31 Teaching Creativity with Computers

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Using computers as an aid to architectural design promotes efficiency -- of that there is no doubt -- but its real merit must surely lie in provoking inventiveness. The medium makes possible the speedy creation and manipulation of images, a holistic, integrational approach to design, the exploration of virtual environments, the real time collaboration in design by individuals at remote sites and so on -- these all fall under my heading of 'efficiency', since more or less the same ends can be achieved, albeit much more slowly and tediously, by traditional methods. But inventiveness, that's something different. For comparison, think of the advent of reinforced concrete. In the early years, the new medium was used, roughly speaking, as a substitute for timber beams; but the genius of Le Corbusier was required to appreciate that concrete had fluid qualities which afforded completely different *kinds* of design opportunities. Can computers likewise revolutionise design? Will new *kinds* of building get constructed as a result of the advent of computers into the design arena?

Tautologically, a person will be receptive to the new possibilities opened up by CAAD only if that person has a receptive mind. A superior tool is best exploited by those best equipped to exploit it. Simple possession of an innovatory tool is not sufficient for using it in an innovatory way. What is required is a creative user, a Le CAADbusier. How can we inculcate such creativity in architects and designers? How can we help such people to be inventive in the use of new techniques and technologies?

In order to avoid getting bogged down, I shall state some assumptions, and then set them aside. The assumptions are not uncontroversial, but discussion of them cannot be undertaken here. The first is that there is such a thing as creativity, even though we may be unable to define it -- that we can give paradigm examples is sufficient. Second, is the assumption that creativity is a good thing; that it is in general desirable for people to be creative. Third, we assume that creativity may be taught, or, more guardedly, that there is not nothing we can do to improve a person's creativity. Many people would wish to dispute this last claim, and for respectable reasons. For example, wit is a form of creativity, yet it seems rather unlikely that we could teach an unfunny person to be funny. However, assuming that we know creativity when we see it, and can find some means of measuring it, then the claim that creativity can be taught may be confirmed by actually devising a teaching programme and measuring its positive effect.[1]

The first thing to notice about creativity is that it comes in many forms: some pieces of music were so outrageously inventive that they caused riots when first performed (e.g. Stravinsky's *Rite of Spring*); in literature, one finds the marvelous surrealism of Gabriel Garcia Marquez or Isabel Allende; or the intricate puns, metaphors and linguistic

deviance in Shakespeare. Elvis Presley's 'That's all right Momma' brought a new dimension of youth rebellion to pop music, with its sneering, aggressive disregard for meaning (an interesting parallel here with a sub-language of Hong Kong called 'Mou-lei-tao') -- creative, but in an obviously different way from the brilliant thought-experiments of scientists such as Galileo, Huyghens, Maxwell and Einstein.[2] The Eskimos have an ingenious way of catching seals,[3] Jerry has unbelievable ways of damaging Tom. James Watt invented the steam-governor, an elegant device for regulating a mechanism by feedback -- a beautifully simple, creative solution. There are also solutions to problems which spectacularly ignore the standard, plodding procedures. Here's one in mathematics: What is the shortest route for the farmer who needs to go from his farmhouse to the river, collect water and take it to his geese?

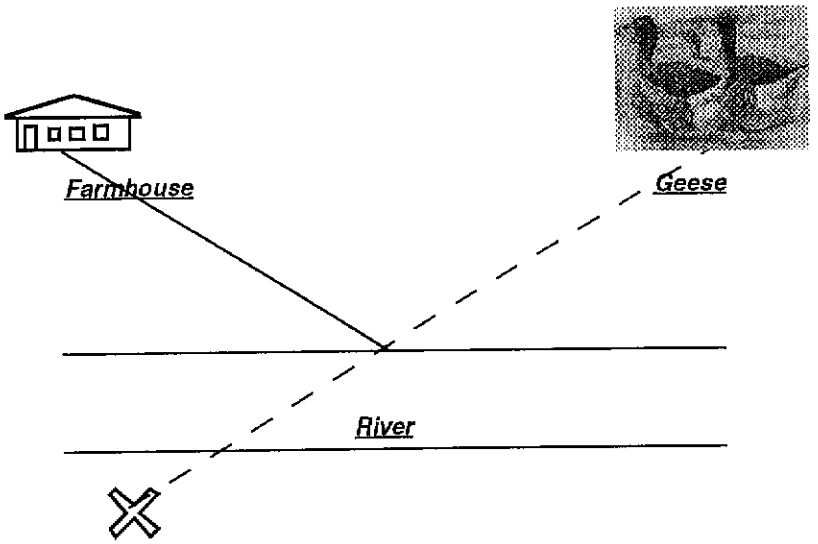

Figure 1

One creative solution (there are others) treats the river bank as a reflecting mirror, so the shortest route for the farmer is equal to the shortest distance (a straight line) between the *reflection of the farmhouse* and the geese.

