Coping with research evidence; a multimedia approach for further training of professional workers in the field of drugs and addiction

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Abstract

This paper outlines and discusses the use of a selfcontained multimedia training programme that allows professionals to improve their scientific thinking and reasoning skills.

In many domains, scientific research produces new knowledge and insights that is of practical importance. Practitioners in the domains should constantly keep up with new research developments to anticipate practical implications or to participate in public debates. However, this often presumes a basic understanding of the applied research methods and the associated scientific reasoning. To support this understanding amongst professionals, the Open University of the Netherlands developed a multimedia computer simulation program. The program design is strongly based on the principles of experiential learning, problem-based learning and constructivism. While using domain-specific cases, the computer program focuses on the cognitive aspects of scientific research, emphasising the strategic decisions, domain-specific choices and discussions on validity that go with the process of designing and interpreting scientific research. So far, the program has been incorporated in a self-instructive course on neurobehavioural toxicology and addiction. In the present article, the design of the simulation program is discussed and evaluated. This includes a description of the educational context and design philosophy. The paper provides examples of the Ecstasy case.

Introduction

Existing knowledge and insights are frequently changing due to new outcomes of scientific research. Factual knowledge is increasing all the time and existing conceptions become obsolete or even appear to be false. In many cases, research evidence may give rise to severe changes of methods, applications and insights in professional practice. Professional workers, managers and policymakers, be it in medicine, health care or any other domain, should constantly keep up with new research developments to

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anticipate practical implications or to participate in public debates. Unfortunately, the transfer of new scientific knowledge to society is often hampered by the fact that most professional workers lack specific research expertise to fully understand its meaning and implications. To be able to do this, one should understand how knowledge within a discipline arises and extends, how concepts are interrelated and what this means for the development of theories. It is the process of scientific reasoning that professionals in the field should become familiar with. Yet, this basic use of research evidence does not necessarily presume practical skills to carry out experiments; it rather demands some knowledge and cognitive skills that allow to interpret and evaluate new developments and results within the domain under consideration.

In the sequel of this paper we will describe a highly interactive computer simulation program (Westera *et al*., 1997) developed at the Open University of the Netherlands, that aims to enhance the basic understanding of research-related issues in a specific domain. In fact, the program is a self-contained, multimedia research practical on CD-ROM that offers students (i.e. professionals) a complex, problem-based learning environment and enables them to construct their own research processes while adjusting a large number of variables and conditions. For practical reasons, cases have only been developed for the domains of behavioural toxicological research and drugs and addiction research. Yet, the program claims to be applicable in many different domains, provided that cases can be developed in these domains that are sufficiently rich and complex and that sufficient research data are available.

First, we will briefly describe the educational context in which the computer program is being used. Subsequently, the computer program itself will be described and discussed in more detail.

The Open University of the Netherlands

The Open University of the Netherlands provides study programs in higher, distance education. The open character involves open admission and a great deal of flexibility for students to compose their own study programs. The distance aspect implies that students study primarily at home, using self-instructive materials that may include printed materials, audio-visual programs and computer programs. Face to face contact between students and tutors, for instance to carry out group assignments and discussions, is occasionally organised in one of the 18 local study centres in the Netherlands. More and more these interactions are facilitated via the Web-based virtual campus of the Open University, which is accessible to all registered students.

The student population of the Open University of the Netherlands takes up some 25.000 students, all of which are adults, on average 40 years of age, 68 % of which have regular jobs. The Open University of the Netherlands offers legally recognised graduate-level courses and university degree programs in many disciplines.

Scientific reasoning as a learning objective

Policymakers and practitioners in health care, nutrition, clinical psychology and drug abuse treatment are often involved in the debates on the practical implications new scientific insights may have. This presupposes that the persons involved have sufficient knowledge and skills in the domain at issue; in particular, sufficient insight in research methodologies and scientific reasoning is necessary.

To meet these demands the Open University of the Netherlands developed a 100 hours self-instructive, introductory course on various issues in the fields of behavioural toxicology, drugs and addiction. The course is primarily meant to address professionals in the field, either as a part of a graduate program in natural sciences, health sciences, social sciences or medicine, or as a single brush-up course. It forms an excellent source of information to anyone professionally concerned with neurobehavioural toxicology, psychology or nutrition and is particularly important for those who wish to gain insight in the neurobehavioural and psychological processes of chemically induced changes in behaviour, drug abuse and addiction. No initial research experience is required, whatsoever.

The course consists of four components: two *textbooks*, a *taskbook* and the *multimedia program*.

