

# MODELLING SOCIAL ALGORITHMS AS DESIGN TEMPLATES FOR EDUCATIONAL SOFTWARE

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## ABSTRACT

Education involves a process of initiating learners into complex socio-cultural processes which may vary from culture to culture and even between institutions within the same culture, making it difficult to design versatile courseware which has some relevance for the social process to be mastered by learners. Moreover, social elements often operate intra- as well as extra-systemically in social processes, which makes it difficult for the courseware designer to differentiate between the commonalities and variables in learning processes. Yet in spite of the complexity of human social behaviour, psychologists have identified social algorithms which apply to various key domains, and which prepare young people for effective social functioning in a variety of life situations. It is the contention of this paper, based on doctoral research on modelling composition, that it is possible to identify social algorithms which underpin human learning, and which might form the basis for effective courseware, given that such programs would require customisable options so as to cater for the extra-systemic elements applying in various socio-cultural contexts. One of the means whereby social algorithms can be identified is provided by Franck's modelling process, which uses the principle of reverse engineering. The modelling process is described in some detail, as is the central concept of the social mechanism (i.e. algorithm) with specific reference to the development of educational software in the form of a process-based writing tutor program.

## KEYWORDS

Modelling, algorithms, courseware, Education, composition.

## 1. INTRODUCTION

This paper is based on doctoral research in which a modelling process was used to identify the social mechanism involved in communicating in written mode. The mechanism comprised a composing algorithm which provided the basis for the design of a writing tutor program: this meant that a social algorithm acted as the design template for the resulting software. The research was carried out within a critical realist orientation, which focuses sensitively on social empowerment through praxis (Archer 1995, 1998, 2002; Bhaskar 1978, 1979, 1989, 1994; Harré 1979, 1986). In critical realism human agency is viewed as the means whereby social practices are reproduced and/or transformed (Bhaskar 1994:92), which is why the focus of the study was on the social relations involved in production (i.e. composing) and not product (i.e. text). In an earlier paper I suggested that the modelling process used in the research had in effect produced a "stochastic social-process algorithm" on which the design of the writing tutor program could be based (Pratt 2005a). Subsequently it became apparent that psychologists actually use the term "social algorithm" in very much the same way, and that social algorithms are deemed significant in social psychology because they not only describe social behaviour but provide young people with concepts which might guide social behaviour (Blunt Bugental 2000). Having arrived at a similar conclusion independently for the learning of social communicative processes, I had tentatively termed such algorithms "conceptual mechanisms". In this paper I would like to focus in more depth on the modelling process used in the research, and the nature of social mechanisms, which are vaguely defined in social science literature generally, but clarified in Franck's (2002) seminal work on modelling. The writing tutor prototype will be used to exemplify how such algorithms can form the basis of courseware design, and how the resulting courseware can provide learners with not only effective tutoring but also conceptual mechanisms guiding social behaviour.

## 2. THE NATURE OF SOCIAL MECHANISMS

This research was carried out within the critical realist philosophy, which, unlike the dominant poststructuralist approaches to composition, does not view reality as a social construct (this is termed the “*epistemic fallacy*”, Bhaskar 1994:48). As critical realism posits a reality independent of human thought (i.e. intransitive) and usually only partially experienced (if at all), hypothesising about the nature of the “real” is offered as a way to transcend the limitations of human experience. Bhaskar’s ontology (see Table 1) shows mechanisms as existing in the “Domain of real”. Unlike experiences and events which are directly accessible to humans (the latter, partially at least) the existence of mechanisms can be hypothesized only, as we have no direct experience of them, only their results: they are postulated *causal* entities, complex systems which are thought to bring about natural and social events. To understand social mechanisms we need to distinguish between the mechanistic operation of natural phenomena and human agency, the latter also constituting a type of causality. In fact, in critical realism human agency is considered to be a key mechanism in not only replicating but transforming social structures (Archer 2002:19, Bhaskar 194:92). In order to distinguish between human agency and the operation of natural elements, I have tentatively suggested the terms “*intentional causality*” and “*contingent causality*” (see Bhaskar 1979:102-3). This is not to imply a simplistic division between animate and inanimate functioning (contingent causality may well be the result of human behaviour), but to distinguish between contingent factors and purposeful human behaviour. The algorithms which underpin human social behaviour can then be regarded as *social mechanisms with intentional causality*.