As this selection of examples illustrates, creative thinking includes manufacturing original and surprising ideas, inventing new products and devising novel, perhaps beautiful solutions to problems. What is immediately evident is that there is a rich diversity of acts that can be called 'creative' and what this strongly suggests is that there is no unique attribute, *creativity* -- there are, perhaps, family resemblances between acts that we call 'creative', but no set of elements common to all creative acts. Think of the creative people you know. Do they have anything in common, or are they creative *in their own ways*? Is there some special ingredient shared by Einstein, Mozart, Euler, James Joyce, Archimedes, Gary Larson, I.M. Pei, Steven Wright .... ? Pretty obviously, the answer is NO. There is no core creativity, and *a fortiori* no mysterious power that could be delivered to an uncreative individual transforming him into a generally creative one. A mathematical dope is never going to be turned into a creative mathematician, though if that person has a certain penchant for writing, you might be able to make him a more creative writer. In some fields, the drawing of cross-domain analogies is a facet

of creativity, but there are other fields, for example, music composition, in which analogising plays little part in creative work.

This being so, an academic programme designed to foster creativity must be steered by the users' particular needs, educational background, career plan etc.. Such a programme doesn't aim for some non-existent core creativity, but rather focuses on creativity in particular areas. It is easy enough (well, it's not *that* easy) to find out from good specialists in different fields, what count as exhibitions of creativity in those fields. If a lecturer in Law, say, complains that his students are not sufficiently creative, one needs to sit down with that lawyer and discover precisely how some legal problems can be creatively addressed or how a creative attitude manifests itself when practising Law. Similarly, it might take a lot of discussion to elicit the exact nature of creativity deficits in students of Architecture. It is important that the design of a programme in creativity should not be left to a psychologist or an educationalist with no specialist subject knowledge. To repeat: creativity in one field may be totally different from creativity in another, and the teaching of creativity requires input from (creative) specialists in these different fields.

Learning to be creative is not to be confused with learning *about* creative thinking and about creative thinkers.[4] There are many psychologists who specialise in the study of creativity but who are themselves highly uncreative. To teach creative thinking is not to treat it as an object of study but as a talent or an ability for which people can be helped to develop an appetite. A truly creative person can not only provide interesting solutions to artificially constructed problems[5] but will find creative answers even when no questions have been asked; will always see scope for the exercise of creativity and find satisfaction in so employing it.

There can be no specific rules for thinking creatively, for following rules is not a creative activity. If there are rules, these will just be general strategic reminders, for example: 'Don't be conservative', 'Switch into a different pattern of thought' etc.. (It is such prescriptions that Edward de Bono in his voluminous writings on 'Lateral Thinking' preaches.) Conforming to rules and conventions may give one a sense of security, but a prerequisite for creative thought is that a person be self-confident and prepared to take risks. One way of breeding such confidence in an individual is to gradually introduce him to more and more demanding tasks, rewarding with praise when he (I mean this, of course, in the gender-neutral sense) displays some originality or independence of thought. Another way is to create a free environment in which people are brought together for 'brainstorming'. This might be semi-structured, with questions posed to the group, and with certain conditions to which members must conform, or it can be completely anarchic, with participants inventing their own questions and responding in a fully unbuttoned way. A programme for instilling creative thinking would likely incorporate an element of brainstorming, together with other activities, such as rôle-playing, to help breed a broader perspective.[6]

How, then, should one design an instructional course which has as its end the fostering of creativity? A conference held at the University of Brighton in April last year, organised by the 'Computers in Art and Design Education' (CADE) group, took as its starting point the question 'How can the computer advance creative work?'.[7] Clearly if the use of computer tools enables us quickly and easily to construct models, perform lively simulations, observe instantaneously the effects of altering different variables

etc., then this acts as a *stimulus* to creativity, if only by removing some of the traditional drudgery. But a more inventive, more creative use of the computer is to have it not just free up time and *facilitate* creative ideas, but actually to teach users how to be creative. The idea may seem absurd: How can a non-creative machine teach creativity? Well, a team of people with whom I have been working is now busy implementing that absurd idea. We are designing an interactive multimedia program which, in a year's time, will be available to all students entering the tertiary institutions. The project is called IMPACT (Interactive Multimedia Program for Critical and Creative Thinking), and a prototype has already been constructed and tested on a batch of 80 users, all of them first-year students in the Arts Faculty of Hong Kong University. I shall briefly describe the rationale of this project, and will go on to make a few remarks about its particular application to architectural design.