The *textbooks* (Niesink *et al*., 1998, Niesink *et al*., 1999) of the course provide the relevant basic knowledge. These books cover the entire range of neurobehavioural toxicology in humans and animals, as well as experimental addiction research and the topic of drug abuse. Emphasised is the understanding of undesirable behavioural changes caused by toxicants and the understanding of how various factors contribute to drug abuse and dependence. Clearly, within all these topics, the interpretation of research data plays an important role.

In the *taskbook*, the students find guidance and support to arrange their study processes. It contains instructions and annotations with respect to the textbook, additional materials on current issues, exercises and assignments. To integrate theoretical and practical problem solving in an active way, a research environment has been simulated with the *multimedia program* on CD-ROM. The learning objectives of the program include the capability to analyse a behavioural toxicological question, to translate such a question into a testable scientific hypothesis, to set-up an appropriate research protocol, to analyse and interpret experimental data and to evaluate as to whether the formulated hypothesis is to be accepted or not.

Description of the multimedia program

The multimedia program aims to enhance the students' basic understanding of research-related issues in the domain. Students are set the task to tackle a general health problem by translating it into a scientific hypothesis and study it by way of a simulated research process. The program offers 4 authentic problem cases in the fields of neurobehavioural toxicology and addiction research:

-'Does exposure to low levels of mercury affect cognitive functions?'

-'Are subtle effects of lead during brain development responsible for behavioural disturbances?'

-'Is Ecstasy an addictive drug?'

-‘To what extent is naltrexone, an opiate antagonist, effective as pharmacotreatment for alcohol dependence?’

The computer program focuses on the cognitive aspects of the scientific process, emphasising the strategic decisions and domain-specific choices that go with designing a scientific study and with the interpretation of results. The program is intentionally restricted to these ‘dry’ components of the research process, because of reasons of demanded functionality and feasibility. The context of distance education would be hardly suitable to facilitate the acquisition of physical manipulation skills like handling animals or administering injections. All such ‘wet’ components, i.e. all components that involve the actual experimentations and measuring activities, are omitted in the program; the presented experimental results originate from authentic experiments. Yet, in view of the course objectives and the defined target groups this approach is considered advantageous rather than restricting.

During the course, students are invited to investigate 2 out of 4 cases (some 6 hours of work) at least, but are free to do more. In addition, to these training purposes the CD-ROM program can be linked to the internal network of the Open University of the Netherlands to carry out the examination. For this purpose, a new case is randomly retrieved from a database of examination cases.

Educational design principles

The program design is strongly based on theories of problem-based learning: these hold that learning is an active and constructive process that is facilitated by supplying students with a proper learning environment, i.e. an adequate problem or case study (Barrows & Tamblyn, 1980). This problem-based approach is seen as being highly motivating in that it reflects a natural way of learning. It is widely adopted in health teaching; sometimes even complete educational systems are based on it (Schmidt & Moust, 1998). In addition, in accordance with theories for constructivist and experiential learning (Brown *et al.*, 1989, Duffy & Jonassen, 1992, Kolb, 1982), the acquisition of knowledge and skills is regarded an individual experience that strongly depends on the characteristics of the learning environment, the learning activities and goals of the learner. From this point of view, it is indicated that the learning environment should be sufficiently rich and complex to allow for sensible experiences. It should also offer well-defined learning tasks addressing clear, operationalised learning objectives. The learning tasks should preferably allow for versatile, explorative and individualised elaborations. The learning itself is regarded an active process of knowledge construction rather than a passive process of being exposed to information. It should include the active manipulation of attributes of the learning environment to facilitate the acquisition of knowledge and understanding at operational levels. Such an approach also supports the acquisition of higher level academic skills, such as critical thinking, creative thinking, reasoning, dealing with conflicting data, reflection and evaluation. It is clear that such design principles which support student control, free manipulation, independence, initiative and self-reliance, fairly match the characteristics and needs of the target population we described before.

So, how to realise a computer program that offers a complex, open and student-controlled learning environment, without affecting the efficiency of the learning process? How to combine ill-structured, multidimensional problems on the one hand and effective support and feedback on the other to prevent disorientation of the students? Here, traditional approaches for computer-aided learning like drill and practice, or teaching dialogues (tutorials) will fail because of their closed and tutor-controlled characteristics. The use of intelligent tutoring systems which meticulously monitor and evaluate the students' activities would hardly be recommendable, because these systems require a pre-structured model of student activities to provide tailor-made feedback (Sleeman & Brown, 1982). Probably, such a student-model would rigorously affect the claim of openness and student control. Furthermore, it is stated that intelligent tutoring systems often fail to generate correct or adequate feedback, because their responses are based on syntactic rather than on semantic cues (Hativa, 1994).

