

## Disruptive Devices: Personal Technologies and Education

*Inaugural Lecture of the Kodak/ Royal Academy of Engineering Research Chair in Educational Technology*

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Educational technology has improved hugely since I began my research some twenty years ago at the University of Edinburgh. We no longer have teletypes that clatter like a volley of machineguns, nor graph plotters whose pens dry up every few minutes. Computers have become a part of education. Every University, college and school in the UK has multimedia machines and almost all secondary schools are now linked to the Internet.

These are the substantial achievements of the last 20 years of educational technology. The other side of the coin is that in primary schools there are 18 children to a computer, the average expenditure on IT per child is just £11 a year and according to the national Ofsted report [1] there are “acute problems in IT in 4:10 schools”.

In secondary schools there is little sign of the technology being used to support deep learning. Instead, computers are used mainly to teach basic IT skills such as word processing and spreadsheets. In the words of the Ofsted report [2] there is “too much of a focus on the teaching of mechanical IT skills at the expense the higher order capabilities”. At this point, I am not going to take the usual approach of calling for more expenditure on IT in education, or better quality software, or improved training of teachers. Instead, I want to consider technology and education from the perspective of the student.

People now own, or have regular access to, a formidable array of technologies. For example, over 50% of teenage children in the London area now have mobile phones (I don't know the national figure, but given that a mobile phone was the number one

Christmas present this year then the figure probably applies to most of the UK).

Increasing numbers of young people own a Sega Dreamcast, a more powerful personal computer than almost any to be found in schools. It has a built in modem for Internet connections, plus an optional keyboard, and a handcontroller with its own screen to run programs while you are on the move.

And within a few years students will be bringing into the classroom or lecture theatre one of these, or something like it.



*Figure 1. Qbe Pen Tablet Computer*

Figure 1 shows a Qbe pen tablet computer [www.qbenet.com], already on sale in the United States. It has the power of a multimedia desktop computer, and a built-in camera. It also offers handwriting and voice recognition: you can write on it with a pen and it turns the handwriting into printed text, or you can speak commands or dictate

text to it. And it is able to connect to the Internet through a mobile phone link.

What has been the response of educational institutions to such powerful personal technologies? Almost universally it has been to see them as a problem: to ban them from classrooms and lecture rooms. And with good reason: these are disruptive devices.

Here is a typical response to student disruption of lectures, from our own staff student meeting:

The widespread use of mobile phones appears to be causing concern to lecturers and students alike. [Need to] to define a mature method of dealing with this problem.

They are quite right to be concerned. Research into teacher effectiveness has shown that the teachers who produced the most gains in student achievement were those who were “well organised, managed student disruptions by monitoring behavior, and enforced rules in a consistent manner” [3].

This is the central dilemma. Learners can command an increasingly sophisticated set of communication and computing devices, which they are forbidden to use within formal education because they disrupt lessons and lectures. Meanwhile, schools, colleges and universities are starved of IT resources, and in many cases are failing to make best use of what resources they have. How can these problems be reconciled?

I want to address the issue in terms of the 3 C's of effective learning: *construction*, *conversation*, and *control*. We learn best when we are constructing our own understanding, relating new experiences to our existing knowledge. Central to this is conversation, with teachers, with other learners, with ourselves as we question our concepts, and with the world as we carry out experiments and explorations and interpret the results. And we learn successfully when we are in control of the process, actively pursuing knowledge rather than passively consuming it.

The description I am going to give of learning as conversation is based on the work of Gordon Pask – not only did he develop an astonishingly innovative theory of learning, Conversation Theory [4], but he was one of the earliest educational technologists and developer of the first teaching system that adapted to the learner. Conversation Theory describes learning in terms of conversations between different systems of knowledge. Pask was careful not to make any distinction between people and interactive systems such as computers – with the great advantage that the theory can be applied equally to human teachers and learners, or to computer-based teaching or learning support systems.

Let us begin with a person engaged in some activity in the world – carrying out an experiment perhaps, or solving a problem, or exploring a park or museum. As the person performs the activity he or she tries out new actions, reflects on how they work and makes decisions about what to do next (Figure 2). The person is actively *constructing* an understanding of the activities. There is continual interaction and adjustment between the person's thoughts and actions. Then, in order to gain from that experience, to perform it differently or better in future, the person needs to form a description of themselves and the activities, to explore and extend that description and to carry forward the understanding to a future activity. That is the minimum requirement for any person, or any system, to learn: it must be able to converse with itself about what it knows.

