Implementing a Learning Model for a Practical Subject in Distance Education

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SUMMARY  T396, Artificial Intelligence for Technology, is a distance learning course provided by the Open University of the UK. It is based around a learning model which combines conceptualization, construction and dialogue. This allows a practical emphasis which has previously been difficult to implement within the constraints of distance education. The course uses commercial software, real-world based assignments and a project to replace the conventional exam. The course components facilitate the successful combination of the practical emphasis and the academic theory. A computer conferencing system allows dialogue between students. The course has been evaluated by student questionnaires and the key criteria received responses in the top quarter of the ratings band.

1. Introduction

T396, Artificial Intelligence for Technology, is a course developed at the Open University (OU) of the UK. It is a distance education course which aims to teach the main principles of artificial intelligence (AI), namely knowledge-based systems (KBSs) and neural networks (NNs), in a practical fashion. Like most OU courses, it comprises a continual assessment component (four tutor-marked assignments (TMAs)) and an examinable component. In the case of T396 the examinable component is not an exam, but rather a project which occupies 12 of the course's 32 weeks.

AI arose from the cross-fertilization of many disciplines. This resulted in a variety of approaches to teaching it, which can stress one or more of its contributing fields. It can be given a philosophical, computational, historical, linguistic, practical, or classical slant. The approach adopted for this course was that AI had provided some useful techniques which could be applied to practical technological problems. The course philosophy was also shaped by research which suggests that in order to achieve 'deep' rather than 'shallow' learning students should actively engage with the subject material and be allowed time to explore concepts in a novel manner [1]. Given such a starting point it became evident that the course material should reflect this approach and thus should aim to give students practical experience of applying these techniques to real-world problems.

2. The Learning Model

There are various approaches to learning which reflect the different means by
which a student can acquire new knowledge. A student can gain new knowledge by:

- **Knowledge transfer**—teachers impart their knowledge to the student by means of teaching, textbooks, etc. This is the conventional approach which can offer high content, but often leads to an understanding of the surface content only. Such 'shallow' learning means the student is familiar with the appropriate terminology and concepts without a full appreciation of the underlying concepts.
- **Active participation**—the student learns by performing appropriate tasks. The active approach often results in deeper learning but in a given time-scale has less content than knowledge transfer.
- **Discovery**—the student discovers knowledge through resources. Again, a deep learning can be achieved but care needs to be taken in order to prevent students being overwhelmed with information.

By combining the elements of all three of these approaches (although with the emphasis on the first two) the learning model outlined in Fig. 1 is derived [2]. The model contains the following components:

- **Conceptualization**—the student receives information about other people's concepts.
- **Construction**—the student uses such concepts to perform meaningful tasks.
- **Dialogue**—the student tests existing concepts and creates new ones through dialogue with other students.

The model suggests that the iterative application of the three-stage cycle is necessary in order to achieve the deep learning mentioned earlier. The model is relevant to T396 not only because it aims to provide students with a greater understanding of a topic, but also because the inclusion of knowledge transfer and active participation addresses the dual aim of academic quality and practical

![Diagram](image-url)
understanding. By the application of appropriate technology and learning material the above learning model was implemented in T396.

3. Resolving the Practical versus Distance Learning Conflict

The practical approach might be accommodated easily in a laboratory setting, but poses more of a problem for distance education. Teaching practical activities tends to require a greater element of supervision, if students are not to be confused or lost by differing outcomes. It has been stated that OU courses in particular have been “highly content-oriented, with students very much acting as educational ‘consumers’” [3]. In order to shift the emphasis to a practical, activity-led one, it was necessary to make some alterations to the usual elements of a distance learning course. However, it was important not to lose any of the academic qualities required in a third level Honours course (equivalent to final year studies at a conventional university). A further difficulty was that the course assumed no prior computing experience and could thus make no assumptions regarding good practice or terminology.

3.1 Generic Software for Generic Skills

The first step in overcoming the barriers imposed by distance teaching was to find software that was easy to use, robust enough to survive the myriad PC architectures possessed by students and that could accommodate all of the teaching material required. Also, given the remit of practical real-world applications, the software should preferably be commercially available. This stresses to students that the AI techniques are practical tools and not just of academic interest.

Two packages were selected, namely flex, a KBS shell system written as an extension to Prolog by LPA Ltd, and NeuralWorks, a neural network system developed by NeuralWare Inc. Both packages already possessed most of the capabilities the course required, for instance forward and backward chaining and object orientation for flex and a range of different neural network types for NeuralWorks. Importantly, both were capable of modification for specific aspects of the course. Thus, uncertainty methods (Bayesian updating, certainty factors and fuzzy logic) were added to flex and a modified Hopfield network was included in NeuralWorks. Both packages have clear menu-driven interfaces and good documentation, and both include a number of tools which students can use to analyze and develop their solutions.