To simulate decision making in a student controlled research process, we would need a system where students are free to design and set up their own research experiments. But how to support these activities in an intelligible way without emphasis on closeness, tutor guidance and control? Scardamalia and co-authors (Scardamalia *et al.*, 1989) suggest that this can only be accomplished by providing the students with suitable tools and information that allow them to diagnose and decide what to do themselves. Nathan (Nathan *et al.*, 1994) intentionally uses the term 'unintelligent tutor' here: the tutor should not claim omniscience, it is the students that take the intelligent decisions.

To address these considerations the course team developed a flexible and open research modelling tool that allows students to design and evaluate their own research processes. To prevent students from drifting away too far from the key problems of the case study, the research process is divided up into five subsequent stages. During their computer sessions, students have continuous access to non-directive support and expert comments. At some crucial points, the program will check the validity of the student's progress. These kinds of checks and feedback definitely require some kind of built-in intelligence; however, instead of the term 'unintelligent tutor' we would rather prefer to use the term 'intelligent coach'.

Program process design

Each case study acts as a starting point for student activities. Cases are represented by everyday speech questions like 'Is Ecstasy an addictive drug?', basically not well-formed in the sense of testable research hypotheses. After selection of a case, the investigation is divided up into five subsequent stages, each of which focus on a simple question. During the investigation the students are frequently asked to write down their findings in the built-in electronic report. The contents of this report is frequently analysed by the program to allow the generation of adequate feedback.

Step 1. Problem analysis (*What is already known from the literature?*)
Here, students have to familiarise themselves with the subject by browsing relevant literature. To this end, the computer provides a database of some

five hundred relevant state-of-the-art literature abstracts on the subject. Students will have to survey what is known about the subject from previous experiments and what aspects demand further research.

Step 2. Problem definition (*What should be investigated?*)
Starting from the findings in the literature, students should try to translate the case assignment into a sensible and testable research hypothesis. This hypothesis should be well-formed in the sense that it should specify what effects should occur under what conditions. An essential feature of this stage is that students specify their hypothesis in their own words as free text input; so, no multiple choice of prefixed phrasings is at hand, whatsoever. To analyse the students' texts, the computer program features an intelligent text-analysing routine which instantly checks and comments on the texts. This routine allows the students to gradually improve their hypotheses. It should be noted that these comments are stated as cautious advises, that in no way restrict or hinder students to take their own choices.

Step 3. Experimental set-up (*How should this be measured?*)
In this stage, students are asked to design the experiment they want to carry out to check their hypothesis. For this purpose, the program offers an extended (though not unlimited) set of research facilities including various modalities of experimental human and experimental animal research, clinical research and epidemiological research. Modelling variables comprise various methodologies, administering methods, subjects, substances, doses, etceteras. On every choice, the program offers detailed hints and expert comments, that allow the students to evaluate and reconsider their design choices. When students have completed their experimental designs an intelligent routine checks whether a satisfactory match can be made to a number of built-in research protocols that originate from authentic experiments in the literature. In most cases, slight deviations from the students' protocols are inevitable, but rarely disrupting.

Step 4. Experiment (*What can be learned from the experimental data?*)
In the program, no actual experiments and measuring activities are carried out. Instead, existing data of authentic experiments are presented in the form of tables, figures, texts etceteras.

Step 5. Discussion (*What is the conclusion for the case assignment?*)
Finally, students should interpret the experimental data in the light of their specified hypotheses. In addition, they should finally discuss the concerned case assignment, while using scientific evidence. Here, the program feeds back on the students' conclusions and on the way the students have dealt with the investigation.

At any stage, students are allowed to return to previous stages, to improve their results. For instance, students may return to the phase of problem definition to adjust their hypothesis and subsequently set up a different experiment. The built-in electronic coach ensures that such iterative approach shows significant convergence.

Technical implementation

The program 'Behavioural Toxicological Research' runs in a windows environment (see Westera *et al.*, 1997, for minimum system requirements). The interface and interaction design is largely based on the standardised interface objects and styles of the Open University of the Netherlands.