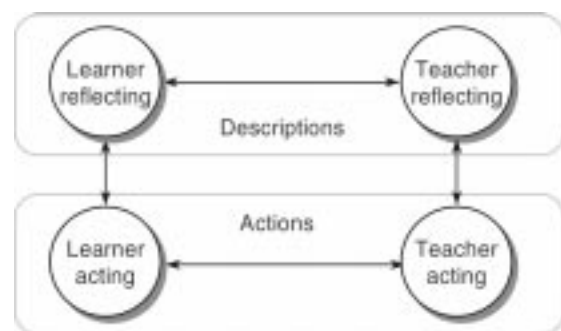


Figure 2. A framework for conversational learning

A more effective form of learning is when people can converse with each other, by interrogating and sharing their descriptions of the world. Let's say that two people – I have shown a student and a teacher, but it could be two students – are working together on some project. Both people are interacting with the world and conversing at the level of actions – “look here”, “what's this?”, “do that”. They are also conversing at the level of reflections - exchanging descriptions of their knowledge: “what do you think of this?”; “why do you do that”?

We can say that the two people share an understanding if Person A can make sense of B's explanations of what B knows, and person B can make sense of A's explanation of what A knows. So, it is through mutual conversation that we come to a shared understanding of the world.

Learning is a continual conversation: with the external world and its artefacts, with oneself, and also with other learners and teachers. And the most successful learning comes when the learner is in control of the activity, able to test ideas by performing experiments, to ask questions, collaborate with other people, seek out new knowledge, and plan new actions.

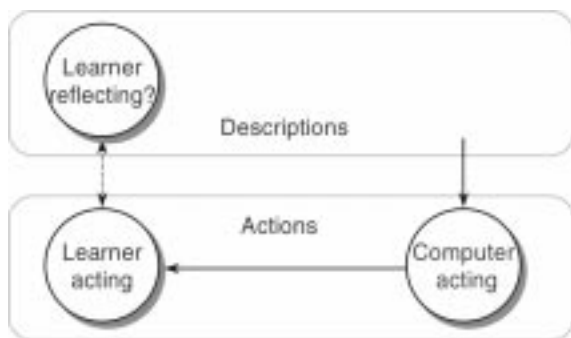


Figure 3. Computer-aided instruction

What place is there for technology within this conversational space? One possibility is for the computer to take the place of the teacher (Figure 3). That is traditional computer-aided instruction, and the problem with it is that it only covers part of the conversational

space. The computer can hold a limited dialogue at the level of actions: “look here”; “what's this?”; “do that”, but isn't able to reflect on its own activities or its own knowledge. And because it can't hold a conversation at the level of reflections, it has no way of exploring students' misunderstandings or helping them to reach a shared understanding. Research in Intelligent Tutoring Systems has gone some way towards remedying this, but we are still at the stage of hand crafting individual systems and a long way from developing a computer that can converse freely about its own knowledge.

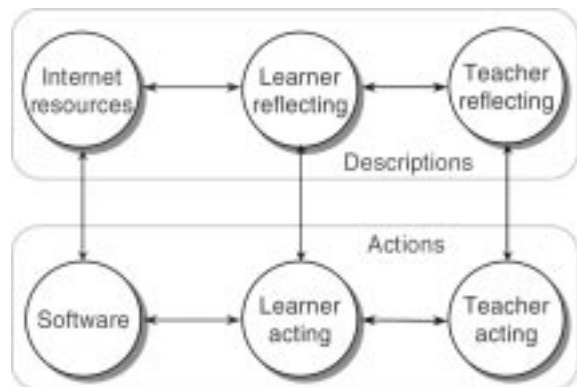


Figure 4. Technology for conversational learning

Alternatively, the technology could provide an environment in which conversational learning takes place – one that enables conversations between human learners (Figure 4). It extends the range of activities and the reach of the discussion, into other worlds through games, software models and simulations and to other parts of this world by using the computer as a means of communication, through phone, email and computer based discussions. Children are comfortable with this use of technology – it is exactly how they use mobile phones, computer chatlines and multiplayer games. The technology provides a shared conversational learning space.

