Computer-Based Strategies for Articulate Reflection (and Reflective Articulation)

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In 1993, the last time ICCE was in Taiwan, theories of situated cognition were promising to change the field of educational computing. What has happened since? It seems that many of the superficial interpretations of situated cognition (that thinking is a physical skill, that knowledge cannot be separated from activity, that learning takes place through participation and not in an individual mind) have been sufficiently refined that they may be considered to accord with current emphases on collaborative learning environments. However, the precept that "'situated' means coordination without deliberation", which, superficially (and, of course, situationists would attempt to clarify that it is much deeper than this), seems to reduce cognition to unreflective practice does not appear to correspond to current system designs. There is now an increased emphasis on learning systems providing an environment not just for practice but also for articulation and reflection. The reasons for this will be discussed and some strategies for promoting articulate reflection will be illustrated with reference to five systems: EUCLID (for geometry problem-solving), BSL (for understanding floating and sinking), STURM (for supporting essay planning), MArCo (for group planning) and STyLE (for learning terminology).

Keywords: system design, reflection, articulation

1 Introduction

The aim of this paper is to consider trends in the development of advanced computer-based learning (CBL) systems in the last decade and, in particular, to focus on strategies for supporting articulate reflection by students. In 1993, the last time this conference was held in Taiwan, there was a heated debate underway concerning the implications of situationism or situated cognition, a specific form of constructivism, for the design of CBL systems. Proponents of this philosophy of cognition considered that a revolution in the way we conceptualise CBL system design was needed.

We do not hear so much about this debate nowadays (for example, at the recent AIED and ITS conferences there was barely a mention of situated cognition). What has happened? Has the theory been abandoned? Has it been entirely accepted, so that there is nothing left to debate? Have some of the tenets been quietly absorbed and some put aside?

The tenets of situationism always seemed rather elusive in the sense that the simplistic slogans which were sometimes put forward to summarise the revolutionary nature of the theory were inevitably accompanied by detailed discussions indicating that the slogans never quite captured the essence of the theory. What appears to have happened over the last decade is that the tenets have been refined so that they no longer seem so revolutionary - and indeed current system designers unaware of the previous heated debate might well wonder what all the fuss was about. For the simple fact is that researchers and designers are situated too. What they do is determined also by their community of practice and environment, and, obviously, over the last decade there have been major changes towards networked learning and lifelong learning, with which situationism is more in tune than the traditional symbol-processing forms of cognitive science, more appropriate for individualised, adaptive systems.

However, there is one current trend in CBL systems, the focus on supporting articulate reflection, which it is difficult to relate to the principles of situationism. Of course, situationists had much to say about articulation and reflection (along with everything else) but most of it appeared to be rather confused. As we will see, this is basically because situationism is a theory of knowledge and performance and not directly one of learning.

In this paper, we will briefly discuss the nature of situationism and consider trends in the design of CBL systems. After considering articulation and reflection in more detail, we will then present various strategies for supporting articulate reflection, illustrated by specific CBL systems, leading to conclusions about CBL system design.

2 The tenets of situationism

Situationism is one of many variants of constructivism. The defining characteristic of constructivism - the principle that learners construct knowledge and do not somehow passively receive or absorb it - is hardly arguable. The corollaries which are emphasised begin to be more questionable:

- that an essential part of what is learned is the context in which learning takes place (both the physical and social environment);
- that knowledge is constructed by learners through actively interacting in situations in which they experience a domain;
- that previously constructed knowledge influences the way learners interpret new experiences and affects their thinking and learning;
- that construction of knowledge occurs over time from the learners' attempts to connect new and previously developed experiences.

Situationism departs from other forms of constructivism in its view of what it is that is constructed. Non-situationists need not necessarily deny that knowledge construction leads to symbolic representations or cognitive structures held in the brain (as conventional cognitive science might be considered to hold). Situationists do not agree that the 'construct' is an entity in this sense.