Table 1. Bhaskar’s three domains (1978:56)

	Domain of real	Domain of actual	Domain of empirical
Mechanisms	✓		
Events	✓	✓	
Experiences	✓	✓	✓

The term “social mechanism” is used with a very wide application in social science literature generally (see Mahoney’s twenty-seven definitions, 2003:14-15). Morén and Blom, in applying a critical realist approach to social work, state:

We define generative mechanisms in social work practice as forces (reasons and motives) which - primarily activated by social workers’ and clients’ united efforts - generate client effects. Generative mechanisms are real, but seldom directly observable (2003:55).

But while “reasons and motives” have true causal force, so does human agency itself, and the algorithmic patterns underpinning the learning of human social behaviour (including rehabilitation and therapy) also constitute a type of social mechanism (Blunt Bugental 2000). Mechanisms are not just social processes, however, but obey a definite form (Danermark 2001, Franck 2002). Franck makes it easier to specify what actually constitutes a mechanism by separating its formal characteristics from its practical operation, while at the same time showing how the systemic relations govern - and thus make sense of - the operation of the mechanism:

How can we recognize a mechanism in a sequence of events? I will propose one answer to these questions: the form of a mechanism, which gives it a certain unity, is the combination of functions which govern its operation in general, or in other words its functional architecture (2002:88).

A social mechanism which operates as a social algorithm can be more easily understood if it is separated into two aspects: its formal characteristics (i.e. as a “system of functions”) and its manifestation in real life situations (i.e. general operational characteristics). Franck represents these as two models: a theoretical model, or system of functions “without which” a social process cannot occur, and an empirical model, or practical means of carrying out the functions in real life situations.

## 3. FRANCK’S MODELLING PROCESS

Models can constitute a type of theory, but it must be remembered that the precise meaning of the term “theory” itself depends on its context and use (Allmendinger 2003). According to Bhaskar, a theory is “a

model conceived, and meant to be taken, as true; i.e. a model in which the entities posited and mechanisms described are conceived as real” (1978:192). Within the context of critical realism theory has a dual role with practice in informing social transformation, and is not viewed as ideologically biased per se (Judd 2002:110). Moreover, observation of social processes is not necessarily compromised by being directed by theory (Sayer 1992:73-4), as Bhaskar’s ontology posits “real” events against which theory can be validated. In the context of this research, which focuses on the design of versatile courseware which can be adapted to different socio-cultural contexts, generalizable models are sought which indicate clearly the intra-systemic factors (i.e. givens) and extra-systemic factors (i.e. local variables) of social functioning. Determining the role of theory is important, as Franck’s modelling process has a theoretical aspect, resulting in the formulation of a theoretical model. A “theoretical model of writing” (i.e. composition) produced in this way is not a “grand theory”, or a comprehensive account of literacy practices, but merely a model of the system of functions “without which” communication in written mode cannot occur (i.e. it describes the felicity conditions for written communication). It is in fact a very lean model much in the fashion of a systems approach (Meehan 1968:63). However, unlike Morén and Blom’s system of “reasons and motives” it is a model with algorithmic force, as it describes the social patterning which learner writers need to follow to carry out a social process.

Franck’s (2002) seminal work on modelling made it possible to achieve this systemic approach. After presenting and providing a commentary on examples provided by modellers working in twelve different areas of social science, Franck arrives at a summary of the key elements of the modelling process as follows:

(1) Beginning with the systematic observation of certain properties of a given social system, (2) we infer the formal (conceptual) structure which is implied by those properties. (3) This formal structure, in turn, guides our study of the social mechanism which generates the observed properties. (4) The mechanism, once identified, either confirms the advanced formal structure, or indicates that we need to revise it (2002:295).

