Vicarious learning and (virtual) case-based teaching in health science education

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Abstract

This paper describes PATSy, an established interactive case-based system that provides students with access to virtual patients. PATSy has recently been extended by the addition of vicarious learning (VL) support to users of one of its subject areas (speech and language therapy). Vicarious learning is the idea that people can and will learn through being given access to the learning experiences of others. The PATSy extension (VL-PATSy) is also described - it consists of a database of VL resources together with a rule-based delivery system. Each VL resource is a short video clip of two students (or a student and tutor) engaged in discussions about various aspects of diagnosing a patient's language disorder. PATSy and VL-PATSy represent an adaptive system for combining case-based teaching and learning with vicarious learning. The paper concludes with a description of an evaluation of VL's effectiveness that is currently underway.

1. Introduction

This paper describes an adaptive technology-enhanced learning (TEL) system in speech and language therapy (SLT), a health-science subject. The system incorporates two forms of pedagogy - case-based learning and vicarious learning. There are two parts to the system: 1. PATSy [4, 12, 13][1] - an established interactive case-based system that provides students with access to virtual patients, and 2. VL-PATSy - a database of vicarious learning (VL) resources together with a rule-based delivery system[2]. Each VL resource is a short (3-6 minute) video clip stored and indexed in a database and delivered to the student by VL-PATSy. The VL database contains around 190 digital video clips. Each clip is a recording of two students (or a student and tutor) engaged in discussions about various aspects of diagnosing a patient's language disorder.

Vicarious learning is the idea that people can and will learn through being given access to the learning experiences of others [2, 5, 14]. Master classes (which have a long tradition in musical training, for example), and the process of clinical teachers going through cases with students, are examples of VL. In these VL contexts, one student is the focus of tutorial attention, but others present also benefit as a result of observing the interaction. The observed student often raises learning issues that are directly relevant to the observing student - ones that the observing student can often identify closely with. Another rational for VL centers around indications that, in e-learning contexts, students often have less opportunity to observe and 'overhear' the dialogue of

[1] *www.patsy.ac.uk*
[2] Vicarious learning project website: *www.tlrp.org/proj/phase111/cox.htm*

others compared to traditional (human, interpersonal) teaching and learning contexts. The case for educational dialogue forming a crucial part of the learning cycle in higher education (HE) has been convincingly made by Laurillard ([11]). We also argue that VL has considerable potential for facilitating professional enculturation and learning to 'talk the talk' of the profession. Exposure to the clinical conversations of expert clinicians helps students learn their profession's 'register' and professional forms of discourse.

VL also relates to other themes in current educational research, such as social learning and case-based teaching and learning. Clinical science education is increasingly adopting *case-based* teaching and learning approaches in which subject knowledge is represented in the form of many example cases which, taken together, embody relevant principles in the domain [10, 17]. This approach to teaching and learning is appropriate for procedures in which it is difficult to give students a set of rules that they may universally apply. Students can learn by induction over a range of cases and build up their own mental case-base thus developing their own case-based reasoning skills. For effective case-based learning, students require access to knowledge represented in the form of many example cases [9, 16, 17]. Case-based reasoning (CBR) is a mode of reasoning that characterises skilled clinicians' approaches to diagnosis. However, experts also tend to exhibit *heterogeneous* modes of reasoning (e.g. a mixture of hypothetico-deductive and case-based reasoning, for example).

A teaching and learning challenge in health science education is to scaffold students so that they can 'boot-strap' their own mental case-base to a degree that is sufficient for CBR to become a viable additional mode of reasoning for them [4]. PATSy and its VL-PATSy extension were designed to facilitate this process. A major aim of VL-PATSy was to create a database of learning experiences and to make them available to other learners. A key consideration was *reusability* - i.e. capturing educational dialogue with a view to extensive re-use. VL-PATSy's VL resources (described below) consist of video clips of students in conversational dialogue with either another student or with a tutor. Each clip represents a conversation about a discrete clinical reasoning event. The participants in the VL clips are engaged in structured 'task-directed discussions' (TDD's, described below).

The rest of the paper is structured as follows: first, we present the PATSy system and its design rationale; then VL-PATSy, the recent VL extension to PATSy, is described.

2. The PATSy e-learning system

PATSy [4, 12, 13] is a internet-based multimedia database system that provides 'virtual' patient cases to students in the clinical sciences. The disciplines represented on the system currently include speech and language pathologies, developmental reading disorders (dyslexia), neuropsychology, and neurology/medical rehabilitation. Sixty-one data-rich and extensively described cases of adults and children with disorders are accessible under those 4 domain headings. Patient case data has been contributed by leading researchers and/or expert clinicians in each of the four fields. PATSy's speech and language domain contains around 25 clinical data-rich cases. The SLT disorders represented refer to a variety of adult acquired speech and language disorders together with child cases describing delayed language and phonological development. The system is currently in regular use by around 30 UK University departments.