The following appear to be the main tenets of situationism (although it is risky to present such a brief list because situationists will always say that matters are really much more complicated than this):

- Knowledge is an analytic abstraction, like energy, and not a substance or thing that can be inventoried [3]. It does not reside "in the heads of tutors, getting there through experience, abstracted but not necessarily accessible in an articulatable form", as asserted in [16]. Knowledge may be represented symbolically, for theoretical purposes, but such symbolic representations are not themselves knowledge, no more than a map is the territory mapped.
- The activities of a person and an environment are parts of a mutually-constructed whole. A person does not act *in* or *on* an environment (or vice versa) but *with* an environment. Therefore, one cannot describe either separately but only in terms of their contributions to an activity. The mind is then a functional property of this interaction between a person and an environment, not an entity that exists in the head. Perception and acting are mutually shaping, or "'situated' means coordination without deliberation" [1], a phrase subsequently elaborated to mean much more than it appears to say.
- Language is the "instrument of social cooperation and mutual participation" [7], rather than a means of describing some separately given reality. Therefore, language is the means to enable learners to participate in a jointly constructed social activity rather than to transfer reality from one head to another.
- Learning is "a process that takes place in a participation framework, not in an individual mind .. learning is, at it were, distributed among co-participants, not a one-person act [11]. This proposition seems less counterintuitive once it is clarified that 'social' does not mean 'in the presence of other people': "an action is situated because it is constrained by a person's understanding of his or her 'place' in a social process" [3]. So an individual reading a book may be situated and engaged in a social process.
- In general, situationism begins with practice and works towards theory (rather than vice versa, as attributed to the symbol-processing paradigm). There is, therefore, an emphasis on learning from apprenticeship, rather than from teaching or formal schooling. This denial of the role of theoretical abstractions, necessarily situation-independent, does, of course, create difficulties with the notion of 'transfer'. One could deny that transfer ever happens [6] or attempt to provide a situationist account of the apparently contradictory notion of transfer ([10], a lengthy but ultimately unconvincing article).

It was striking that the studies that led to the theory of situated cognition were mainly studies of performance (grocery shopping, Liberian tailoring, reasoning about land rights in the Tiobriand Islands) and not of learning (e.g. of how a Liberian tailor becomes competent). It was rather assumed that the only or the best way to acquire the situated knowledge that people appear to have was for them to be immersed in the 'community of practice' - as if, after observing expert skiers on the mountainside one concluded that a novice skier should learn within that community, when in fact the opposite happens, with novice skiers being excluded until they are capable of joining. It was also implicit that because knowledge was observed to be situated this was therefore a desirable state of affairs - that it should be the aim of education to help learners acquire such situated knowledge.

In response to the question "So, what should we as system designers do differently, according to situation cognition?" a list [2] was provided (where I have omitted the "rather than .." clause which ended each item, in order to focus on the nature of the proposal, not its purported contrast with alternatives):

- participate with users in multidisciplinary design teams
- adopt a global view of the context in which a computer system will be used
- be committed to provide cost-effective solutions to real problems
- facilitate conversations between people
- realise that transparency and ease of use is a relation between an artefact and a community of practice
- relate schema models and computer systems to the everyday practice by which they are given meaning and modified
- view the group as a psychological unit.

As we look at the list today we may conclude that it is not so controversial. Situationism has been sound in its broad proposal - that we would do better to concentrate on restructuring the social-cognitive settings within which students learn than to try to manipulate the internal information-processing of students. However, there is one aspect which is missing, or at most muddled, within situationism and that is the role of activities specifically to aid learning (not performance), such as articulate reflection.

3 Reflection and articulation

By *reflection* we mean more than 'deep thinking', as in the everyday sense. We mean the consideration of one's own thought processes, problem-solving strategies, knowledge and skills. In short, thinking about one's own thinking. In general terms, this reflection needs to be both motivated (so that the learner feels there is some potential gain in pausing during the problem-solving process) and supported by some kind of externalisation of the learner's thought processes (so that there is something upon which the reflection may focus).

Reflection is therefore an interruption to action. With competent problem solvers, where there is no intention to seek improvement in any related activity, there may well be no reflection. If situated cognition implies action "without deliberation" then this appears to leave no place for reflection, although it has always been a key component of cognitive apprenticeship [4]. Reflection was considered to be the fourth and last stage of the cognitive apprenticeship process. However, it was considered appropriate only in domains for which the target process is external and thus readily available for observation and comment and also bears a relatively transparent relationship to concrete products.