Two different types of model are developed as a result, a theoretical model and an empirical model (i.e. as apparent from empirical *observation* - not to be confused with Bhaskar’s empirical *domain*, the domain of ideas resulting from human experience). Both models represent different aspects (i.e. formal and applied) of the same social mechanism. Franck’s summary of the modelling process can be separated further into the following stages:

1. The **properties** of a social system are carefully observed and defined.
2. A **theoretical model** is formulated on the basis of the functions needed to achieve the above properties: the model consists of an “architecture of functions”.
3. The **mechanism** which achieves the system’s properties is inferred from applying the theoretical model to real-life situations or data.
4. An **empirical model** is formulated, depicting the operating of the mechanism in a real-life situation.
5. The empirical model may need to be **tested** in a real-life situation or against data, to see whether it actually generates the properties of the system.
6. The theoretical model is **validated** by being tested against the empirical model, to see whether the theoretical model needs adjustment to fit the real-life functioning of the social system.
7. If the theoretical model, that is the system of functions, is seen to be generalizable so as to explain the properties of a process in another discipline or field, it can be said to have the force of a **principle**.

The above breakdown shows how Franck’s solution to the clear identification of social mechanisms is not only elegant in its use of classical induction in deriving the models but eminently practical. In actual instances of modelling there can be considerable overlap and recursion, particularly in stages 1.- 4. where the empirical model may well pre-empt the deeper level system of functions which would form the theoretical model (Franck 2002:96). This initially appeared to be the case in my own research, but closer inspection revealed that I had in fact followed two cycles of modelling, the first implicitly in my masters study. If one considers the courseware as a type of social mechanism, a third cycle had in fact begun before completion of the doctoral study.

The cycles involved in modelling written composition are shown below in Figure 1. In the first cycle, which involved working from the property of composition as a process carried out in a complex series of complex stages, the functions were identified as data-gathering, idea generation, idea organising, editing and evaluating. It was already apparent that this was an algorithm, but not a true theoretical model, as the

communicative functions are masked in written mode. The literature identified the stages which might be involved in the social mechanism of composing, which facilitated the formulation of an empirical (i.e. practical) model of five stages closely associated with carrying out the functions already identified (Pratt 1990:457). The model was tested out on young learners and seen to bring about changes (some marked) in composing behaviour towards composing procedures identified in the literature as those used by competent writers (1990:459-463). Thus the practical model produced so far was not only validated in data but could already be shown to constitute a social algorithm assisting the learning of social processes by providing young people with concepts which might guide social behaviour. However, to distinguish it from mere rule-of-thumb, and to ascertain how social influences might work with the system - particularly with regard to local academic requirements - further testing took place in the form of over forty video protocol analyses in diverse academic contexts over a period of fifteen years.

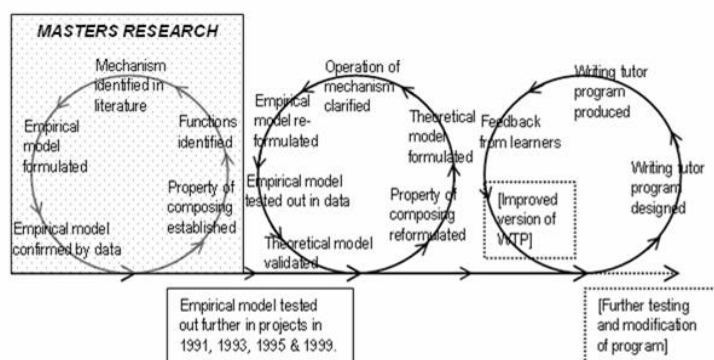


Figure 1. The cycles involved in modelling written composition

For the doctoral study a theoretical underpinning for the empirical model was sought in order to justify its use as the basis for a writing tutor program. In the second cycle of modelling the property was reformulated as communication in written mode, as by now it had become clear that the functions were in fact those without which communication could not take place (i.e. felicity conditions for communication). These were identified as the contextual, ideational, interactive, social and reflexive functions. For communication to take place, it first needs to be *contextualised* by being set in a specific context, and some form of *interaction* is required, which in turn generates *ideational* content. The *social* function relates to the social loading of the message, and the *reflexive* function operates much in the manner of a feedback loop regulating the interaction. The system of functions is relevant to communication in general, and composing can be viewed as a specific social mechanism (not the only one, however) for effecting distanced verbal communication. The systemic or formal representation of the mechanism lies in the system of functions; the actual manifestation of the mechanism in real-life social functioning lies in the pattern of recursive composing strategies identified by researchers and educationists. Shaughnessy (1977) stressed the need for learners to experience composing systemically (i.e. as an algorithm). Britton (1981) in particular noted the key role of expressive writing (i.e. carrying out the ideational function). Raimes (1985), Spack (1984), and Zamel (1985) emphasised the interactive nature of the process and the need for revision (i.e. the recursion in writing). Widdowson (1984) emphasised the focal and enabling acts involved in composing (i.e. ideational and interactive functions), and the need for models of language use geared to the learner's own experience (i.e. models which could function as social algorithms).