The aim of the course was to familiarize students with the concepts and principles involved in using AI techniques, not to produce expert programmers for any one system. Thus, the selected software needed to be sufficiently generic so that its principles would be applicable to whatever alternative system the student might encounter in the future. This aspect was particularly important in selecting the KBS software, as many such shells and languages exist and the temptation to select one that provided a good interface at the cost of being strongly typed (in the manner of conventional programming languages) had to be avoided. The selected software used an English language type structure that might easily be transferable to any new system. Its relative transparency meant that students who were new to programming were not confronted by unintelligible software code. flex also possess a number of tools to aid the user in constructing object-oriented hierarchies and rule-based systems. A flex desktop, including the representation of an
Fig. 2. A *flex* desktop, including an object hierarchy.
Fig. 3. A NN in NeuralWorks.
object hierarchy, is shown in Fig. 2 and an example of a flex rule for boiler control is given below:

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rule steam_check
  if the release_valve is open
  and the flow_rate is high
  then the steam becomes escaping.
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NeuralWorks also offered generic capabilities by providing easy-to-create neural networks that could then be subject to a high degree of modification. The package also included a number of typical tools which students could use to analyze the behaviour of a network. Thus, a great deal of flexibility and power was available to the students, far beyond that which the course could realistically hope to cover. The type of network typically created in NeuralWorks and a few of its adjustable parameters are shown in Fig. 3.

By using flexible tools it was intended that students wishing to go further than the course, or those implementing AI solutions in a work environment, would find the tools adequate for their purposes. This was intended to reinforce the practical emphasis of the course.

3.2 Practical Guides

Having selected appropriate software it was then necessary to develop guides that would help the students to use the software and also provide the academic detail required. In keeping with the philosophy of the course to expose students to real-world situations whenever possible, it was decided that textbooks written independently of the course would provide the academic background [4, 5]. In addition to these books two study guides were produced which provide the students with practical examples which they run using the course software to illustrate the content of the textbooks. The study guides also provide extra explanation of the books in a conventional distance learning style. For example, the theory of fuzzy logic and an example relating to boiler control was given in [4], corresponding to the conceptualization stage in Fig. 1. This concept was demonstrated in terms of flex implementation in the study guide. The course adopted a learning by example methodology. For instance, the principles demonstrated in the fuzzy logic example were then used by the students to develop a fuzzy braking system for a train in flex, corresponding to the construction stage in Fig. 1.

3.3 Continuous Assessment

The continual assessment element of the course follows the same principles. Each assignment is based around a practical application of the techniques learnt (construction), but also demonstrating the theoretical principles involved (conceptualization). The process of critical analysis required in the TMAs helps to realize both of these stages for the student. For instance, one TMA asked students to investigate the capabilities of NNs to interpret measurements from a fault diagnosis system. Signals from the diagnosis system were to be classified into one of three classes of fault. Using NeuralWorks, students constructed appropriate neural networks to train and test on the data. By plotting initial data and expanding the training files, the concept of linear separability, which the students had previously studied, was
made concrete. In this case two of the classes were linearly separable, while the third was not. The implications of this are evident in the performance of two different versions of neural network (single layered and multi-layered perceptron), which the students investigated.

The practical emphasis of the course was reflected by constructing each assignment question in terms of a 'technological story'. For instance, the use of Hamming distances in training Hopfield networks was couched in terms of a manufacturing company that wished to classify components. The use of a real-world base for applying the principles provides the students with a foundation on which to build their discussion of the AI techniques.

3.4 The Project

Given the emphasis on practical work in the course, an exam was deemed inappropriate. The exam was replaced by a project which utilizes both KBS and NN techniques to provide solutions for a real-world problem. Unlike the OU's individual, 32-week project T401 [6] (which is often focused around a student's area of employment), T396 sets one project for all students, with clearly defined tasks. A 5000-word project report constitutes the examinable component of the course. As with the TMAs, the project is based around a real-world problem, which like the assignments forms a 'technological story'. The project is broken down into subtasks which demonstrate the capabilities (and limitations) of the two AI techniques.

In the first year of presentation, the project involved the analysis of hand-written postcodes taken from actual envelopes. The data were pre-possessed and then various NN architectures were investigated to see which provided the best recognition rates for the characters of the postcodes. The output of the most successful network was passed to the KBS component, which checked against valid postcode structures and also offered possible suggestions for alternatives (e.g. 1 and I being mistaken). In the second year of presentation, the project required comparison of the use of NNs and KBSs to control an aluminium die casting process. A simulation of the process was provided to act as the students' 'reality', from which they gathered data and against which they compared the performance of their solutions.

4. Computer Conferencing

As yet no mention has been made of the third stage in Fig. 1, namely dialogue. By engaging in dialogue, students are able to verify their own understanding and if necessary modify their concepts. Learning can be viewed as a social activity and it is this aspect that is often very difficult to realize in the distance learning context. Given such a practical-based course it was important to avoid the feeling of isolation. It is easy for a student's progress to be halted by a simple error such as misspelling a variable name. In order to overcome this, all students are provided with access to a computer conference, using SoftArc's FirstGlass system. In choosing a conferencing system it was necessary to find software which would be easy to use, and thus provide no barrier to its integration into the course, and also one which could fulfill the administrative requirements of the course team. The FirstGlass package is icon-driven and most students reported familiarity with its use within a very short time-span. It also provides the course team with abilities
such as monitoring the readers of a message, approving files, restricting access to certain areas and so forth. An example of the FirstClass 'desktop' is given in Fig. 4.