Articulation is the process of verbalising, for the benefit of oneself or others, the thought processes and problem-solving activities that are occurring or have occurred. Articulation is important for three reasons. First, at the philosophical level, the link between language and thought, the later sometimes being considered to be a kind of 'internal language', may mean that the act of making verbally explicit may in itself help develop the thought processes being described. Secondly, articulation may bring into the open current (mis)understandings so that they may be inspected, discussed and edited by oneself or others. Thirdly, being able to provide an articulate explanation is itself a worthwhile educational objective. Situationist researchers may be in awe of remarkable, but inarticulate, problem-solving processes but generally we prefer a solution which is accompanied by some explanation of how it has been derived.

For computer-based learning systems, we need to support *both* reflection and articulation together, neither alone being of much help to the system or the learner. The system needs to provoke reflection but it needs to receive some information about that reflection if it is to provide support.

4 Strategies for promoting articulate reflection

In this section, five strategies intended to promote articulate reflection are described, illustrated by projects underway at Leeds.

4.1 Present novel problems which require articulation for their solution

If one presents a traditional geometry problem (such as Figure 1, on the left) to an expert, a solution is obtained almost instantaneously, with the expert often being unable afterwards to say precisely how the solution was obtained. Asking the problem-solver to describe the process during problem-solving only interferes with the process. Such problems, characteristically, have the fortunate properties of being complete and non-redundant, that is, every thing that needs to be known is in the figure and there is nothing in the figure which is not needed in the solution. Problem solvers therefore soon realise that any step is likely to be a useful one.

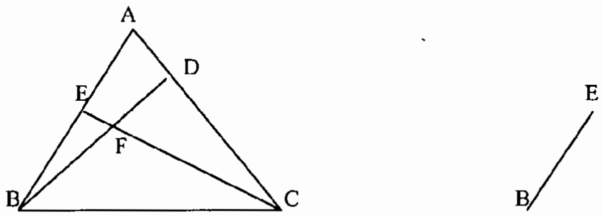


Figure 1. (a) A 'traditional' problem: Given BCF=FCD, CBF=EAD, BF=5, what is the length BE?
(b) An 'incomplete' problem: What is the length BE?

If, however, we present an 'incomplete' problem (Figure 1, on the right), then solvers have to think carefully before asking for information which they hope will be useful. For example, for this problem, we might ask:

"Is there a line parallel to BE?"

"Is there another line through point B?"

Even experts (at traditional problems) have difficulty in devising an effective series of questions for such problems. Generally, however, those with a better understanding of geometry realise that more 'conceptual' questions (such as those to do with parallel and perpendicular lines) are more useful than specific questions, because they are related to the inferences (opposite angles, exterior angle, etc.) which need to be made.

The EUCLID system (Figure 2) has been implemented to enable solvers to solve such problems and enable them to develop an understanding of geometry concepts. Users use the right menu to ask questions of various forms and the left menu to apply inference rules, thereby making explicit their problem solving process. The system records the questions asked and this provides a focus for reflection.

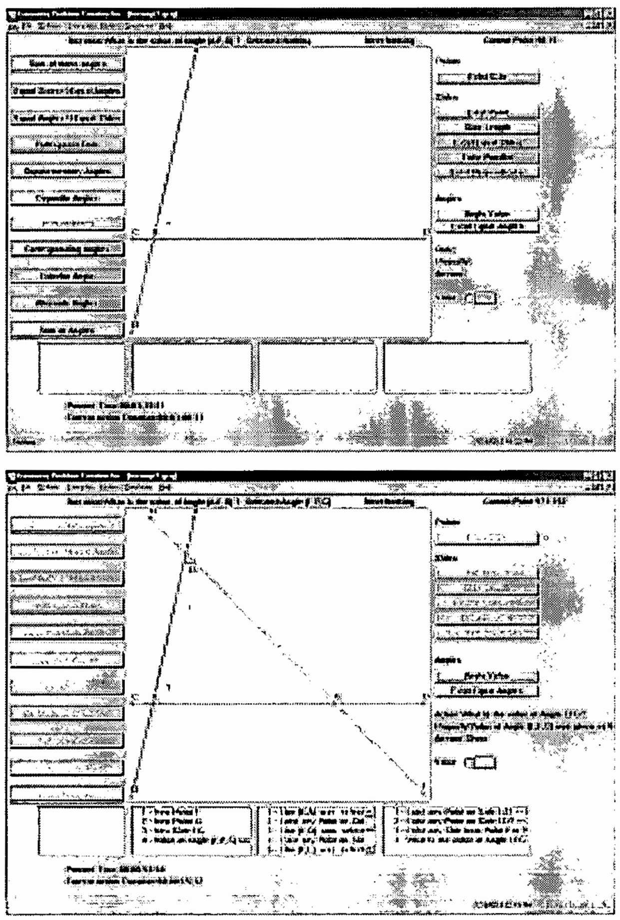
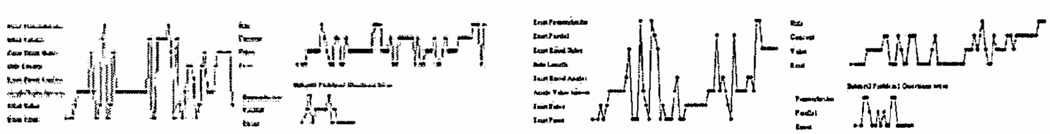