Identifying the system of communicative functions clarified the nature of the social mechanism involved in written composition, which made it possible to formulate a more analytical empirical model (Figure 2). This still represents the five original stages but with slight differences in terminology (the only significant change being in representing "data-gathering" as "contextualizing/data gathering"). The second empirical model also shows how the function of each stage impacts on the next: the stage *affects* (as "effectors") the function of that stage and *affects* (as "affectors") the subsequent carrying out of other functions in other stages. The main advance of the analytical model was that it showed not only the intra-systemic operation of the social (i.e. in editing) but its the extra-systemic operation as the contingent factors which act as input into the whole composing system.

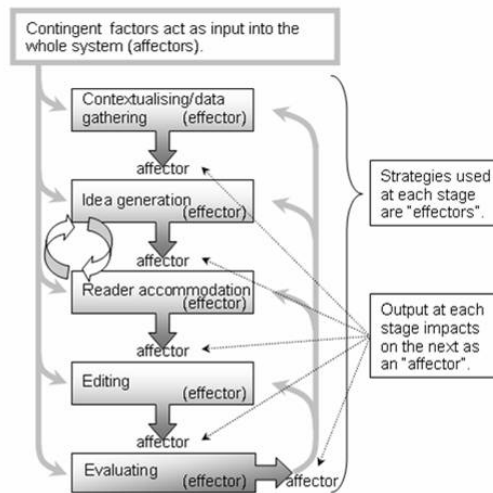


Figure 2. The “analytical” empirical model of composing

As Figure 2 suggests, this means that local socio-cultural influences can permeate all stages of composing. Applied to academic writing, different types of knowledge construction will have impact on what the writer does throughout composing. The second empirical model provides a more satisfactory explanation (i.e. than the first) as to why specific instances of composing are so idiosyncratic, and also explains why, though acknowledged to be systemic, composing has so far defied any attempts to explain its operation. To continue with the second cycle of modelling, the analytical empirical model could then be validated with reference to the previous data as well as in further video protocol analyses. The theoretical model was then validated by virtue of its close correspondence with the empirical model. The theoretical model was considered to have the potential for being a generalizable principle, as it had already been used as the basis for designing mixed-mode courses (Pratt 2005c), and could therefore be viewed as a course design principle. The first empirical model, which I shall term a “pedagogical model” (i.e. to distinguish it from the second empirical model) was considered to be a better basis for the proposed writing tutor program, because it simplified composing processes for young learners. When translated into software it could also be made to contain an input option so that learners could be prompted to identify and input extra-systemic social requirements. In the third cycle of modelling shown in Figure 1, the writing tutor program has had initial response from users, which has suggested improvements, but still needs to be tested out thoroughly in a variety of different learning contexts before any major modifications are made.

#### 4. THE RESULTING COURSEWARE

The writing tutor program was designed as a help menu contained in a movable menu bar which sits above the word processor display on screen: while it runs on Microsoft (at present) it does not interact with MSWord, and could in fact be re-programmed for use with any operating system. Its main advantage is that it can remain on display to be consulted while the learner is composing on MSWord, unlike most Microsoft menus, which invariably disappear the moment the user starts to follow the instructions. The actual operation of the writing tutor program is described in more detail in other accounts (Pratt 2005b): my focus in this paper has been to show how the social algorithm derived from the modelling process has been translated into courseware design. While I have said that the pedagogical version of the empirical model of composing formed the basis for the writing tutor program, the terms used for the actual stages (i.e. the central composing algorithm) were simplified so that their meaning might be self-explanatory to the user. They therefore appear on the main menu (in Figure 3) as “Preparing to write”, “Writing rough drafts”, “Revising for your reader”, “Editing and proof-reading” and “Evaluating your writing”. These correspond to the communicative functions shown on the right hand side of the main menu in Figure 3, and in fact a consideration of the deep-level communicative functions was very helpful in arriving at the final choice of wording in the main menu.