Now carry this powerful technology into the classroom or the lecture theatre and we have a recipe for chaos. The students create links to the outside world – to a world of activities

and conversations that they control, and that match neither the teacher's agenda nor the curriculum (Figure 5).

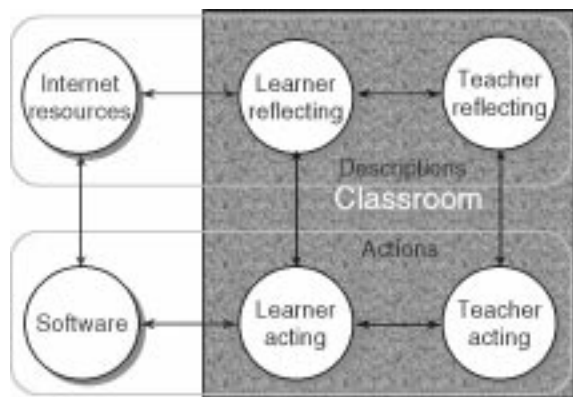


Figure 5. Computers and conversation in the classroom

As educators we could take a number of stances. We could ignore the problem and hope it will go away. It won't: the tensions between personal technology and institutional education will increase as students breach the sealed world of the classroom and lecture hall by bringing in computers that are able to communicate with the outside world.

We could attempt to forbid it, but this just becomes a challenge for students to find new ways of communicating. It has already happened with mobile phones – forbidding their use in class has led to school students using the simple messaging system (SMS) that comes with most new phones as a way of conversing behind the teacher's back, and not just across the classroom, but to other classrooms, in other schools.

Or we can welcome students who bring their own personal communicators and computers, but in the full knowledge that they will disrupt traditional teaching and that this disruption needs to be managed. This is not an argument for technological determinism – for saying that because students come armed with new technologies then education must adapt to accept them. There is a more defensible case for moving to more conversational approach to teaching and learning. The skills of *constructing* and

exploring knowledge, *conversing* and collaborating with peers, and the ability to *control* one's own learning – the 3 C's – are fundamental requirements of effective learning.

They are also skills prized by employers. These words are from a Report by the Royal Academy of Engineering on 'Engineering Higher Education':

The 'self-reliance' skills usually mentioned as key are negotiating, action planning, exercising judgment, networking, self-awareness and confidence.

In other words, the 3 C's.

Higher education has already started the long march away from lecture-based teaching towards creating managed spaces for conversational learning that build on the students' own technologies, activities and resources. It will require a collaboration between teachers and learners, working together to create shared resources and activities that meet both the aims and constraints of the curriculum and students' own projects, knowledge and interests. It will also involve a partnership with companies to provide the technologies and services to support personal conversational learning.

The mix might include something like this:

- Shared online learning systems that provide the core course resources and teaching materials, developed as a partnership between staff, students, professional institutions and companies
- problem-based learning through lab classes, field trips and study at home and in the workplace
- support for personal learning, including helping students to create their own learning resources and also to form learning networks of people with similar needs and interests
- collaborative project work
- formative assessment, and
- the option to choose, from day to day, whether to study on or off campus

There will still be an important role for lecturing and silent reading – but not necessarily in lecture halls and libraries. There is certainly a need for a campus – as a community of scholars – but not necessarily in a single location.

I realise that this is sounding abstract and idealistic (in the same way that the idea of linking together all the computers in the world and sharing their information in a worldwide web might have sounded hopelessly idealistic twenty years ago), so I'll conclude by giving three short examples of how this vision of a conversational learning space can work in practice: two from projects in which I am involved, and the third from a successful but unconventional company that we hope to work with. They span the range from professional training, through informal adult learning, to school-age education.

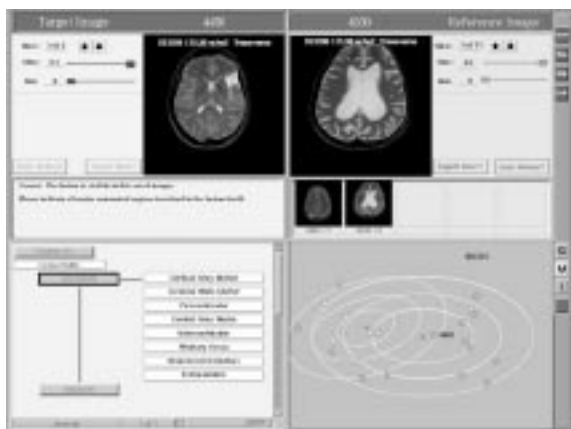


Figure 6. Interface to MEDiate

MEDIATE is a project to develop a computer-based training and decision support system for neuroradiologists (Figure 6). The partners are the Universities of Sussex, De Montfort and Birmingham, and the Institute of Neurology. MEDiate assists radiologists with the difficult task of describing abnormal images of the brain, ones that exhibit lesions such as this. At present radiology is taught mainly by apprenticeship. Trainees are apprenticed to consultant radiologists and learn through a form of conversational learning by taking part in case conferences. The problem is that