Figure 2. The EUCLID system, showing the starting problem (above) and midway through a solution (below).

The questions may be considered to be of four kinds: existence, value, conceptual, rule application. Users' strategies may then be plotted, showing differences between novice (focussing on specific questions) and expert (asking more conceptual questions) problem solvers [12].

Figure 3. A trace of two subjects' solution of the problem shown in Figure 2.



4.2 Provide an appropriate language, especially where the proper language is too formal

Most people can venture an answer to a problem such as that shown in Figure 4, but find it hard to give a justification for their solution. They simply do not have the technical or everyday words to express their justification. Here are two typical explanations:

"The shape of the bottom of the boat is slanting and the gradual change of the slope... helps it float. In the block....no gradual change of slope....so it sinks."

"Something to do with the shape. Don't know why....saw on TV where the speed of motion depends on shape."

It does not help to provide a list of technical definitions (buoyant force, etc.).

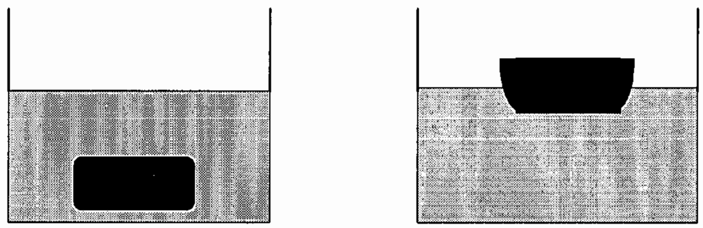
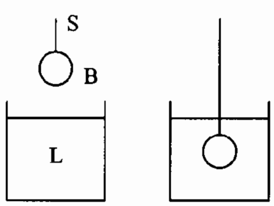


Figure 4. A floating problem: *A lump of plasticine sinks when it is placed in water. When the same lump of plasticine is shaped into a boat, it floats as shown on the right. Explain this phenomenon.*

Instead, we might try to provide an intuitive, informal language which may provide a bridge to the technical language. For example, consider the situation (Figure 5) in which a body B hangs from a string S above or in a liquid L (in a infinite container). B, S and L are the only things we need to talk about. What can we say if we make B heavier (but the same volume)? S has to hold it up a bit more. What if L is denser? What if B is a cylinder not a sphere? ... fairly soon, one starts using B, S and L for the forces associated with them (without, of course, necessarily using the word 'force'). Once one has this 'language', more complicated questions can be tackled: When a body is lowered into a liquid do B, S and L change in the same way if B is a sphere and a cylinder? How do B, S and L change if the body floats when it is lowered?



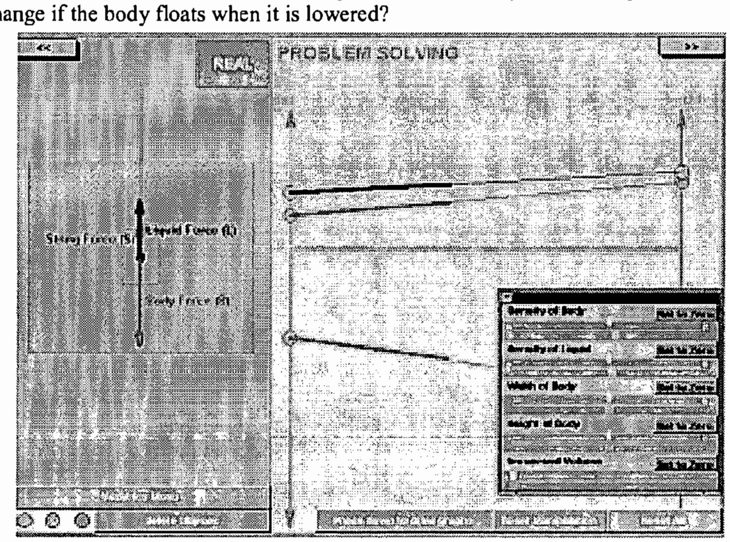


Figure 5. The BSL situation and the BSL environment for experimentation and problem solving.