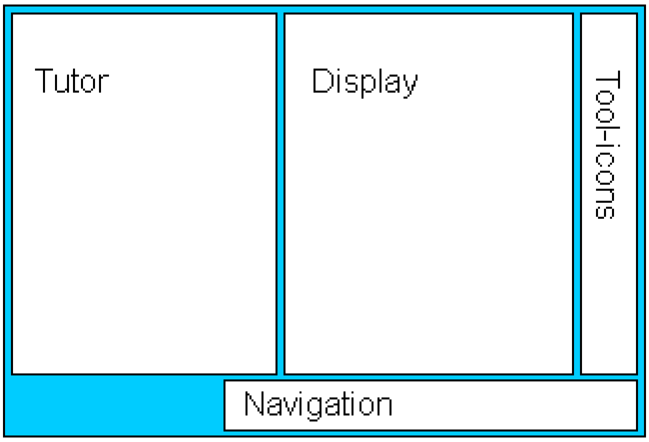

Figure 1. Functional area's in the program's interface.

The screen lay-out shows four functional area's (see Figure 1).
The left half of the screen is reserved for the electronic coach. The right half of the screen is available for special tools and functions the students need during their investigations. These tools can be activated with the icons at the far right side of the screen. The bottom line shows buttons to navigate along the various research stages. We will briefly review some of the screen objects.

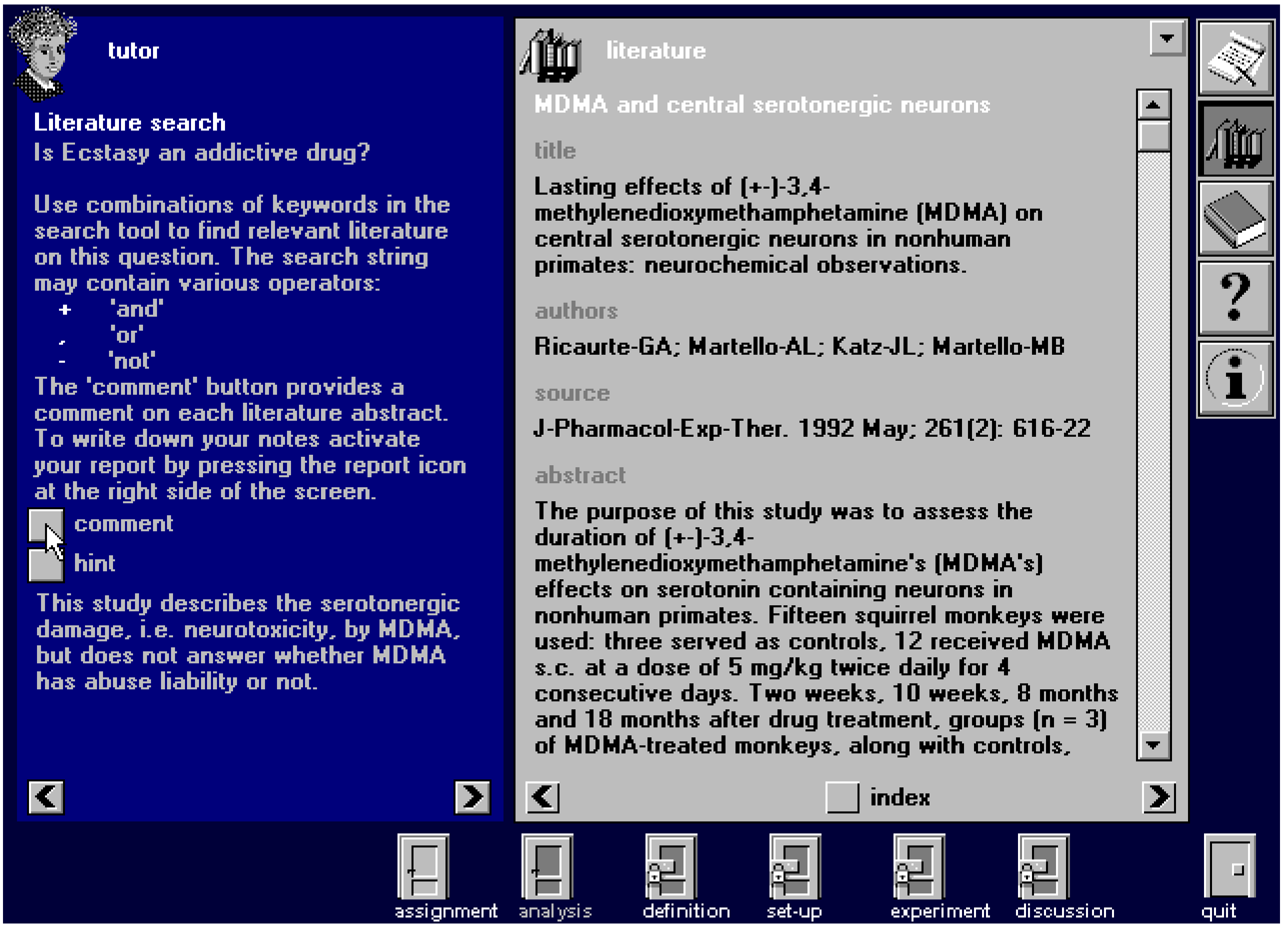

Figure 2. The interface showing the tutor and a literature abstract.

