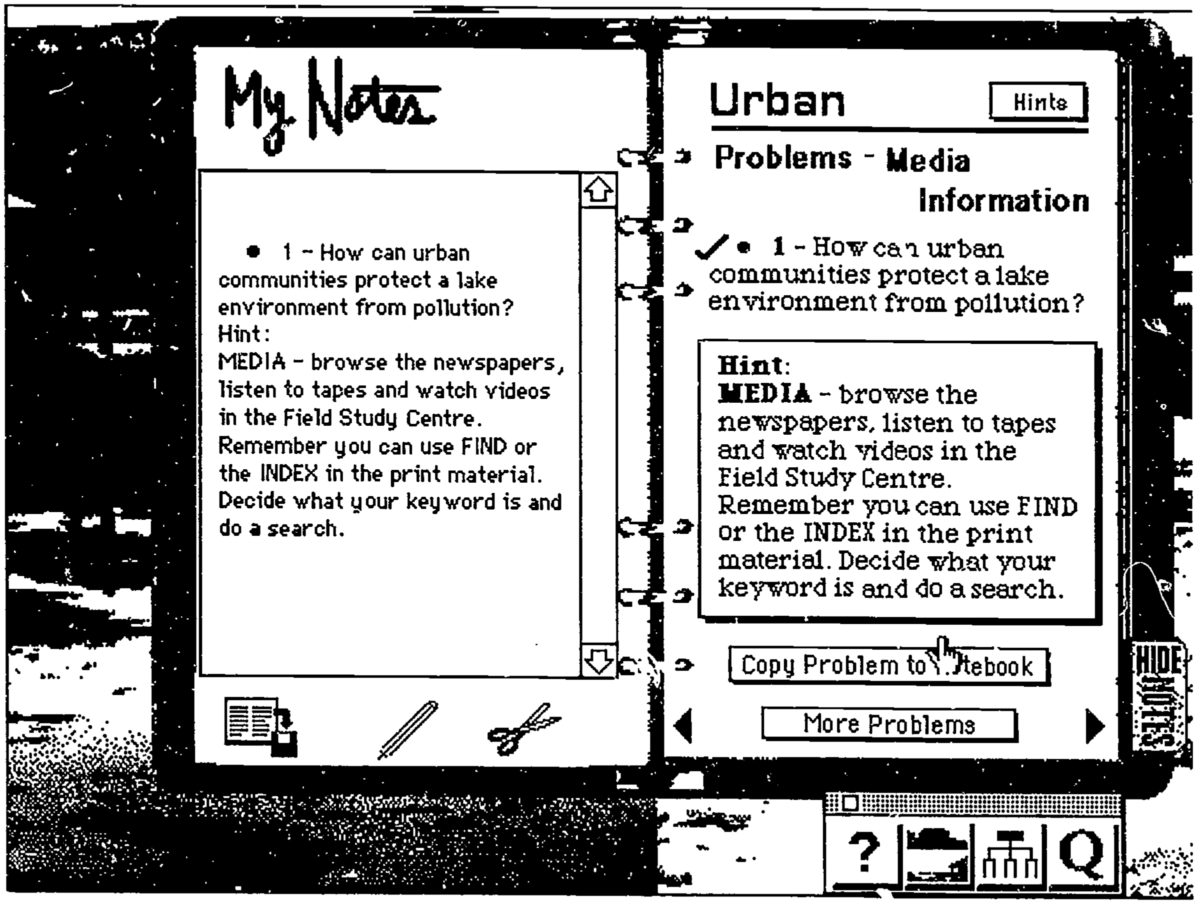

Figure 2: Investigating Lake Iluka where the user is presented with . ·. ,blem and a set of suggestions to help them solve a problem not simply choose an answer to prepared multiple choice questions. (Program from Interactive Multimedia Pty Ltd, Old Parliament Hourse, Canberra)

Metacognitive Support in Investigating Lake Iluka

Paris & Winograd (1990) have defined metacognition as knowledge about cognitive states and abilities that can be shared among individuals, including the affective and motivational aspects of thinking. Cognitive strategies can be addressed directly in the structure of an information landscape. The affective and motivational aspects of metacognition are embedded in the interface.

The problem solving nature of Investigating Lake Iluka lends itself to metacognitive support through a number of means:

- cognitive self-management: Students should form good plans, use a variety of strategies and monitor and revise ongoing performance. The notebook within Investigating Lake Iluka allows the student to collect and manage information from a variety of sources. Transcripts are not provided for video and audio material as this is not consistent with how students would process material in these media outside the package. They must organise and edit what is potentially an overload of information, within the broad constraints of an open-ended problem.

The role of the teacher is vital to the editing process at this stage. Students need to be encouraged to be critical in appraising the relevance and credibility of material. They also need to be guided through the development of a report on the problem posed.

- provision of prompts: Hints accompany the problems posedwithin each ecosystem. Students choose to access these hints, which guide them to explore various areas of the landscape or measure certain physical, chemical or biological characteristics with the toolkits provided.