The BSL system (Figure 5) was designed to help students articulate and reflect upon their thinking about buoyancy and floating concepts. The evidence is that students are enabled to provide more articulate explanations, and, through experimenting with the simulation, can test out hypotheses and develop conceptual understanding [13]. For example, here is an extract of an explanation given while using BSL:

S: "Increase depth of submergence....as you increase....body force will remain constant, I guess....your liquid force, I guess is going to increase because....due to the height....you are going deeper..."

E: "What height is that?"

S: "The deeper....as you go deeper into the water, there is water pressure pushing it up. But I am not very sure about the string force...as you go deeper, the string force is getting less because of the upward force of the liquid....so....the thing is getting less....I think it's getting constant....I guess."

4.3 Monitor the student's activities and help him to articulate his problem-solving strategies

Imagine that you are a music undergraduate and you have been given the following essay assignment: "In what ways was Schumann a more romantic composer than Beethoven?" Imagine also that your tutor has kindly provided a list of potentially useful web addresses (music dictionaries, biographies, examples, etc.). How would you proceed?

The planning stage of writing involves goal setting, content generation and argument building. The potential argument structure of an essay should not emerge after all information has been gathered but should guide the information-gathering process. Therefore providing advice on appropriate research strategies should help students begin to build an argument structure from the material which they are reading. We have identified a number of strategies potentially useful for tackling essays of the form "Compare A and B with respect to X", such as:

- identify the characteristics of X (so that you may compare A and B with respect to each characteristic)
- see if the characteristics of X change over time (so that you may see when A and B best fit X)
- search for discussions of whether A (or B) has a specific characteristic of X or not
- consider whether there is an exclusive-or relationship between X and some Y (so that, if so, you might consider A (or B) with respect to Y

The STURM (Studying, Teaching and Understanding Research Methodologies) system has a catalogue of such general purpose information-gathering strategies. The idea is that as a student browses the web resources the system maintains a simple model of the information of which they are aware and then when a student asks "What should I do next?" it is able to provide advice, by determining which of its strategies are applicable at that time. For example, if the student has accessed a resource which suggests that a characteristic of romanticism is that it is more descriptive or programmatic than abstract a number of steps might be proposed, including an instantiated form of the third one above: "See if Schumann's music is descriptive". Of course, it is conceivably useful to present an abstract form of the advice, as being potentially helpful for all essays of this type. As the student carries out this browsing, what he discovers begins to form the structure of the essay. For example, finding out (from the second piece of advice above) that the notion of romanticism changed considerably from the Beethoven to Schumann eras provides one basis for organising the essay.

4.4 Require students to develop problem-solving strategies in a group and help to resolve conflicts

There has been much discussion of the idea that cognitive conflict triggers reflection. However, it is clear that such conflict does not always trigger reflection and, if it does, it is often quite shallow. Partly, this is because the notion of conflict is itself quite shallow, amounting to the holding of a proposition and its negation. The resolution therefore involves only the consideration of which proposition(s) need to be discarded. 'Strategy conflicts', however, are more subtle. If a strategy is a partially ordered sequence of steps to achieve some goal, then two strategies may conflict in various ways, for example, some of the steps may be out of order, different ones may be in parallel, etc. It is not always clear whether the differences are significant. If there is a significant conflict, its resolution involves more than just deleting one or more components. In short, the resolution of strategic conflicts is likely to provide a basis for deeper articulate reflection than ordinary cognitive conflict.