- The electronic coach (tutor)
Being the students' help and stay, the tutor object is always available (Figure 2). It provides various kinds of support, like assignments, instructions, hints and feedback. Great effort has been put in the quality and level of detail of the feedback. On several occasions, the coach utilises an intelligent routine to analyse the inputs of the students and hence enabling tailor-made comments. In particular, intelligent feedback is generated when students are formulating hypotheses and when setting up experimental designs.

- Research tools
One of the tools allows students to select and display relevant literature abstracts from an extensive *literature database* on (neuro)behavioural toxicology and addiction research[1]. In the stage of experimental set-up, students specify their desired experiment with the help of forms in a *protocol tool*. On completion of these forms, the protocol tool calculates the best match of the student's protocol against the built-in protocols. Special mention deserve the animated *audio-visual sequences* that are available for each built-in protocol (Figure 3). These audio-visual sequences focus on the procedural aspects of the selected experiments.

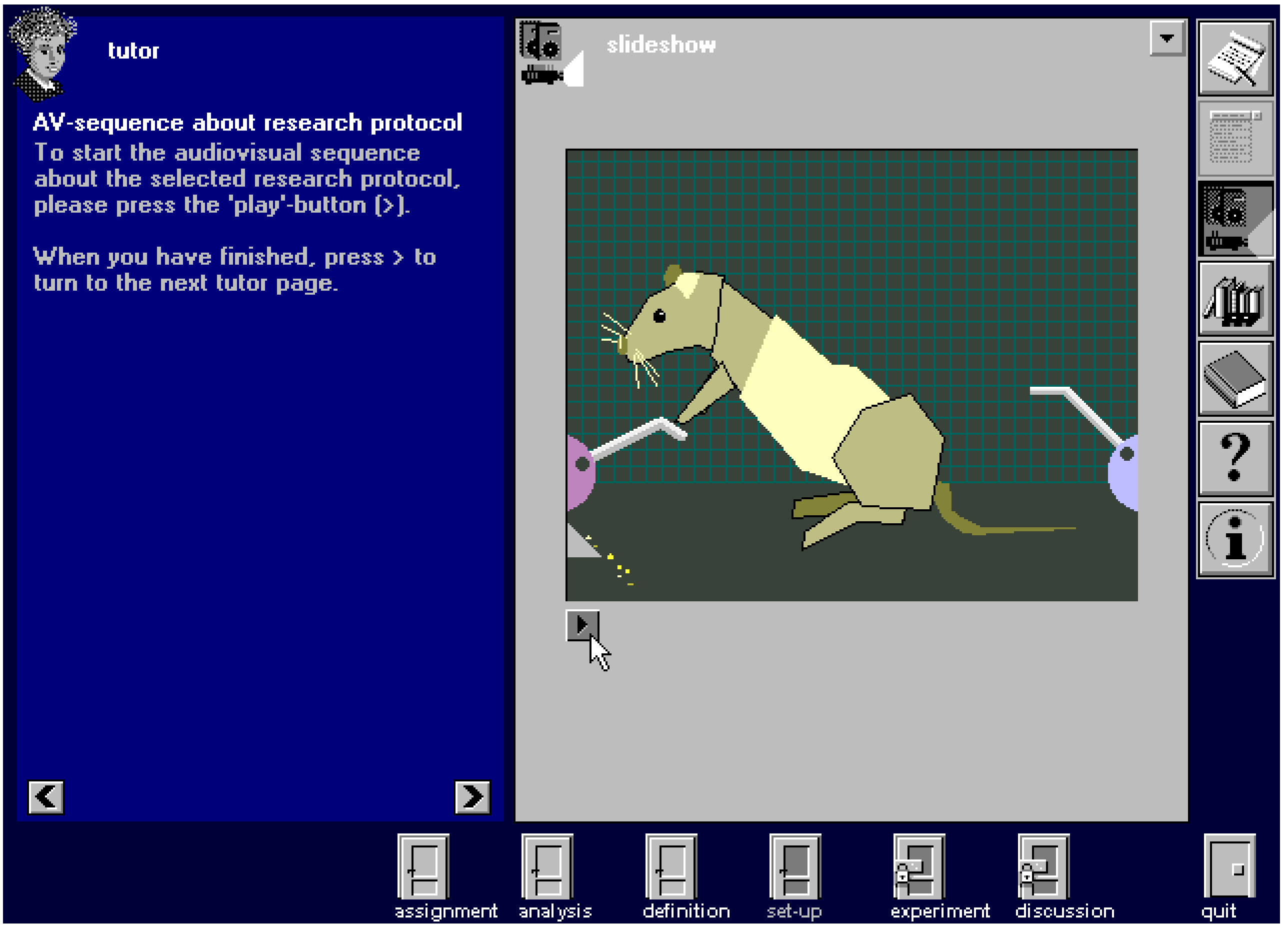

Figure 3. A snapshot of the interface showing an audio-visual sequence of a research procedure.