How is the program constructed? The main content is a body of tasks and activities which are supposed to elicit creative responses from the user. At the first stage, a task is written up as a *lesson-script* -- rather like a film script, with directions concerning duration of each screen, buttons for options, visuals etc. The lesson-scripts are converted by the programmer into lessons. These vary in length between a couple of minutes and twenty minutes (average engagement time). A well constructed lesson employs the minimum of text on screen and offers maximum opportunity for interaction. Each lesson has its own flow diagram, showing optional and non-optional routes. Sections of the route will be under the user's control, but sometimes an (artificial) intelligent *supervisor* will intervene to dictate the routing.

There are certain elements of the content of the program that are accessible to any user. For example, the user is posed this problem: 'You are a doctor, and one of your patients has an inoperable stomach tumour. There are some rays that, at sufficient intensity, could destroy the tumour, but would also destroy other organic tissue. How can you rid the patient of the tumour without destroying the healthy tissue surrounding it?'[8] If the user needs a clue, he is given an audio-visual demonstration of how a general captures a fortress by dividing his army into battalions, sending battalions down different roads all of which converge on the fortress.

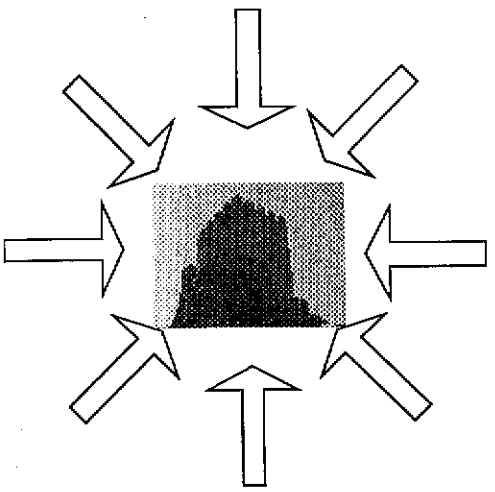

Figure 2

The supervisor, which is the real guts of the program, helps to determine the route from one lesson to another and decides which lessons should be concealed from a particular user-group. (I say user-*group* because most of the lessons are designed for multi-user mode.) Typically, any given user or user-group will be exposed to only a small subset of the available lessons. The artificial supervisor performs its supervisory rôle by drawing upon a user profile obtained at logon, and by monitoring the user's performance as he progresses. There are many dimensions of user-performance, most of them measurable by the program itself (e.g., the time it takes a user to perform a certain task) others supplied to the supervisor algorithm by user self-evaluation.

Since there is no general, core creativity, but only creative approaches to different activities, IMPACT is sensitive to the background and needs of the individual user. In a university setting, as soon as a user logs on, background information on him will be retrieved from the University's central files, so that the artificial supervisor knows the student's academic history and his proposed course of University studies.[9] Some further information will be elicited from the student at logon, such as his hobbies and the time he has available for the IMPACT session. The supervisor is then ready to recommend a particular starting point in the program for that student, and will be able to tailor a particular route, taking into account the user's ongoing performance and the preferences that the user has, from time to time, the opportunity to express. Clearly, a student with, for example, little maths background, would not be exposed to sections of the program which presuppose advanced mathematics.

There are several dimensions of performance, including visual imagination, critical skill, speed (i.e. how quickly a given task is performed) and the quantity of creative ideas that a user or group of users has when interacting with the program. (One of the research problems of this project is to identify the crucial dimensions of performance. Some psychologists have suggested *fluency*, *flexibility* and *originality*.) If a user is found to be performing well in one dimension, the supervisor may channel him towards tasks that involve competence in another. A key decision is whether to build on a user's strengths or to focus on those dimensions of performance in which he is weak. Obviously there are limits to what one can usefully do in the latter direction, and a sensitive supervisor may decide that enough is enough, and will try to boost the user's confidence by feeding him easier tasks, or by just taking him on a joy-ride.