The MArCo system (Figure 6) is designed to support two or more students in group problem solving and then to resolve potential conflicts. Conflicts happen through dialogue and are inevitable in group problem solving, and, indeed, are beneficial to it. To provide support, the system needs first to model individual activities and to detect conflicts. We distinguish between a 'difference of views' (where agents have different views but have not yet communicated them to each other); a 'disagreement' (where the agents inform each other about their different views but a discussion does not then follow); and a 'conflict' (where the agents try to convince one another about their own points of view). Conflicts may be of various kinds [17]:

- non-task related or social conflicts
- belief conflicts, i.e. conflicts about facts and rules within the domain
- contextual conflicts, related to defining what exactly is the problem being solved
- reflector conflicts, related to how goals are selected

- intention conflicts, concerning the steps to be taken to solve a problem
- goal-definition conflicts, relating to defining the goal
- goal-achievement conflicts, concerned with disagreements about whether the goal has been achieved.

For example, a belief-conflict is defined as:

Bel_Conflict(x,y,s) = def[Bel(x,s) and Bel(x,Bel(y,~s)) and Intend(x, Bel(y,s))]

According to this definition, x has a conflict with y if x intends that y should change his belief to conform to x's, but not necessarily vice versa. We can also define a mutual belief conflict:

Mutual_Bel_Conflict(x,y,s) = def[Bel_Conflict(x,y,s) and Bel_Conflict(y,x,~s)]

The distinction is important because, in the first case, x may be mistaken about y's beliefs and the conflict situation may cause confusion, whereas the second situation has more potential for articulate reflection. Similarly, we define a collaboration and a mutual collaboration as:

Collab(x,y,p) = def[Bel(x,p) and Bel(x,Bel(y,p)) and Intend(x,strategy(x,p)) and Expects(x,Intend(y,strategy(y,p)))]

Mutual_Collab(x,y,p) = def[Collab(x,y,p) and Collab(y,x,p)]

In a mutual collaboration, the strategy(x,p) and strategy(y,p) are interleaved or merged to contribute to a problem solution; in a mutual cooperation, the strategies are concatenated (i.e. they are independent and both contribute directly to the solution).

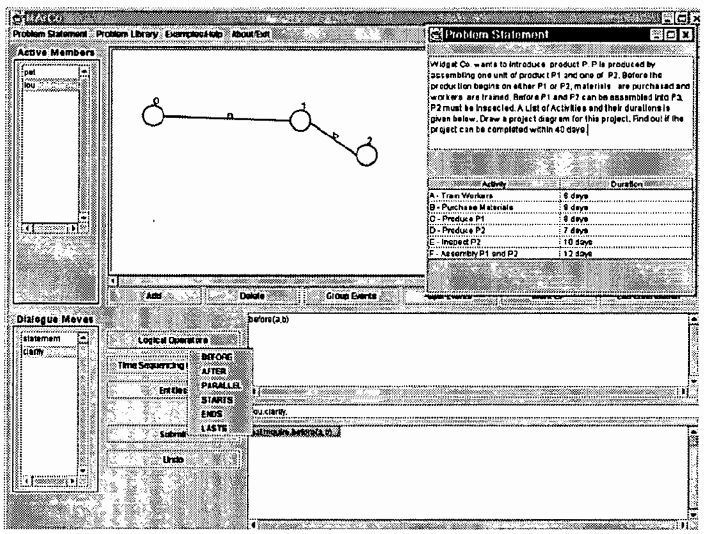


Figure 6. The MArCo system

The MArCo interface provides:

- a graph window, where members of the group build a common graphical solution
- a constraints window, where members may discuss the constraints and goals of the problem
- an active members window, showing who is involved in the discussion
- a dialogue region, where members contribute by selecting dialogue moves and selecting the content (from the graph window or the constraints window)
- a dialogue record, maintaining a history of the interaction.

On detecting a conflict, MArCo may (1) simply inform the group that a conflict has been detected, leaving the group to decide how to proceed; (2) after detecting a conflict, ask a member who has expressed a view different to the group model to elaborate on his apparent change of mind; (3) suggest actions that may lead to more refined solutions, by, for example, building up solutions involving more members of the group.

4.5 Present the student with a representation of his own understanding, which he may discuss and edit

Presenting the learner with an externalisation of their thoughts, e.g. System: "You seem to think that money markets operate with short-term investments", will not by itself provoke much articulate reflection. The system needs to be able to sustain a focussed interaction probing the justifications for such beliefs.

STyLE-OLM (Figure 7) is an environment for interactive diagnosis where a learner and a computer system are involved in an ongoing dialogue about the content of the learner model [8]. It supports the elaboration of the definitional structure of a terminology domain. It provides a communication medium based on a graphical representation of conceptual graphs that allows externalisation of the learner's conceptualisation of the domain and thus articulation of his domain structural model. An interactive model based on dialogue games maintains the communication between the learner and the computer.