Once an experiment has been decided on, the outcomes of this experiment become accessible in the *display tool*. These experimental results may include graphs, tables or even recorded interviews (Figure 4).

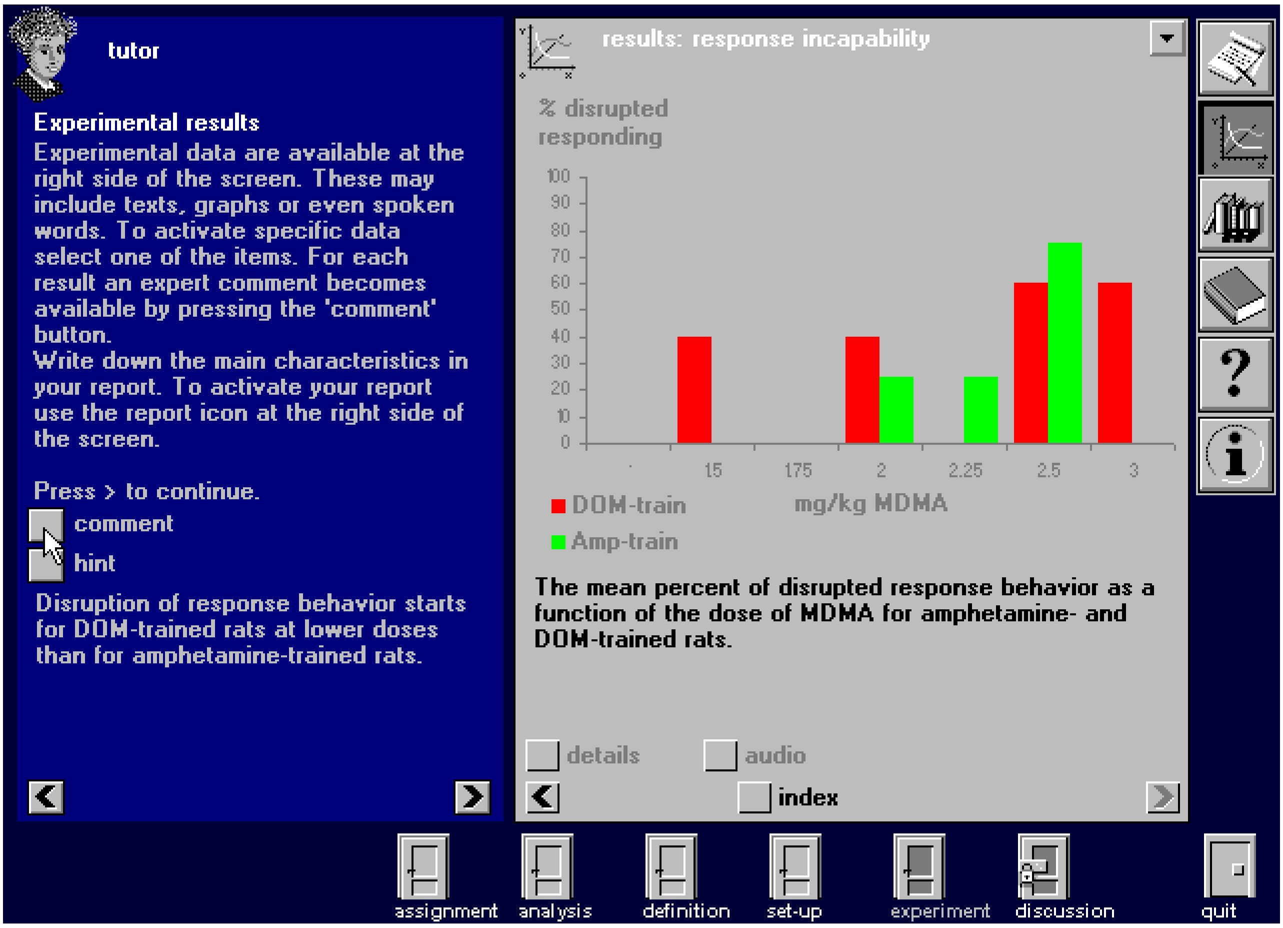

Figure 4. The interface during the experiment stage.