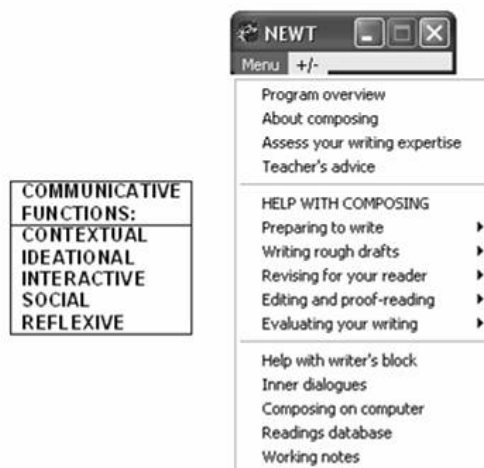


Figure 3. The communicative functions underpinning the writing tutor program main menu

It must be noted that the sequence of the HELP WITH COMPOSING core appears to show composing as a neat chronological sequence (i.e. a simplistic write-by-numbers approach). However, because this is a help menu, and because learners come to the program with very different needs and priorities, users may well start at any stage of composing (there are suggestions for use, but as we know, users rarely read the instructions first). Designing the program around a help menu meant that it was possible to pack much more of what is involved in the social process of composing into program form than was possible in a static flat diagram print diagram (the form in which the pedagogical model was initially communicated to learners). The fact that menus can be collapsed has meant that more in the way of advice, information and subroutines can be displayed on the main menu. For example, “Assess your writing expertise” is a self-test which at the same time hints at key issues in composing, which are picked up in text lessons (e.g. “About composing”). The main menu leads to submenus with more detailed advice, guidance (and even subroutines at each stage, as in the “Help with blocks” and “Inner dialogues”, shown in Figure 4). Mouse clicking on HELP WITH COMPOSING folds up the menu into the five stages only, so that learners may focus on composing if/as they need and keep the screen uncluttered.

All of the resources one can build into a program, however, are of little use unless the program is based on a social algorithm which faithfully reflects the social process involved. The writing tutor program is so far the only example of software based on composing which reflects the extra-systemic as well as the systemic operation of composing. The systemic operation of composing is represented in its being underpinned by a theoretical model of communicative functions, the formal element of the social mechanism, as shown on the right hand side of Figure 3. The extra-systemic elements (which learners would have difficulty understanding framed in those terms) are included in the forms of an input option which is made through the “Teacher’s advice” item on the main menu (see Figure 3), the results of which are displayed in the submenus for each stage (e.g. “Teacher’s advice on writing rough drafts” in Figure 4). When clicking on “Teacher’s advice on writing rough drafts” the student would see the display shown in Figure 5. The term “Teacher’s advice” was chosen for local social input because social requirements are mediated by individual teachers, who may have idiosyncratic preferences over and above local academic (or subject) requirements, and whose preferences may well impact on the performance of each communicative function. For example, one teacher who volunteered to test out the program informed me that she instructed her students not to use the word processor at all until they had drafted in rough. There is no evidence to support this practice as being more effective than other idea-generating strategies, but as the teacher is the final arbiter of the student’s progress, learners need to heed their own teacher’s advice over and above that of the program designer. At a higher (i.e. tertiary) level, a lecturer had proscribed the use of the word “Zimbabwe” in first-year student assignments on Land Reform, because in a multicultural student group in South Africa it would very likely lead to emotive writing rather than the quasi-legal style that Industry required students to acquire.

