

Online Collaborative Design Projects: Overcoming Barriers to Communication*

NIALL SCLATER, HILARY GRIERSON, WILLIAM J. ION AND STEVEN P. MACGREGOR
*Educational Systems Centre for University of Strathclyde, Turnbull Building, 115 George Street,
Glasgow G1 1RD, Scotland, UK. E-mail: n.sclater@strath.ac.uk*

As course provision is expanding in the emerging virtual universities, the majority of Internet-based education revolves around online course materials and asynchronous discussion forums. One of the less exploited aspects of the Internet however is its ability to enable students to work together at a distance on collaborative design projects. A wealth of new technologies enables high levels of communication between students working at a distance. Sometimes, though, communication breaks down. Some of the technologies are still unreliable and many are not easy to use. Students are faced with working together in new ways and must develop effective means to collaborate using the technologies available to them. At the University of Strathclyde's Faculty of Engineering students have been working on collaborative online design projects since 1997. Building on the original ICON project, developed under the Clyde Virtual University initiative, a number of projects have identified barriers to communication between students. In describing the educational and technical environment for these design projects, this paper highlights the difficulties and shows ways in which students and staff have developed strategies to overcome them.

INTRODUCTION

CLYDE VIRTUAL UNIVERSITY (CVU) was established in 1995 at four Scottish universities together with the Glasgow School of Art as a means of exploiting the Internet collaboratively within a virtual learning environment [1]. A range of online courses has been developed for the *Lecture Theatre* while text-based discussions take place in the popular *Virtual Café*, backup textual materials are available in the *Library* and web-based assessments are found in the *Assessment Hall*. This virtual university infrastructure is used as a conceptual model for the academic staff development programme in new technologies at Strathclyde University [2] and has inspired a number of associated projects.

The Clyde Virtual Design Studio (CVDS) was developed in 1997/98 by the University of Strathclyde and the Glasgow School of Art as a part of CVU [3]. CVDS is a computer-based design project with an environment capable of being operated both locally and across a distance using communication techniques such as video conferencing and whiteboarding. The main objective in building the design studio was to provide a platform for investigating the feasibility of using computer networks as a means of communication in educational design projects. The design specification for CVDS reflected the communication needs of design project work and the constraints imposed by the educational environment. The key elements of the specification were:

- to provide a design environment accessible from any location via the Internet;
- to provide a comprehensive range of facilities within the environment to allow teams to collaborate—these teams could be separated geographically or be located at the same site;
- to implement the environment using low cost and low maintenance equipment and systems—recognising the budgetary and security constraints of design education;
- to provide a flexible environment capable of supporting different structures and durations of design projects.

CVU and CVDS provided the supporting environment and stimulus for a number of collaborative design projects: ICON1, ICON2 and the Internet Design Project.

COLLABORATIVE DESIGN PROJECTS

The icon projects

ICON (Institutional Collaboration Over Networks) began in June 1997 [4]. The students came from the Product Design Engineering course at the University of Strathclyde and the joint course of the same name at Glasgow School of Art/Glasgow University. The main objectives of the ICON projects were as follows.

1. To ascertain the practicality of facilitating Internet-based remote collaborative design projects for students.
2. To introduce students to remote design environments and technology currently being adopted in industry and to investigate any

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- obstacles encountered in implementing and utilising this technology in design education.
3. To investigate the impact of the technology on the effective teaching and practice of the design process.
 4. To study the ability of the technology to overcome cultural differences between the participating institutions and to generally promote inter-institutional collaboration.
 5. To encourage diversified learning.

The product design engineering degrees taught by each of the participating departments incorporate many common elements, however each of these departments presents its course from a different pedagogical perspective. ICON aimed to encourage the students to share their knowledge base in an attempt to widen both their individual and institutional skill sets.

Both ICON projects took place across the Internet using the environment provided by the CVDS.

The Internet design project

Building on experience gained through the ICON projects, the Internet Design Project (IDP) is part of a module in the Computer-aided Building Design course at the Department of Architecture & Building Science. A small pilot of two groups of two students took place in the summer of 1999 and the Internet Design Project ran for the first time in November 1999 with a class of 44 students. The IDP investigates and allows participants to experience the use of new Internet technologies to communicate across distances within the discipline of architectural design, in this instance as a tool for communication between designers and clients at the early stages of a design project.

The main aim of this project is to introduce postgraduate architecture, building design engineering and interior design students to the concepts and environment of Internet communication and its application to professional practice, e.g. text communications; the sending, sharing and marking up of drawings; and co-operative/collaborative working. The project also aims to develop transferable skills, new communication skills, organisational skills, and to promote co-operative and collaborative work. Emphasis is placed on the communications aspect of the project and for the most part the new networked and distance Internet communication tools have proved effective. However barriers have also been encountered and both students and staff had to establish methods of overcoming these problems.