It may seem somehow paradoxical that the vehicle chosen to help people improve their creativity is itself a non-creative computer. There are, however, several respects in which IMPACT is superior to human instruction.

a. Think of the scale of the operation. At this University we have an annual intake of some 3,000 students; introducing them to creative thinking is far beyond the reach of available human teaching resources. But IMPACT replicates the qualities of a good teacher. That is, the program allows for a high degree of interactivity; help can be called up, but is also offered spontaneously by the program.

b. IMPACT makes heavy use of sound and graphic material, including video. A human cannot compete as an edutainer. Take this simple creative task as an example: Join the nine dots with four straight lines, keeping your pen on the paper -- i.e. making a maximum of three changes of direction.

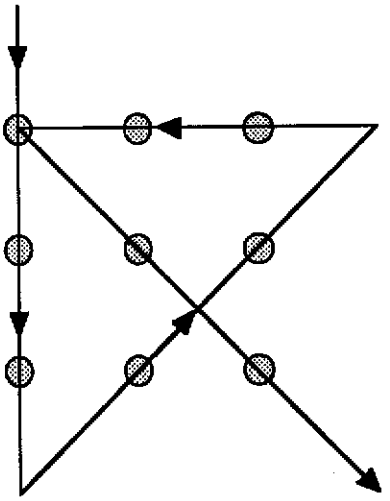

Figure 3

This can be presented more engagingly via computer -- e.g. have light bulbs which go out when you traverse them, and its easy to 'rub out' after a failed attempt. Prompting can be given by the program, e.g., the grid can be made to shrink, thereby giving greater prominence to the suroundings. This is an exercise in creativity, and it provides a good metaphor for creative behaviour in general -- we have to break out of the grid; go beyond traditional patterns.

c. The user has a high degree of control over such things as the time spent on a task and revision of stuff that proved interesting or difficult -- this would be impossible in even a smallish class.

d. The AI supervisor is able to manage the task-setting better than a human teacher -- bearing in mind the complexity of the route-determining algorithm, and not forgetting that the supervisor can take account of the user's expressed preferences.

e. The program is indefinitely extendable -- instructors can add their own lessons. One job for the future is to design an authoring tool enabling non-experts to program new lessons.

f. Traditional computer usage is non-social but, as we have seen, a co-operative group is conducive to creative thought. So, much of IMPACT will be designed for multi-user mode, with the possibility of a big-screen display and simultaneous input from several users. Multi-user mode provides an environment for brainstorming free from the presence of any unwanted authority figure. This is the preferred mode of use for IMPACT. Working on the program with friends or classmates helps instill confidence -- a pre-requisite for creative thinking. Multi-user mode makes possible peer-evaluation of performance, which is input to the supervisor algorithm.

At this early stage of development, it is vital for us to measure the effectiveness of the program. Users are invited to fill in a questionnaire as they are proceeding through their engagement. We, the designers, want to find out which lessons are boring and which seem helpful or otherwise to the user in the sense that the user feels that his creative juices have been stimulated or awakened. As a matter of fact, the IMPACT program contains a lesson (still incomplete) on questionnaire design -- and we should have learned from it ourselves, since the instrument we're now using is far from ideal. Preliminary findings are, unsurprisingly, that users prefer short lessons and don't like long explanations. The demand seems to be for high entertainment value and, in this context, I think that's legitimate.

What sorts of activities would be particularly relevant to fostering creativity in architectural design? As I mentioned before, this is the point at which someone like me consults an expert like you. An architect may already have some philosophical notion of what counts as creativity in architecture. More pedestrianly, he may have acquired a clear sense of creativity-deficits in his students, and may have some ideas how to remedy these. Speaking in a purely amateur way, I would hazard that some students lack creativity in the use of technology, in the exploitation of different materials, that some have a too rigid conception of inside and outside. So activities start suggesting themselves:

- Design a real building modelled on a Kline bottle. Further constraint: it must not be a construction for an exhibition where the 'outside' environment is artificial -- the point of the exercise is to get people to rethink the concepts of 'inside' and 'outside'

- Design a building which works equally well turned upside down. There is a deliberate ambiguity: do we just want floor plans in reverse order, or do we want a building that would function perhaps differently, but plausibly, if we physically stood it on its head?