Involving students in situations where they can inspect and discuss their models is a reflective activity which leads students to think about their domain knowledge as well as to articulate, validate, and challenge the robustness of their domain competence. STyLE-OLM provides a variety of reflective situations. It encourages the student to make statements about his beliefs and allows him to go back to his previous claims about these beliefs and (possibly) to change his claims. Throughout the interaction, the scope of the articulated beliefs is extending and he is provided a manner to explore various aspects and alternatives for expanding his beliefs. Additionally, the system leads the learner to search for and render grounds that support his beliefs.

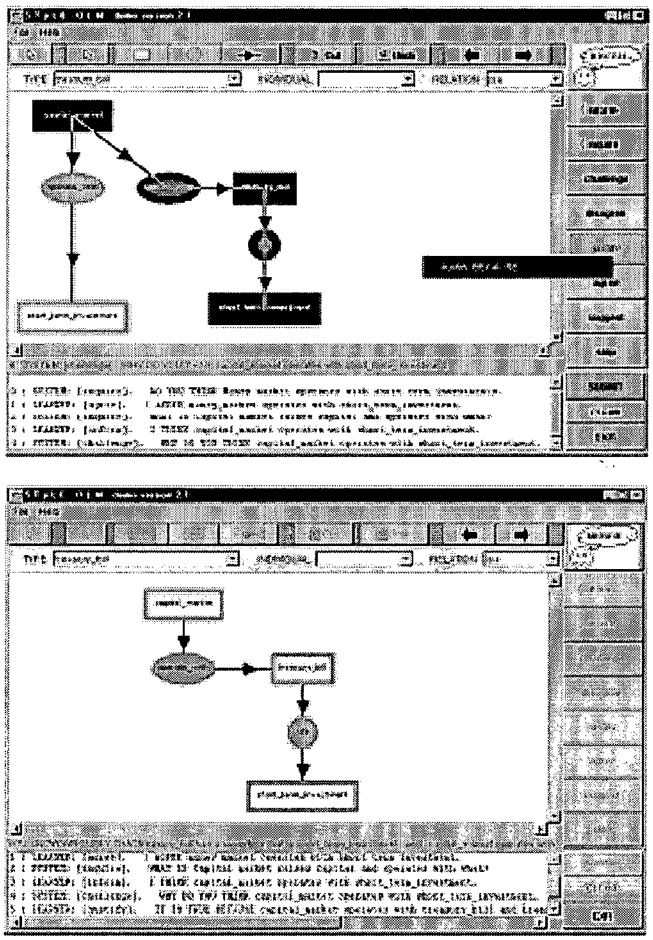


Figure 7. The STyLE-OLM system

STyLE-OLM provides two modes: DISCUSS, where a learner can discuss aspects of his domain knowledge and influence the content of the learner model (figure 7 above), and BROWSE, where a learner can inspect the current state of his learner model (below).

The graphical tools on the top allow the student to manipulate the graph that will present the proposition of his communicative act. He adds illocutionary force by selecting a dialogue move from the right area of the screen. Both the student and the system contribute to the discussion in the same way - by selecting a graph component and a dialogue move. The bottom text window shows a generated transcript of the dialogue. The learner can browse this textual form of the dialogue history or a graphical one. As the dialogue proceeds, the system makes plausible inferences about what further the learner believes on the basis of what is explicitly asserted, and from this a dialogue strategy is determined. The dialogue is guided by general explanations of misconceptions, for example, that an entity may be believed to be a member of a class if it has some features of that class. The example shown presents a situation of a session with STyLE-OLM in a Finance domain.

STyLE-OLM is called by STyLE (a learning environment for Finance terminology) to solve problems with the diagnosis faced by the components that analyse a student's performance. In this example, initially, the learner model contains information that the learner knows some aspects of the terms MONEY_MARKET and CAPITAL_MARKET but often mixes these terms. STyLE-OLM initiates a dialogue to explore the learner's knowledge about these terms and to find possible reasons for his beliefs. This is an extract from this interaction (note that is a generated transcript - all communication is actually done graphically, using the graph and menus):

STyLE-OLM$_{[inquire]}$ DO YOU THINK MONEY_MARKET operates with SHORT_TERM_INVESTMENTS.
Learner$_{[agree]}$ I AGREE MONEY_MARKET operates with SHORT_TERM_INVESTMENTS.