- Additional supportive tools

To enhance the self-instructive nature of the materials, the program is equipped with three hypertext systems. First, there is an extensive help facility for supporting the operation of the program. Part of this help facility is context sensitive: help about any screen object is available by clicking the secondary mouse button. It comprises explanatory texts as well as animated, audio-visual instructions. The second hypertext system concerns a glossary comprising over one thousand specialist terms in the field of (neuro)behavioural toxicology and pharmacology. The glossary can be accessed from any text in the program. The third hypertext system concerns the database of literature abstracts; in various texts in the program, students are referred to relevant abstracts via hotwords. These three hypertext systems, that are partly linked to each other, constitute a powerful tool to provide just-in-time information.

Evaluation and Conclusions

As part of the quality assurance and development strategy of the Open University of the Netherlands a field test of the computer program has been carried out. Formative evaluation with a group of ten students has been used to adapt and improve the program. By now, the final version has been utilised by some hundred students as part of the academic degree program

‘Food, nutrition and toxicology’. A survey amongst these users provided additional information about the functioning of the program as a learning tool. As a third source of information serve the reports of the examination cases that have been used in the students’ assessment procedures.

The survey amongst students showed that they consider the authentic cases highly motivating and adequate with respect to the learning objectives. In addition, students judge the program to be quite appropriate as a self-instructive educational means. In particular, the students appreciate the clear and simple way of operation of the program, the didactic structure and the quality and depth of the contents. Students also appreciate the openness, complexity and richness of the program that allows them to manipulate the simulated research process to a large extent. They also report to fall back frequently on the detailed tutor comments to keep on the right track. From these comments, we conclude that the development team has succeeded in finding the right balance between the pursued students’ freedom and autonomy on the one hand, and the need for an effective guidance and support mechanism on the other. In particular, the built-in intelligent routines allow the students to gradually improve their performances without being discouraged or getting stuck.

Information on the quality and effectivity of learning could be derived from the examination results. In an examination case, students are thrown upon their own resources, while no feedback is available. Assessment is performed by the examinor using the student’s electronic report. Here, it appeared that most of the students are able to demonstrate high quality scientific reasoning skills: indeed, most reports show excellent results. In view of the reported studyloads (2-3 hours per case) and the complexity of the cases, the approach is concluded to be highly efficient and effective. Yet, a few of the students did not manage to generate high-quality and substantiated solutions to the case problems. Additional interviews with these students showed that they lacked the required theoretical background and they had underestimated the complexity of the computer practical. This validates the basic assumption that theoretical knowledge and understanding are conditional to scientific reasoning skills. It also demonstrates the validity of the assessment procedure.

The electronic reports of the students appear to be a highly efficient and cost-effective assessment means. The examiner can quickly and objectively assess whether a student has correctly applied scientific methods during the elaboration of the problem. Because of the pre-programmed format, the evaluation of the report of an examination case lasts no longer than about 15 minutes per student. This is a very short period of time, compared to the evaluation of other written reports.

Yet, at some points students were critical. Some of the students were disappointed to find out that no actual experimentations are being carried out in the simulation, but that only experimental results are displayed; this suggests that a more pronounced statement on this subject is needed at the start of the program to adjust expectations timely and to avoid misunderstandings. Indeed, dynamic simulations could have been included, but for two reasons we decided not to include these. First, the main object of the program is to give insight in the conceptual aspects of scientific research rather than training the related operational skills. Secondly, from the perspectives of cost, feasibility and functionality the use of dynamic simulations would not be appropriate in our application. Obviously, this restriction should be communicated more clearly. Another comment of students was that the program is self-contained and does not allow to include new information from journals, the World-Wide-Web or other resources. Indeed, this is true and it might be a good idea to include the possibility of such external resources as well. However, one should realise that such an extension would greatly hamper the possibilities to provide built-in tutor comments on the materials.

The program has been designed case-independent; that is, code and data are strictly separated. This allows extension with other cases or even extension to other disciplines, provided that sufficient authentic data are available. Due to their limited life cycles, examination cases will regularly be taken out of circulation. These cases, however, can easily become available for training purposes when they are extended with tutor feedbacks. This way, gradually, a broad variety of tutored cases for training in the present domain will arise.