- Design a building for a moonsite, bearing in mind that the force of gravity on the moon is only 1/6 that on Earth. What possibilities does this open up both in terms of design and also constructional techniques? Then do the same in reverse -- a building for Mars, this time thinking simultaneously of designing an old-age home where gravity really is a weight on the shoulders of the residents.

In order to build into IMPACT a set of lessons specifically related to creativity in design, we need to think about activities such as those I've just mentioned, but which lend themselves to a multi-media, interactive environment, possibly in multi-user mode. One such activity would be to give users the possibility of experimenting with interpenetrating shapes, for example an ovoid piercing a hyperbolic paraboloid. This is a particularly important pedagogical exercise: John Bradford of the HKU Department of Philosophy informed me that our students have great difficulty envisaging stairs -- how and where a flight of steps starting on one floor would emerge on the next.

Another kind of activity would be the use of virtual reality with real-time programming, so that the user is adjusting the virtual environment as he moves around in it. This would obviously be a much more sophisticated kind of interaction than touch-screen, and the technology is not yet in place. Given the IMPACT framework, as I've described it, I issue an invitation to participants at this conference: Think about aspects of

creativity in design and think creatively about how such aspects might be instilled in an IMPACT type of lesson. The IMPACT team will be delighted to hear your suggestions, and, if they are feasible and not too crazy, we shall be happy to implement them in our program.

APPENDIX: A creative exercise in creativity.

An invitation of a similar sort was made to those students who have used the program. They identified weaknesses in the various lessons when answering the questionnaire, and were invited to *write their own lesson*, one which illustrates a *fallacy* as creatively as possible. Their lesson must be a significant improvement on textbook presentation -- lively and fun, so that the message will stick. This is how the task is presented to students before their engagement with IMPACT:

Exercise on Critical and Creative Thinking

This is an exercise in creative thinking, and relates to what you have learned about fallacies. Before doing the exercise, you will need to work through the computer program IMPACT. This should take about one hour. Each *tutorial group* should sign the booking chart -- so that students will be working on the program in groups of 4 or 5 (this is to encourage 'brainstorming'). The aim of IMPACT is to improve your creativity. Each student will be given a questionnaire about the program, and you should return the completed questionnaire to your tutor when you hand in the exercise. There will be a (non-monetary) reward for the best exercises.

I have asked you to look out, in your own everyday lives, for examples of errors in reasoning. The present exercise calls for each student to select one such error and write the text for a computer lesson which explains the error in a creative way, so that anyone running the lesson on a computer will enjoy learning about the error. Quite possibly, many of the errors of reasoning that you find will be examples of well known fallacies that have been named, but it is also possible that you will find new ones, in which case you can assign your own title. I would much prefer you to find an example of your own, but if you try hard but don't succeed in finding one, you may pick an example of an argumentative error from any logic book and write your script to explain that error. If you do this, you must mention the book where you found your example.

Please note that I am asking you *not* to write a computer program, but only to write the script for one (something like a film script), together with a flow chart which shows how your 'computer lesson' is organised. The sample included here is part of the script for the lesson in IMPACT called 'The Man who Climbed Lantau Peak'. A useful maxim is that text which will be displayed to the user on screen should be kept to a minimum. One picture (or one sound, or one weird effect) is sometimes worth a thousand words -- but in your script you must, of course, *describe* that picture, sound etc., so that a programmer could convert your script into a computer lesson. (Of course, if you *want* to write a program, and not merely a script, you can do so, or you can write a demo for the WWW using the HTML mark-up language).

Your grade for this exercise will count towards final coursework grade. The exercise will be considered as the equivalent of one essay. You will be given credit for:

- Interesting examples of argumentative error
- Clear illustration of the error in your script
- A perspicuous flow chart
- A lively, creative script which (if transformed into a computer program) offers many options to users, and really gets them to understand the nature of the error.

The 'reward' mentioned above is that any really good scripts will be programmed as an IMPACT lesson, with credit given, on the screen, to the author.

Notes

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[1]. John Gero informs me that one existing programme measures its success by the increase in the volume of patents granted to participants after completion of the programme.

[2]. See Roy Sorensen, *Thought Experiments* (New York, Oxford University Press, 1992). The lyrics of `That's all right Momma' have been attributed to Bob Dylan, but this seems to me chronologically suspect. However, Dylan can certainly be cited as a creative exponent of the meaningless.