there is very little structure to the method. Each consultant has developed his or her own private language to describe images. Different consultants use different terms to describe the same feature on an image or, even worse, use the same terms to describe different features. There is a well recognised need for a more structured approach to teaching and describing radiographic images and it is this problem that the MEDiate system addresses.

Our team carried out a detailed study of how radiology is taught and practised. One clear finding was that trainees have very little spare time. They can't take the time to sit in libraries or computer labs, and so any computer-based learning must fit into the gaps in their busy schedule – in the hospital, at home, when travelling – which means a personal and portable system.

Our project has access to an archive of over 1200 cases with their associated images, all carefully described in a structured Image Description Language. The computer system we have developed calls on this archive for its teaching. It provides a novel graphical display, the overview plot, shown in the lower right corner of the screen, to show the distribution of cases across diseases. The overview plot is rather like a cluster of stars and galaxies, with each "star" showing a case and each "galaxy" representing a cluster of cases in a disease. The user can interact with the plot to gain an overview of the case archive by clicking on cases and comparing their images and descriptions.

Then either the computer or the student can select a case for tutoring. The student looks at the Magnetic Resonance (MR) Images for the case, showing virtual 'slices' through the patient's head and attempts to describe the abnormal features by selecting terms from the structured language. The computer responds and guides the student towards a full and correct description. The student's activity with the system is logged and the aim is for this to compile a profile, not just of the student's performance, but also for providing information to teachers of radiology on

which cases students find difficult or easy to diagnose.

One difference between MEDIATE and a conventional computer-based teaching system, is that the same core system and interface is designed for use by novices, by practising radiologists and by radiology experts. The novices can use it learn the language of radiology and to make accurate descriptions of cases in the archive. Practising radiologists will be able call on MEDIATE to help them in describing difficult cases. They could add a new case from the MRI scanner to MEDIATE, describe the images in the structured language and then see where the computer displays that new case on the overview plot. If it appears beside some case already in the database then the radiologist can call up the images and compare the two cases. If it lies at the boundary between two diseases the radiologist can consider these as possible diagnoses.

An expert radiologist can employ the same technology to describe exceptional cases which will be added to the archive as a resource for teaching or research. Or the human expert can review cases that have been described by the radiologists, checking that they are correctly described, perhaps conversing with the radiologists about errors in the description, before the case is added to the archive. MEDIATE is being designed as a shared online resource, for conversational learning by trainee radiologists, for supporting day to day radiological reporting, and for research – with all the users both benefiting from and contributing to the system.

A computer environment with similar aims, of shared conversational learning, but a very different type of user, is H2G2 [www.h2g2.com]. H2G2 is the web based version of Douglas Adam's Hitchhiker's Guide to the Galaxy. Just like the Guide in the Douglas Adam's book it provides a handy source of information on life, the universe and everything. Unlike the one in the book, this Hitchhiker's Guide actually exists, on the worldwide web. The interface is not very exciting – no fancy graphics or video, just

text. It is the way the system is managed that's innovative.

H2G2 is run by a staff of around 6 paid employees, plus 30,000 unpaid researchers. Anyone may sign up to be a researcher and is given their own web space where they can develop entries for the Guide or chat online with other researchers. They can submit an entry on any topic they wish, and as you may expect they range from the sublime – lucid explanations of theoretical physics or artificial intelligence – to the ridiculous, such as 'How to cook a poached egg'. Once you have developed an article you submit it to the Guide editors. They may accept it, and perhaps edit it, then add it to the Guide. Or they may reject it. Rejected entries can still be read, by searching through the main index, and looking at the researcher's own page. Each Guide entry then becomes the nucleus for a discussion, where other researchers add comments and ideas, some of which get accepted into the main Guide.