STyLE-OLM[inquire] WHAT IS CAPITAL_MARKET raises CAPITAL and operates with WHAT?
Learner[inform] I THINK CAPITAL_MARKET operates with SHORT_TERM_INVESTMENT.
STyLE-OLM[challenge] WHY DO YOU THINK CAPITAL_MARKET operates with SHORT_TERM_INVESTMENTS?
Learner[justify] IT IS TRUE BECAUSE CAPITAL_MARKET operates with TREASURY_BILL and TREASURY_BILL is a SHORT_TERM_INVESTMENT.

The screen shot in Figure 7 depicts the environment at the moment when thc learner constructs and submits his justification. STyLE-OLM may continue the dialogue:

STyLE-OLM[challenge] WHY DO YOU THINK CAPITAL_MARKET operates with TREASURY_BILLS and TREASURY_BILL is a SHORT_TERM_INVESTMENT?

At this time the student may challenge the robustness of his domain beliefs. He switches to a browse mode where he looks through the current state of the learner model. The lower screen shot in figure 7 presents this stage. The learner realises that his claim that CAPITAL_MARKET operates with TREASURY_BILL and TREASURY_BILL is a SHORT_TERM_INVESTMENT is wrong. He can now ask the system to help him to explore the domain knowledge about these terms. The learner may switch back to a discuss mode where he asks questions:

Learner[inquire] IS IT TRUE TREASURY_BILL is a SHORT_TERM_INVESTMENT?
STyLE-OLM[inform] I KNOW TREASURY_BILL is a SHORT_TERM_INVESTMENT.

The learner now realises that this domain belief is correct and asks for the other part of his wrong belief:
Learner[inquire] IS IT TRUE CAPITAL_MARKET operates with TREASURY_BILLS?
STyLE-OLM[inform] I DO NOT KNOW CAPITAL_MARKET operates with TREASURY_BILLS.

The learner has now clarified the wrong part of his beliefs. Now, he could possibly withdraw his claim that CAPITAL_MARKET operates with SHORT_TERM_INVESTMENTS, ask what CAPITAL_MARKET does operate with, or explore his knowledge about SHORT_TERM_INVESTMENTS by making claims about other examples of short term investments.

5 Related work

There are, of course, other strategies for promoting articulate reflection not illustrated by the Leeds systems, for example:

- Use a 'reflective follow-up' in which, after a problem has been completed, the student is stepped through his solution steps in comparison with the steps that the system itself (as an expert problem solver) would have taken [14].
- Use a simulated peer (which has access to an expert domain model) to prompt a student to explain the reasoning behind his actions [9].
- Require students to complete sclf-cxplanations, that is, to provide explanations to cover gaps in worked examples [5].
- Provide an interface for students to express their theories of how to do inquiry [18].

Finally, to indicate that articulate reflection is not always beneficial, consider the following problem: "Two glasses, two inches and four inches wide, are both filled up to one inch from the top. Which glass has to be tilted the most before the liquid pours out?". When people close their eyes and imagine the glasses being tilted they always answer correctly - but when twelve pairs considered the problem and engaged in some discussion about it, none of them answered the problem correctly [15]. Evidently, there are times when articulate reflection in a group does not lead to productive outcomes!

6 Conclusions

Ideas about the design of computer-based learning environments have evolved over the last decade. We no longer have such heated debates about the implications of apparently contradictory philosophies. The tenets of what appeared to be the most revolutionary philosophy (situationism) have largely been absorbed, although there is, of course, much work to do to develop practical applied systems. However, this has probably occurred not as a result of any philosophical conversion but as a result of changes in the technological and social context, in particular, the growing emphasis on networked, lifelong learning. Somewhat paradoxically, however, situationism's genufleetion to efficient and effective problem-solving performance, without apparent reflection or traditional teaching, led to a neglect of aspects which are crucial for learning, if not performance. In particular, the role of articulate reflection was never clearly integrated into the theory of situationism, because its ideas about learning were inferred from its theory of performance. Computer-based learning systems designers, however, have proceeded to develop a number of strategies for supporting articulate reflection, as illustrated in this paper, indicating that they continue to be more influenced by their own communities of practice and social and technological contexts than by theoretical philosophies (as situationism would predict).

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