[3]. A.D. Moore, *Invention, Discovery, Creativity* (New York, Doubleday, 1969), p.9: `To live through the Arctic winter, the Eskimo must have seal meat, seal blubber, sealskin and sinews with which to sew the sealskin clothing. Here and there, the seals keep breathing holes open in the ice sheet. They can stay down for extremely long periods, but must sooner or later come up to breathe. When a seal appears, the Eskimo is there with his spear. There is a difficulty, however. The seal has a very keen sense of hearing. When a hunter walks to a hole, no matter how quietly, the seals hear him and avoid that hole. This could mean starvation for the Eskimo and his family.' So two Eskimos walk *in step* to the seal's breathing hole; one walks on and the other waits to spear the seal who, fooled into believing that the danger has passed, pokes its head above the surface.

[4]. See, e.g. D.B. Wallace and H.E. Gruber (eds.) *Creative People at Work* (Oxford, Oxford University Press, 1989). A person might find it intimidating or depressing to read about the creativity of geniuses, and may feel deterred from striking out on his own. Sometimes, however, such reading is inspirational.

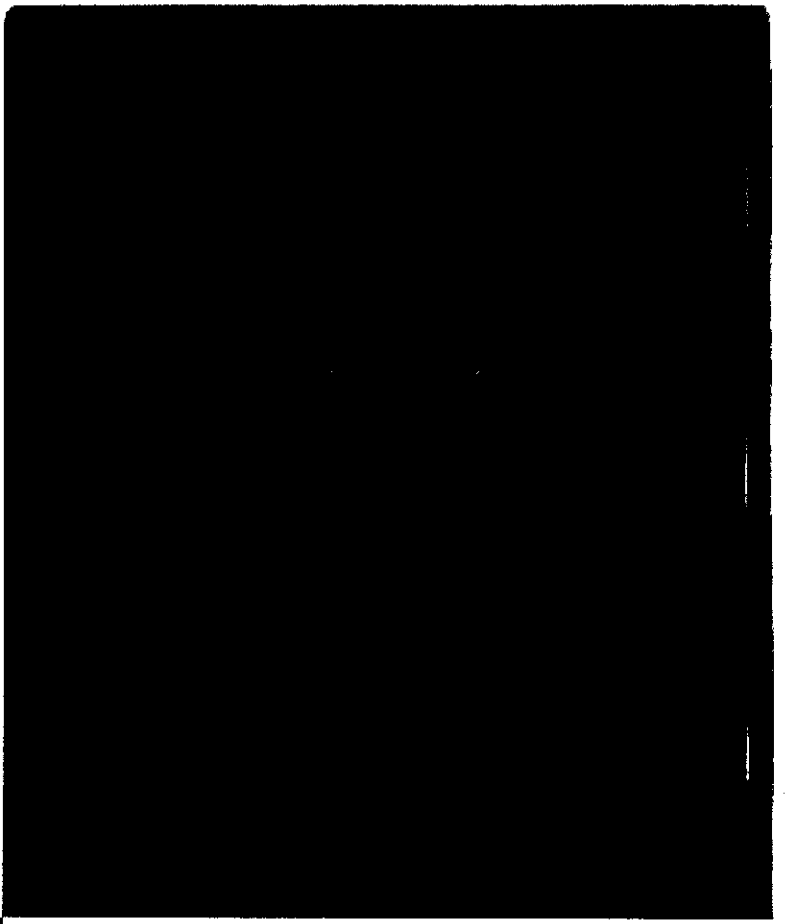
[5]. For many such 'artificial' examples, see R. Finke et al., *Creative Cognition: Theory, Research and Applications* (Cambridge MA, MIT Press, 1982).

[6]. Various methods for stimulating creativity are discussed in M.I. Stein, *Stimulating Creativity* (New York, Academic Press, 1974), Vols. 1 & 2; B .Joyce and M. Weil, *Models of Teaching (3rd Edition)* (Englewood Cliffs, Prentice Hall, 1986), Chap.10.

[7]. A CD-Rom `Digital Creativity' based on that conference is reviewed by Susan Nowak in *The Times Higher Educational Supplement*, April 12, 1996.

[8]. Source: K. Duncker, `On Problem Solving' *Psychological Monographs* 58 (1945) #270.

[9]. Some people at the conference were worried about `Big Brother' aspect of this. Be assured that the only purpose of retrieving information about a user's academic background is to protect that user from those parts of the program that he would be unable to handle, and to provide him with lessons that he might find interesting.



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ISBN 9627-75-703-9