  The role of the teacher is to ensure students record data collected in a systematic and scientific way.

- experience of experts: the reference book and a number of media reports give the student the chance to gain from the experience of those who specialise in ecology.

  The role of the teacher is to help students evaluate issues of hidden agenda, conflict among experts, alternate sources of information and timing of information release.

You need specific and accessible knowledge to solve problems. An information landscape such as Investigating Lake Iluka provides the knowledge base and the knowledge schemas of experts in association with a mechanism for the student to collect, analyse, assimilate and synthesise responses to problems. The ability to see a bigger picture is facilitated by rapid information access and retrieval.

Embedded content independent strategies are general learning strategies incoporated within available content. They support local learning but emphasise strategy transfer as well (Osman & Hannafin, 1992) . A well structured information landscape will provide a template for a range of content. The strategies used in Investigating Lake Iluka could well apply to other tools and other problems.

Evaluation Strategy

The evaluation involved three main approaches. Expert review of the package, one–on–one testing of the prototype materials via video observation and interviews and in-depth case studies, including the verification of the methods for data analysis of complex multi–path data This type of data collection varies from subject to subject and requires the development of special techniques for its analysis and interpretation. Examination of the contents of the incorporated notebook provided some indication of the pattern of student use of both physical and metacognitive tools in the package. This formative aspect of the evaluation was be used to guide decisions on debugging and enhancing the package. A further evaluation strategy was employed with classroom groups of students, who were set learning tasks individually in the multi–media environment, and tracking data collected for analysis.

Analysis of the collected data provides the group with an interesting opportunity for the continued development of techniques to extract the maximum amount of information for feedback to developers and those who commission interactive materials. Simple statistics such as how many users have used the system and the lengths of time they used it are relatively simple to extract, but more sophisticated analyses of how a particular interactive package is actually being used (what sections are being used, to what extent, what is not being accessed, where users exit the system, by what method, and so on) were examined and the results used to provide feedback on the future specifications for new versions and added features.

Expert Review

A naive expert tester had an educational background in Mathematics and Computers. He was asked to review the program and to verbalise his actions and thoughts. He had not been introduced to the program before. His commentary was observed and recorded, and comments and observations were added later.

The naive expert's responses were about two main issues: interface conventions and the conceptual structure and functionality of the package.

Interface Conventions

- Text transfer to the Notebook: he wanted to cut and paste. He tried to "Drag" across the text as a method of 'select all', and felt that a click was not a standard method to cut and paste. "If I click on there (the text) I get the whole the lot. I can't just pull a sentence off". He found the process of editing a little confusing, but realised this was necessary otherwise text would be corrupted by the novice user.
- The recording of measurements in the Notebook: he was confused as to what the pencil was used for. He felt once the hand symbol moved into his notes it should automatically turn into an "I" beam so he could write. The naive Expert wanted to use the pencil to activate this. "I was looking for a tool to turn the hand curser to an "I" bar.

Conceptual Structure and Functionality

Early in the testing process, he realised that he needed the help screens to fully understand how to use the program. After the introduction finished he worked through all of the Help screens. "I now feel that I have an understanding of that".

Within an ecosystem, the naive Expert selected a problem and used the Notebook to review the question and hints. He kept losing the question which was not at the top of the notebook (he had other data in there), as the scroll bar jumped back to the top each time the notebook was opened and closed. This was subsequently rectified by putting the heading "PROBLEM" and a blank line before the problem in the notebook, so it was more easily located.

He found measurement from the image of the ecosystem a wonderful idea, and set himself a problem of investigating wind speed in different areas. It took some trial and error getting measurements into the Notebook as the pencil was turned off and also hidden by toolkit. The naive Expert expressed the desire to establish a transect for measurements to make a set of multiple readings.

Within the media room, the naive Expert noted the video titles didn't give an idea of content and expressed a desire to see these indexed. He opened the notebook while a video was playing and began typing. "That is really good, that you can play the video and enter data."

Having used the program once, the naive Expert felt confident about its use and moved through the media room easily on his second visit while solving a different scenario problem. He was still confused about the pencil, but with trial and error was able to record measurements.

The naive Expert was impressed with the full screen presentation of downloaded notebook contents for editing in a word processor. The main outcome of this evaluation can be summarized as a series of guides to faciltators:

- Work through the Help screens early in the introduction of the program to students.

- The Teacher's manual should emphasise that editing capacity is only on the blue pages of the Notebook and is activated by clicking within the notes.
- There should be a demonstration early in the presentation of the program so students know to turn the pencil on to begin recording measurements.

User Evaluation (Teachers and Students)

Evaluation of the package by teachers and students in the early stages of completion resulted in a number of insights into the design features of the application and also helped to focus the package objectives. The package was introduced to two classes of year 11 students studying the topic of ecology. Extensive observations were made of the student use of the package, as well as their response to the percieved outcomes of its use.