Figure 7. Entry on Buff Orpingtons in H2G2

Here is a very short, but not atypical, entry, on Buff Orpingtons (Figure 7). Buff Orpingtons, in case you don't know, are a breed of hen. No, don't ask why there's an entry on Buff Orpingtons, it's just that kind of a guide. It has a somewhat whimsical guide entry which starts "A Buff Orpington is not, as one might think, a way to paint an English rural town. Rather it is a chicken, one of the so-called 'heavy breeds', which are raised for their meat." Perhaps more important than the entry itself, it sparks off a discussion

among people who have read it, in this case a discussion about egg production.

H2G2 is a highly efficient and cost effective learning environment – and one that over 30,000 people have signed up to join in the past five months. Its format, of creating a conversational learning environment based around topics of interest, involving learners as researchers, and creating threads of discussion around the learning materials is a model that universities could well explore. Interestingly, the company is now developing a version of the Hitchhiker's guide for mobile handheld devices.

Which leads me to the final example: HandLeR. HandLeR stands for Handheld Learning Resource and is based on the premise that instead of preventing students from bringing personal technologies into schools and universities, we should encourage them, by putting schools and universities into their personal technologies. The drawings in Figure 8 are by 11 year old children of a 'personal computer of the future'.

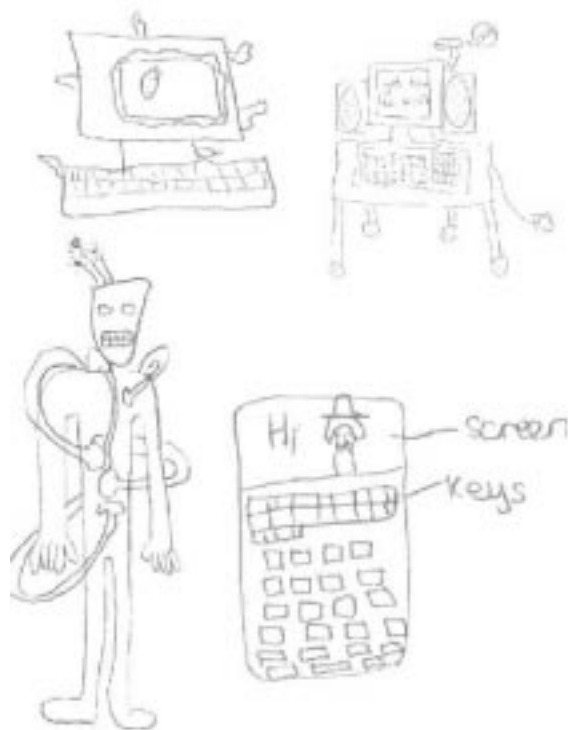


Figure 8. Drawings by 11 year old children of a 'personal computer of the future'

Let's assume that within four or five years many students will own one or more handheld computers, as powerful as current laptops, with a large colour screen, and capable of wireless communication. That is not a farfetched assumption. Current games computers such as the Dreamcast are at least that powerful. A new generation of UMTS mobile devices will be on sale next year offering high speed communication. And if a handheld computer plus video communicator becomes available for less than £500 then you can be sure that most students will find a way of buying one.

Our aim is to carry out research into how such devices can be made to work as aids for lifelong learning – for capturing everyday events, and sharing them with other people, managing personal knowledge and experiences over long periods of time, and supporting personal learning projects. This involves not only the technicalities of mobile communication and the design of multimedia learning environments, but also how to bridge the gap between formal and informal learning, and the changes that schools and universities need to go through to accommodate not just the new technology but also the new ways of learning.

Here is a short video, based on a BBC Tomorrow's World programme, showing 10 year old children on a field trip to learn about Birmingham's canals. The HandLeR device they are taking with them was developed as a group design project by our 3<sup>rd</sup> year MEng students (Figure 9). The video shows a school field trip, but it might just as easily have shown individual children, or adults, learning at a distance in communication with a tutor, or a group of canal enthusiasts creating an online 'Hitchhiker's Guide to the Canals'.

Commentary from the videotape:

A HandLeR, or Handheld Learning Resource, is a personal mobile learning device. We are developing a range of HandLeR technologies for learners of all ages, as part of a project involving the University of Birmingham, Kodak, The Royal Academy of Engineering and BT.