PATSy is designed for use as an adjunct to traditional methods of clinical training. It is a richly interactive multimedia database containing video, audio and images. It provides an electronic archive for case-based research as it contains rich collections of test data on research participants. PATSy has been designed to meet the needs of both students in initial clinical education as well as by professional clinicians undergoing continuing professional development. It offers health science students an opportunity to practice diagnostic reasoning on 'virtual patients'. Students can access real patient data in the form of videos, assessments, and medical histories. The virtual patients can have psychometric and cognitive assessment tests 'administered' to them by learners[3]. Typically, PATSy is used in blended learning contexts - tutors integrate online PATSy sessions with lectures. It is designed to complement taught content and clinical placements. PATSy is particularly well-suited to case-based teaching and for use in problem-based learning contexts. It helps students gain experience on a varied range of cases, which helps them build their mental case-base to the point where they may be able to begin to use case-based reasoning as well as hypothetico-deductive reasoning in their clinical diagnoses. PATSy also has built-in student-system interaction recording, making it an educational research instrument for the microgenetic study of students' clinical reasoning skill acquisition. The log records in detail which tests are accessed and the order in which they were 'administered' to virtual patients. The system can configured to periodically prompt students with questions such as: '*What conclusions can you draw from what you have just seen?*', '*Where do you want to go next (further test data?, introductory video?)*', '*Why?*' Students' typed responses to these prompt questions are interleaved with the system-generated log data.

To summarise, PATSy addresses several challenges currently faced by educators and students:

- Changes in educational teaching methods and the increasing use of case-based approaches in which subject knowledge is represented in the form of many example cases
- Ready access to people with brain-injury by users, for clinical training or research
- Opportunity for unlimited pre-clinical training and rehearsal opportunities for facilitating students' familiarity with an adequate range of speech disorders and increased technical knowledge of assessment ahead of meeting 'live' patients.
- Opportunities for students to practise and hone their diagnostic repeatedly on the same (virtual) patient ('learning by doing')
- Access to rare cases - PATSy contains many rare cases.
- Authentic assessment - with traditional clinic-based training placements, educators cannot assume that their students have seen similar patient cases. With PATSy, though, a whole class can experience and discuss the same cases and can be set a 'virtual' patient to diagnose under exam conditions.

As mentioned above, the PATSy system has recently been extended by the addition of VL support resources. The idea is that if a student becomes 'stuck' (reaches a reasoning impasse[4]), the system is able to detect it and offer a choice of relevant VL resources. The VL-PATSy extension to PATSy is described in the next section.

3. VL-PATSy

Task-directed discussion (TDD) exercises were used as a way of generating reusable educational VL dialogues for a range clinical reasoning issues. TDDs are language games and are commonly used in teaching English as a second language [15]. Each TDD is a 'discrete language activity with a set goal' [14]. The advantage of using the TDD methodology is that students often have difficulty with generating spontaneous discussion 'to order' and capturing natural dialogue is very difficult, especially when it has to be topic-focussed and suitable for observation by subsequent vicarious

[3] Interested readers are invited to try the demonstration 'walkthroughs' on the PATSy website (*www.patsy.ac.uk*) to obtain a clearer impression of the system

[4] Defined in [7] as 'an inability to apply formal knowledge in a clinical setting'

learners. To illustrate: a sample TDD addressing a difficulty in formulating hypotheses might be: *"You view a video of a client, who seems to cope well in conversation with the therapist, despite having very obvious expressive difficulties. What would be the first area of communication that you would look at and why?"* Other types of TDD focus on the use of professional language, eg. *"Read the following description of a client's communication difficulties and then rephrase it in professional terminology"*. To target TDD development, we identfied a large range of clinical reasoning issues by studying, in depth, pairs of students as they diagnosed a previously unseen case using PATSy under exam conditions. Student-student dyads and student-tutor dyads were videoed as they took part in the discussions and video clips showing successful resolution of reasoning difficulties were incorporated into VL-PATSy [3, 7, 8]. Nearly 200 VL clips on a wide variety of subject (SLT)-specific and more generic (domain independent) clinical reasoning issues were captured, meta-data tagged and stored in a structured database on VL-PATSy. The diagnostic behaviour of experienced clinician/educators was also studied in order that expert models could be characterised for use as models against which students' patterns could be traced using an approach that is akin to 'model-tracing' [1, 6]. One outcome of these studies was the development of a seven-level classification scheme for classifying the level of diagnostic statements made by students [7, 8]. Students using PATSy with its VL extension can either browse VL clips themselves at any point as they work through a case or, alternatively, the VL-PATSy system can monitor their activity on PATSy and offer VL resources when 'reasoning impasse' rules fire[5]. VL-PATSy rules are event-condition-action (ECA) rules which fire if certain events are detected. For example, an ECA rule might fire if if a student using PATSy administers an unusual or inappropriate sequence of language tests to a virtual patient. A common example is the use a test of language function that is too narrow or 'fine-grained' in its focus at an early stage of diagnostic testing. ECA rule firing results in an appropriate selection of VL video clips being proactively offered. The content of the clips in this example would cover topics such as 'hypothesis testing'. Clips with content metadata tags corresponding to '*a student and tutor discuss how understanding what a test does helps with planning a test strategy*' and '*a student and tutor discuss confirming and disconfirming a hypothesis*' might be offered. There are several types of ECA rule - for example some rules check for use of professional terminology when students make reflective notes in the PATSy log. ECA rules are defined using XML mark-up language. An example of the rule for detecting and responding to the example above might be paraphrased as 'when a student moves from test X to test Y, but X→Y is an inappropriate testing sequence, then offer relevant VL video clips'. Relevant VL clips are selected on the basis of their descriptive metadata (described in next section). ECA rule firing conflicts are resolved in the current version of VL-PATSy via rather simple mechanisms. First, rules are divided into 'top priority' and 'normal priority'. Top priority rules are fired if trigger conditions hold and these have precedence. The two level hierarchy is supplemented with a second simple mechanism, namely "if several rules fire simultaneously, then choose one rule at random and discard the rest."