The T396 FirstClass conference is moderated by course team members who occasionally contribute information. Primarily, however, its function is to allow the informal exchange of views and help that students would give to each other in a conventional university. The conference is subdivided into topics for each of the assignments and the project. Thus, when completing a TMA a student can engage in the dialogue stage of the learning process by posting a message to the conference. Many students reported that even though they did not post a query, their understanding was greatly enhanced by reading the questions and answers of other students. The conference was viewed by the students as a tool with a very specific function. If they encountered difficulties in an exercise they would generally check the conference and then post a message if the requisite information was not already available. There was little of the general chat often found in conferences associated with level one or two courses.

This aspect of the learning model has traditionally only been possible in distance learning through limited face-to-face contact such as tutorials, summer schools and study groups. T396 students have access to six face-to-face tutorials through the year, but often students cannot attend these, for many of the same reasons that encourage them to become distance learners in the first place (e.g. work or family commitments, geographical distance, disability, etc.). While many important aspects of face-to-face communication are not available in the computer medium, the conference has generally been successful in facilitating some form of dialogue, as the following student quotes indicate:

I thought the conference was a very good way of breaking the usual feeling of being on your own when on an OU course—it breaks the feeling of 'distance' in distance learning.

This conference has been vital in retaining an easy link to the University.

Since 1988 I have studied many OU courses. Since I started using FirstClass a couple of months ago I have felt less isolated in my studies. It has been a bonus to find out about other related material to the course (such as magazine articles, lectures etc.) which in previous years of study I would only occasionally find out about at tutorials.

The conference is viewed as an essential part of the course and in order to stress this to students they are obliged to log-on in order to obtain data files necessary to complete their assignments, as well as to receive communications from the course team.

5. Course Evaluation

T396 was evaluated after its first year of presentation by means of a questionnaire. T396 was one of 45 OU courses evaluated in this manner. Of the many questions asked, several are salient to the claims of this paper. Responses were based on a four-point scale, ranging from 1 ('very much') to 4 ('not at all').

Firstly, it has been argued that the course presented an integrated approach—the project combined both KBS and NN techniques and the practical activities implemented the theory found in the text. Support for this approach can be found
in that T396 students reported studying more of the course content than students of any of the other courses.

It has also been argued that the project offered advantages for the assessment of a practical course over a traditional exam. In response to the question “Did you find the exam project a fair test?” the students showed T396 to be deemed fairer in this respect than most other courses, with an average response of 1.63 compared to a mean over all courses of 1.83.

It has also been suggested that practical activity is a valuable way of teaching, but has been difficult to implement in distance learning. There is some evidence that students who are traditionally used to a greater content-based approach were somewhat surprised by the demands of this course. The questionnaire showed that, with hindsight, students were less well prepared for the demands of the course than they had expected. This may reflect the lack of experience distance learning students have with practical-based activities, particularly the demands of a project.

There is an assumption in the learning model that active learning promotes deeper understanding of the topic and promotes student interest. Active learning is best represented by the project in this course. Within the course, students were asked for each block “Did you find the block interesting?” For block 1 (KBSs) the mean response was 1.9 and for block 2 (NNs) the mean response was 1.7. The project, block 3, was regarded as the most interesting with a mean response of 1.5. This suggests that concentrated practical involvement does arouse student interest. Students were also asked “Did you find the block time consuming?” Blocks 1 and 2 both produced mean responses of 2.4 while the mean response for block 3 was 1.4, indicating there may be some connection between time span spent and value gained from study material.

With regards to the course as a whole mean, responses to the questions “Did you find the course interesting?” and “Did you enjoy the course?” were within or near the top quarter of the ratings, with values of 1.41 and 1.77 respectively.

6. Conclusions

By deciding upon a practical approach to the teaching of AI techniques, the course team has put two factors into contrast: the non-practical implications of distance learning and the need for hands-on experience demanded by the course. The successful combination of these has been achieved by the application of a learning model to the course production. The course materials implement the model in a number of ways. Firstly, the selected software meets both the academic and pragmatic needs of the course and thus accommodates both the conceptualization and construction stages of the learning model. Secondly, the learning material provides concrete examples of theoretical points that both reinforce the theory and provide practical experience with the software, allowing for task-based learning. The conventional exam has been replaced by a project that examines a real-world problem, providing the students with more in-depth experience in using the tools and the advantages and disadvantages of each. All of the practical work (exercises, assignments and project) is constructed around a technological story which provides a framework for the students to construct their concepts. Lastly, the use of a computer conference supplements tutorials and allows students to participate in dialogue and thus test and modify their concepts.

The course has been evaluated, and many of the responses have been found to
support the claims made in this paper. It is our contention that this course demonstrates how a practical subject can be made amenable to distance education. Many engineering topics which previously have either been thought to be too practical or have had much of their practical content removed for the purposes of distance education could be taught in this way.

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REFERENCES