A group of students has produced a demonstrator HandLeR for children. They put together a package that includes a handheld computer, a mobile phone on a PC card and a computer video and stills camera. They also wrote the software to allow children to capture events, take notes, find learning resources and call up Internet pages. The child can access all of these tools through an easy interface based on a cartoon rabbit. Click on the rabbit's eyes and you are connected to the camera, click on the rabbit's brain and it brings up a topic map. From there, a click on one of the topics may lead either to a multimedia presentation, some learning material, or an internet page.

Here, a group of children are off on a field trip to explore the canals of Birmingham. First they call up the topic map to discover their mission.

Their mission in hand, they look for information that can guide them to answer the questions. They can move through the map following trails of related topics. Some of the trails lead to material on the HandLeR, others to link up to internet pages, and clicking on the topic loads the internet page by a mobile phone connection.

Then two groups set off round the canals to collect their evidence. One group has to find out how canal boats are powered and what they are used for nowadays, the others to go and discover about canals in the past.

The first group finds that modern canal boats are powered by an engine, under the floor. They use the electronic pad to make a note of it. The handwriting recognition isn't perfect. Each letter has to be written separately and it regularly makes mistakes, but it does work well enough to take short notes. In the future HandLeR should be able to link these notes into the topic map.

The other children are on their way to another part of the canal to find the answers to their questions, about the canals of 150 years ago.

[The children set up a phone connection from one HandLeR to the other.]

Claire makes a note on the HandLeR to work on later for their report. Then it's time to find the answer to the second question. "What were canals used for in the past?"

The computer has a digital still and video camera controlled from the screen. A click of the pen shows the camera's viewfinder and Curtis takes a picture of the warehouse. It can also record several minutes of moving pictures. As Matthew moves the HandLeR round, the camera captures the scene as a digital movie.

The children have collected the evidence, which they can then piece together into a shared report.

That's one use of a HandLeR – for school field trips, but its main purpose is as a device for children, or adults, to carry with them, as a personal learning aid. Here are some models of what a HandLeR of the future might look like, made by the students on the group design project. This one could double as a games machine, and this is a more traditional looking one, designed as an electronic book. But what's most important is that HandLeR isn't a piece of hardware, it's a software environment, so that when the child goes into school it could appear on a school computer, or on a machine they bring with them, and then at home their HandLeR topic maps and tools could switch to a games console, or a digital TV.

This is only first step towards something much more ambitious – a personal aid for lifelong learning.



*Figure 9. Prototype HandLeR developed by the MEng Group Design Project*

All the hardware shown in the video is available now, though it costs around £3000, and for our HandLeR project we are using a Fujitsu Stylistic pen computer, a Kodak video computer camera, and for communication

both a Nokia GSM phone card – a mobile phone on a card that plugs into the computer and provides a slow (9600 baud) data phone connection – and also a wireless local area network system that gives high speed communication with a range of about 100 metres from a base station.

The future is closer than you might think. The first device from a major company that is specifically designed for mobile conversational learning arrives next year. Hewlett Packard has just announced last week what they call a ‘handheld learning appliance’ that combines a mobile phone and computer. This is how the president of Hewlett Packard described it at the press launch:

The appliance opens up a new set of possibilities for how educators can teach because they literally can have the world at their fingertips in the classroom. Getting bored in a French class? Connect with a class in France.

If only it were that simple!

She is right, though, to say that we have a new opportunity with personal technologies to create worldwide webs of learning, that link students around the world into communities of shared knowledge and interest. And British Universities, with their foundation in tutorial teaching and discursive learning, are well placed to seize that

opportunity. To misquote Disraeli: A University should be a place of creativity, of collaboration, and of conversation.

Designing the technology for worldwide conversational learning is (now) fairly straightforward; designing and managing the learning is hard!

- [1] Office for Standards in Education (OFSTED), “Primary education: a review of primary schools in England: 1994-98,” . London: The Stationery Office, 1999.
- [2] Office for Standards in Education (OFSTED), “Secondary Education 1993-97. A Review of Secondary Schools in England”. London: The Stationery Office, 1998.
- [3] R. S. Pravat, “From Individual Differences to Learning Communities – our Changing Focus,” in *Educational Leadership*, 1992, pp. 9 - 13.
- [4] A. G. S. Pask, *Conversation Theory: Applications in Education and Epistemology*. Amsterdam and New York: Elsevier, 1976.