3.1. VL-PATSy implementation considerations

It was important that the VL-PATSy extension was independent and separate from the existing PATSy system - it therefore links to the PATSy via a message exchange system. Other requirements were that the system should be resilient, scalable, extensible and maintainable. VL-PATSy was therefore implemented using a three-tier architecture consisting of (1) a front-end tier (an information, or content presentation layer), (2) a middle tier (a monitoring and notification mechanism), and (3) a backend tier (multi-role server components). A rule editor allows the server's services to

[5]A screenshot of the VL-PATSy extension to PATSy can be seen at *www.vicarious.ac.uk/vl-patsy.jpg*

be extended if domain experts (e.g. speech and language clinician educators) want to add rules to the rule store.

The front end tier is a combination of the presentation layers of both the PATSy and VL-PATSy systems. The features of it are: (1) the rule server is provided with frequent messages about the learner's server requests as soon as they arrive at the PATSy server, and (2) in 'push' mode (as opposed to learner-controlled browse mode), VL-PATSys responses are indirectly driven - by the learner's activities rather than by his/her direct requests.

The back-end tier (3) is concerned with low-level learner behaviours (as recorded by PATSy's continuous user-system interaction logs). These are mapped onto more abstract ECA events so that VL clips can be offered concurrently and asynchronously, without blocking or interrupting the PATSy system's normal mode of operation. Other backend tier components include a database module, which is responsible for the management of metadata for video clips and ECA rules written in XML. The database module is based on a database-featured communication middleware known as a 'tuple space'.

The middle-tier is a monitoring and notification mechanism (ie. a 'spy'). One of the most important interactions between PATSy and VL-PATSy occurs via the processing of log data. The middle-tier must mediate between PATSy and VL-PATSy in order to relate the user-system interaction log data from PATSy to the delivery of vicarious learning content by VL-PATSy. Two crucial designs are imposed on the middle-tier - (1) The rule server must be informed of events that happen in each learning session and at the same time PATSy must run normally without noticeable loss of performance. An event is routed to relevant rule components that in turn react to the event and fire appropriate VL delivery actions. ECA rules have been used for mapping the relations between learner behaviours and the delivery of VL content.

In addition to developing VL-PATSy, it was also necessary to add metadata to the database of language tests associated with the virtual patient cases on PATSy. A 'Test Description Language' (TDL) was developed for that purpose. Similarly, VL video clips were also tagged with rich Video Description Language (VDL) metadata representing what type of PATSy virtual patient they are relevant to, characteristics of the dialogue participants (e.g. student-student/student-tutor), clinical reasoning issues covered in the dialogue, *etc*. Both the TDL and the VDL mark-up schemes were developed to XML standards.

4. Conclusion

PATSy and its recent extension, VL-PATSy, represent an adaptive system for combining case-based teaching and learning with vicarious learning in an on-line adaptive system.

VL-PATSy extends PATSy by allowing mixed initiative[6] access to vicarious learning (VL) resources by students. VL offers an innovative form of learner support during complex cognitive tasks (clinical reasoning).