The information landscape structure of the program relies heavily on teachers understanding of the processes that can be practised and the nature of the problems posed in the problem section of the the program. The performance support tools, such as the notebook, are an integral part of the investigative design, but they do rely on good direction by teachers. As an example of this issue one of the inbuilt problems in the Mangrove Ecosystem was posed by one of the teachers in these initial trials—"What types of animals are adapted to this environment?"

After setting up small groups, demonstration of the navigation process and a brief practice with the use of the note book, the class was given the opportunity to use the package over a number of class sessions. The expectation from the teacher was that students would read or collate the relevant information from the package. They would analyse the information and present a synthesised statement of the key characteristics of the animals of the mangrove ecosystem. The students had no difficulty collecting the information via the notebook cut and paste facility, but for the majority of groups, the teacher recieved a complete printout of the "Animal and Plants Book" information for every animal that lived in the mangroves. Thus they have not attempted to analyse the pertinent information and remove sections which did not answer the question. Two groups did attempt some synthesis of the information, but again tended to include rather than exclude irrelevant information.

Interviews with the students and teachers revealed that they did have skills to synthesize such data, and had previously demonstrated these skills, but the students admitted that the power of being able to extract, in electronic form, every bit of information on individual animals from the package compared with the usual practice for such tasks of having to type in their response, or write it out by hand proved to be too attractive not to include all that could be collected. Even after a class discussion of the type of report the teacher was expecting the importance of synthesising information to produce a concise answer, the final reports by students were much longer than the teacher would normally received, if written resources were supplied to the students. After using the complete package, the skills required together with the necessity to edit and tighten reports was seen as an important learning point for students. It was seen as a new skill which up to the availablity of this technology had not been an issue.

Observation of the use of the navigation facilities indicated that the students had little difficulty in finding information in the package that they sought. The "help" facilities were only used occasionally. It is important to note that all the help was provided in three ways. Help on how the package worked and how to use the measuring tools was provided by animated movies of the screens with accompaning explanation. Help on how the package was organised conceptually was provided through a stack map which was allways available and also allow navigational "jumping" between sections. the third form of help was provided through the use of hints and suggestions about where to look to solutions and what might be important concepts, this last form was highly context specific and provided specific ideas related to the learning task.

Other Teacher Evaluations

Information was collected on teachers response to the use of th package with their class and also through use of the package in workshops at local conferences. A number of key issues arose from this trialling. Some of the recommendations were incorporated in the release version, and others will be incorporated in future developments of the package. Most of the key issues raised by teachers were not to do with the internal workings of the package, but to do with the teaching process and organisation of their classes.

Many schools do not have large numbers of machines with CD-ROM facilities. Teachers were concerned that, even though they believed that the package would strongly support the teaching process, lack of technology would reduce the impact, and in some schools mean that teachers would not use the package. A strategy to maximise the availability of the program to students was adopted. Two versions of the program were placed on the CD-ROM, one which relied on the video segments on the CD-ROM disc, and one which did not use the video materials and could be copied to hard disc. Each package then represented a licence to use twenty copies of the hard disc version and one copy of the CD-ROM with the video segments.

The other key issue raised by teachers was related to appropriate teaching and learning strategies. Many teachers wanted guidance on how to organise cooperative group learning, independent research and guided inquiry lessons. It was considered that this teacher support could not be incorporated into the package directly, but was added as part of the printed materials distributed with the package. There was also considerable interest expressed for ideas on how to integrate field trips into use of the package. Ideas on use of the package before visiting a field site and on following up the field trip were considered to be important to add to the support materials.

The teachers involved in the initial class testing of the program were particularly excited about their students use of the notebook concept and were surprised at the ease with which their students used this inbuilt tool. However, they did find that students took notes and saved their notes effectively at the end of each session, but had difficulty determining what data they had previously collected when they started a new session. Teachers proposed that previously saved notes should be able to be read back into the package so that students could more easily continue their investigation. This feature has not been incorporated into the current version.

There was also a general consensus amongst the teachers that the package had a much wider application than ecology education. Many teachers envisaged application to geography and especially English, in the form of media studies. One interesting aspect of the evaluation involved discussion of student access to the video and audio scripts. The design team had intended to incorporate this feature, but teachers disagreed. They proposed that it was necessary for students to develop skills in summarise information from such media sources and if the students had access to a textual form, this would negate development of an essential skill for students.

Teachers evaluating the package were particularly supportive of a number of features of the package that they saw stongly supporting the teaching and learning process. The features of the package noted in this context were:-

- the level of interactivity
- the measuring tools
- the notebook facility
- the video and audio resources.

Their main concern was that teaching support ideas should be available with the package so that they could use the package to the maximum advantage.

Future Developments

On the basis of this inital work we have been encouraged that the package does in fact require the user to take control of their learning. The metacognitive supports do work well to provide a structure and support for problem solving. The main drawback has been the reluctance of the students to edit out redundant or unessary text in their reports. As a result it is suggested that future versions of the software incorporate:

- Prompts or advice on report format either though expert opinion or structure.
- Expert scientists, how they would approach the solution to the problem (Guides) (Hints mainly focussed on where to look in the package.)
- Report generation incorporating other media.

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