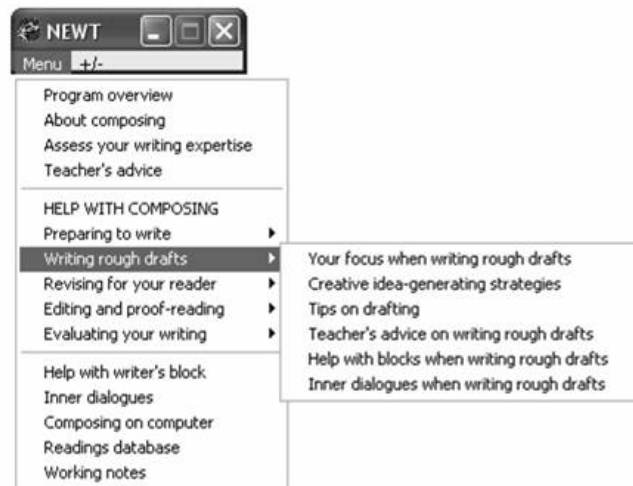


Figure 4. A submenu with more detailed advice leading off the main menu

It is not my prerogative to judge either of these strictures: my aim as program designer is to ensure that students are prompted to question teacher requirements so that they are made explicit, and to accustom teachers to articulating them clearly to learners on request, particularly in multicultural settings, where any socio-cultural bias tends to remain implicit and therefore unchallenged.

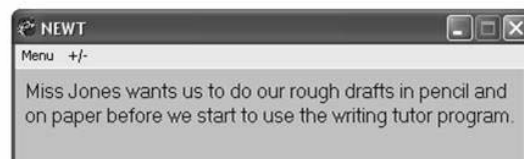


Figure 5. An example of learner input through the “Teacher’s advice” item

## 5. CONCLUSION

In this paper I undertook to deal with the notion that, in designing courseware to assist the learning of social processes, it is important to identify the social algorithm encapsulating the social process, so that program design can be based on deep-level social patterning rather than ad hoc “guesstimates” or rule-of thumb. I have suggested that, if the courseware designer works within an orientation which posits the existence of a real world common to all humans, versatile programs which can be used in very different socio-cultural contexts can be developed. While I was obviously engaged in a long-term investigation into the nature of written composition spanning twenty years, the reader should be reassured that Franck’s modelling process actually expedites the finding of social mechanisms. Franck’s (2002) work, involving twelve very different social science disciplines, demonstrates that his modelling process can be used to arrive at the essence of any social process, whether the mechanism involves or impacts on human agency. Its value lies in the possible development of generalizable principles which can give social science research something of the status (and continuity) of research in the natural sciences: “The explanatory power of a theoretical model constructed in this way can equal the explanatory power of natural laws” (Franck 2002:298).

It remains to state that the writing tutor program which the modelling process informed has not yet not been tested out exhaustively. As it was designed so that learners could use it according to their individual needs, it is not likely to show meaningful trends when taught and tested in mass situations. For that reason it will be tested out in a materials development project in the latter half of 2006 where I plan to work closely with different academic departments and to run case studies and interviews with students to gauge a variety of responses to the program, with the intention of developing the software further. Preliminary user response from twelve of the students who took part in the last set of video protocols (i.e. validating the models) was very encouraging. After a very brief exposure to the program, all students declared the program self-explanatory and easy to use, and said that they themselves would use it if it were made available in computer

laboratories. There were also various helpful suggestions for more animation and chunking of text, as well as music and colour, which budgetary constraints had restricted in the prototype. One ESL student in particular used the program to self-diagnose his writing problem. When left alone to look at the program for twenty minutes, he concluded that his most serious error had been not to consider his audience and purpose before starting to write, and not to establish the exact nature of the academic expectations operating in this specific case. The fact that the program helped an isiZulu-speaking student writing for a lecturer of Dutch descent to identify a problem arising from implicit socio-cultural expectations should indicate that this program is not a skills-based or “write-by-numbers” approach. Moreover, the value of the pedagogical model as used up until now has been in diagnosis of problem areas, resulting in a range of adjustments, from marked to minimal (e.g. from a complete change of composing focus to a writer’s merely leaving the dictionary alone when rough drafting). Until the program based on the model is thoroughly tested out by a variety of users, however, no firm claims can be made about the efficacy (or otherwise) of the writing tutor program.

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