In conclusion, we will briefly discuss the strenghts and weaknesses of this technology when applied in the drugs and alcohol field. Clearly, common pros and cons of computer-assisted learning apply. The programme is self-contained and supports various ways of independent learning (students are free to decide when to study, where to study and at what pace). Its interactivity provokes active learning and its multimodality is well known to enhance the quality and efficiency of learning (Fleming & Levie, 1985). The educational design of the programme under consideration allows for various learning strategies, while the built-in coach is patient and intelligent and provides tailormade guidance and support. Such characteristics are supposed to match very well with the characteristics and needs of the target groups: a heterogeneous group of hard-working professionals in the drugs and alcohol field, showing substantial differences in prior knowledge, compromising on time for study and looking for efficient ways to keep their expertises up-to-date.
While running cost for the educators are extremely low, development costs for multimedia are substantial. Such investments are only acceptable when sufficient returns can be expected within a reasonable period of time. An important con is that computer programmes are notorious for their failures, both technically and pedagogically. Installation and performance failures may easily arise when some "exotic" computer is used that does not meet the regular standards. Also, the user is presumed to have basic computer skills. In many educational programmes, users have very little possibilities to use their favorite learning strategies; most programmes have fixed structures and do not adapt to individual differences. In addition, stand-alone applications may hinder social interaction with fellow students. In many cases, face to face sessions to enhance collaboration and discussions are urgently needed, though computer-mediated communication via the Internet becomes an favourable alternative (Westera, 1999).

From a pedagogical point of view, the present programme is concluded to offer a successfull educational means for independent learning, providing freedom and autonomy on the one hand and an effective guidance and support mechanism on the other. Extension to incorporate facilities for collaborative work via the Internet might be the next step.

References

Barrows, H.N. & Tamblyn, R.M. (1980). *Problem-based learning, an approach to medical education.* Berlin-Heidelberg: Springer Verlag.

Brown, J.S., Collins, A. & Duguid, P. (1989). Situated cognition and the culture of learning, *Educational Researcher*, 18, pp. 32-41.

Duffy, T.M. & Jonassen, D.H. (1992). *Constructivism and the technology of instruction: A conversation.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Fleming, M. & Levie, W. H. (1985). *Instructional message design*. New York: Holt, Rinehart and Winston.

Hativa, N. (1994). What you design is not what you get (WYDINWYG): Cognitive, affective, and social impacts of learning with ILS -An integration of findings from six-years of qualitative and quantitative studies. *International Journal of Educational Research* (Special Issue: Computer-based integrated learning systems: Research and theory. Guest Editors: N. Hativa & H.J. Becker), 21, pp. 81-111.

Kolb, D. A. (1982). *Experience, learning, development: The theory of experiential learning*. New Jersey: Prentice Hall, Englewood Cliffs.

Nathan, M.J., & Resnick, L.B (1994). Less can be more: Unintelligent tutoring based on psychological theories and experimentation. In S.Vosniadou & E. de Corte (Eds.). *Technology-based learning environments,* Berlin-Heidelberg: Springer Verlag, pp.193-199.

Niesink, R.J.M., Jaspers, R.M.A., Kornet, L.M.W., and Van Ree, J.M. (Eds.) 1998. *Drugs of abuse and addiction: neurobehavioral toxicology.* Boca Raton: CRC-Press.

Niesink, R.J.M., Jaspers, R.M.A., Kornet, L.M.W., Van Ree, J.M., and Tilson, H.A. (Eds.) 1999. *Introduction to neurobehavioral toxicology: food and environment*. Boca Raton: CRC-Press.

Scardamalia, M., Bereiter, C., McLean, R., Swallow, J. & Woodruff, E. (1989). Computer-supported intentional learning environments, *Journal of Educational Computing Research* 5, pp. 51-68.

Schmidt, H.G. & Moust, J.H.C. (1998). *Probleem-gestuurd onderwijs, HO-reeks.* Groningen (The Netherlands): Wolters-Noordhoff.

Sleeman, D. & Brown, J.S. (eds.) (1982). *Intelligent Tutoring Systems*. London: Academic Press.

Westera, W., Niesink, R.J.M., Vos, M.M.H.L.S. & Berkhout, J. (1997). *Behavioural Toxicological Research*, Multimedia program, Open University of the Netherlands. Minimum system requirements: 386-processor, MS-Windows 3.1, 4 Mb RAM, CD-ROM player, audio, 6 Mb of free diskspace, VGA-compatible. Literature abstracts by courtesy of the National Library of Medicin, Silverplatter and the American Psychological Association. More information about this program is available on the Internet: (http://www.ouh.nl/info-alg-coo-catalogus/681dr.asp).

Westera, W. (1999). Paradoxes in Open, Networked Learning Environments: Towards a Paradigm Shift. *Educational Technology*, 39, 1, pp. 17-24.