An evaluation of VL's effectiveness is currently underway in the form of a controlled, between-groups comparison of student-tutor dialogue and student-student dialogue using a multiple baseline design. A rich range of process data is being captured and learning outcomes from two types of VL (student-student, student-tutor) will be compared using a range of measures. Learning outcomes will be assessed by triangulating rich multiple source data. The learning outcome measures consist of multiple-choice tests of SLT knowledge and also via students' performance during the diagnosis of an unseen patient case under exam conditions. In addition, each student's interactions with

[6]Student 'pull' via a VL clip browser, or system 'push' via VL-PATSy rule firing

PATSy and VL-PATSy have been logged. These data include the number and sequence of accesses to PATSy virtual patient content during the experimental period, VL-PATSy rule firing patterns, and the VL resources that were offered to the student and/or browsed by the student. The aim is to relate the number, nature and type of VL resources viewed by a particular student during the several-week intervention period to individual learning outcomes in within-group (individual difference) analyses. We also plan to look for changes in the use of professional register in, for example, students' typed reflective log entries.

5. Acknowledgements

The support of the Economic and Social Research Council is gratefully acknowledged (ESRC TLRP grant RES-139-25-012). Thanks also to colleagues Professor Rosemary Varley, Dr John Lee, Dr Julie Morris, Kirsten Hoben, Dr Barbara Howarth & Susen Rabold.

References

[1] Anderson, J. R., Corbett, A. T., Koedinger, K., & Pelletier, R. (1995). Cognitive tutors: Lessons learned. *The Journal of Learning Sciences*, **4**, 167-207.

[2] Cox, R. (2005) Vicarious learning and case-based teaching of clinical reasoning skills. Presented at the Technology, learning relationships & networks seminar in the ESRC TLRP Seminar Series on *Contexts, communities, networks: Mobilising learners' resources and relationships in different domains.* Open University, Milton Keynes, October. Paper available at `www.tlrp.org/dspace/`

[3] Cox, R., Hoben, K., Howarth, B., Lee, J., Morris, J., Pang, J., Rabold, S. & Varley, R. (2005) Clinical reasoning skill acquisition: identifying learning issues and developing vicarious learning resources, *T*eaching and Learning Research Programme Annual Conference, (University of Warwick, November). Available via 'Publications' link at: `www.tlrp.org/proj/phase111/cox.htm`

[4] Cox, R., & Lum, C. (2004) Case-based teaching and clinical reasoning: Seeing how students think with PATSy. In Brumfitt, S. (Ed.) *Innovations in professional education for Speech and Language Therapists*, London: Whurr.

[5] Cox, R., McKendree, J., Tobin, R., Lee, J. & Mayes, T. [1999] Vicarious learning from dialogue and discourse: A controlled comparison. *Instructional Science*, **27(6)**, 431–457.

[6] Heffernan, N. T., & Koedinger, K. R. (2002) An Intelligent Tutoring System Incorporating a Model of an Experienced Human Tutor. *Proceedings of the Sixth International Conference on Intelligent Tutoring Systems*, Bierritz, France.

[7] Howarth, B., Hoben, K., Morris, J., Varley, R., Lee, J. & Cox, R. (2005) Investigating students clinical reasoning: Analysing think-aloud protocols and integrating multiplesource data. *Proceedings of the 11th Biennial Conference of the European Association for Research in Learning and Instruction (EARLI)*, Cyprus, August.

[8] Hoben, K., Varley, R. & Cox, R. (2007) The clinical reasoning skills of Speech & Language Therapy students. *International Journal of Language and Communication Disorders*, **42**, 123-135.

[9] Irby, D.M. (1994) Three exemplary models of case-based teaching. *Academic Medicine*, **69**, 947-953.

[10] Jonassen, D.H. (1996) Scaffolding diagnostic reasoning in case-based learning environments. *Journal of Computing in Higher Education*, **8(1)**, 48-68.

[11] Laurillard, D. (1993) *Rethinking University teaching: A framework for the effective use of educational technology.* London: Routledge.

[12] Lum, C., Cox, R., Kilgour, J., Morris, J. & Tobin, R. (1999) PATSy: A multimedia, web-based resource for aphasiologists and neuropsychologists in research and education. *Aphasiology*, **13**, 573579.

[13] Lum, C. & Cox, R. (1998) PATSy - A distributed multimedia assessment training system. *International Journal of Communication Disorders*, **33**, 170–175.

[14] Mayes, J.T., Dineen, F., McKendree, J. & Lee, J. (2001) Learning from watching others. In C. Steeples & C. Jones (Eds.), *Networked learning: Perspectives and issues.* London: Springer.

[15] Skehan, P. (1988) *A cognitive approach to language learning*. Oxford: Oxford University Press.

[16] Whitworth, A., Franklin, S. & Dodd, B. (2004) Case based problem solving for speech and language therapy students. In Brumfitt, S. (Ed.) *Innovations in professional education for Speech and Language Therapists*, London: Whurr.

[17] Williams, S.M. (1993) Putting case-based learning into context: Examples from legal, business and medical education. *Journal of the Learning Sciences*, **2**, 367-427.