DESIGNING ICON AND IDP PROJECTS

Encouraging interaction

Interaction is a central feature of the learning process and has been encouraged throughout the ICON and Internet Design projects. Moore [5] notes three types of interaction which take place

within distance education. Learner/content interaction is a vital process which enhances the learner's understanding of a concept or subject area. It ranges from the reading of a book to the use of 'interactive' computer courseware. Learner/instructor interaction, regarded as essential by many in education, helps to motivate students and stimulate interest in the subject. A third form of interaction, learner/learner, can occur without the presence of an educator. Of course it is possible and indeed desirable to include all three modes of interaction in a distance course.

Learner/learner interaction is being exploited within many online courses mainly in the form of asynchronous text-based discussions. Where students come together to pursue a common objective rather than just to discuss a subject their motivation may be enhanced. In most courses working together is not encouraged; the competitive and apprenticeship models appear to be dominant in higher education [6]. Even within collaborative projects students find it hard to distance themselves from the culture of competition. In one study [7] a student admitted that he had found a useful website but decided not to share the information with others due to his competitive feelings with regard to the assessment. Cooperative learning may in fact be more effective when students are made aware of the personal transferable skills which it can enhance and which are increasingly required by industry. These were key considerations in the design of ICON and IDP.

ICON began with a week-long collaborative design project involving four pairs of students [8]. Participants came from the Product Design Engineering course at the University of Strathclyde and the joint course of the same name at Glasgow School of Art/Glasgow University. The students tackled different design briefs and were asked to provide a design solution and to present their findings at the end of the project. They were constrained to use network-based technologies such as audio/video conferencing and chat and were not permitted to communicate by any other means. Although many difficulties were encountered throughout the week, the project was considered a success in that it demonstrated the potential for virtual collaborative design projects in an educational environment. The success of ICON led to a second project, ICON2, being run over an eight-day period in September 1998 [9–11]. On this occasion an enhanced set of communication tools in the form of the Clyde Virtual Design Studio (CVDS) was used as the collaborative environment.

The underlying approach to the ICON projects involved developing a cost effective and accessible approach to computer-based collaborative design projects that educators could implement easily and efficiently. This included using no new application software, as much freeware as possible and no ISDN—in general a low-powered system. The

artificial environment which was created (the projects lasting for a matter of days, as opposed to a semester) was also meant to be as non-restrictive as possible and included a concerted effort to record as much information as possible for post-analysis.

Harasim et al. [12] note the importance of group size when designing collaborative activities. Too many participants may mitigate against effective decision making, particularly in an asynchronous environment. They suggest that having three to four members in a group is manageable. ICON showed that collaborative design projects could be effective with *dyads* or pairs of learners. IDP involved eleven project groups, each containing four members. The

remit for each of these groups was to design a studio and living space in Glasgow city centre, for an artist of a particular discipline, over the Internet. The initial group task was to formulate the brief with the 'artist/client' (one of the five course tutors) and to develop it towards a satisfactory design solution using Internet communication tools. Each group had to create a web log to document all communications, decisions and design development (in both text and image format) and prepare a web presentation of the final design of the studio.

The IDP lasted for three weeks, two weeks to communicate and design and a final week to put together a web-based presentation. The week prior to the project was spent creating web pages.

Table 1.

	ICON1	ICON2	IDP
Project introduction	In the six weeks prior to the ICON1 project three briefing sessions were arranged to introduce students to the project methodology, the technology and the other participating staff and students. Design teams randomly chosen from a group of volunteer students.	All teams participated in an initial three day sacrificial project during which the students conducted their primary research whilst familiarising themselves with the communication and design tools. Design teams randomly chosen from a group of volunteer students.	A seminar on group working was held. All students had prior knowledge of e-mail & file attachment procedures. Students were introduced to communications software during the project. Class of 44 organised themselves into 11 design teams of 4. Some groups were familiar with their team members others were not.
Duration	5 days	8 days	3 weeks (including 1 week preparing web presentation)
Design interface	Project website created, incorporating design briefs, project schedules and online technical support.	Facilitated through the customised interface of the Clyde Virtual Design Studio (CVDS) which provided access to desktop applications, communication tools, date management facilities and a reference area.	Design briefs and photos were hosted on course web site. Each group shared web area for purposes of web log/diary.
Technology	Cross platform PC/Mac, CuSeeMe, Netscape Communicator beta release. Audio conferencing provided for all teams but only one video link. Microsoft Office, BSCW (Basic Support for Co-operative Work), Netscape Navigator, Paintshop Pro, Adobe Photoshop, AutoCAD, PeopleSize.	PC only, Netscape Communicator final release, Microsoft Net Meeting, 3D Studio, Video conferencing provided for all teams. Microsoft Office, BSCW (Basic Support for Co-operative Work), Netscape Navigator, Paintshop Pro, Adobe Photoshop, AutoCAD, PeopleSize.	Cross platform PC/Mac (e-mail & designing) Netscape Communicator 4.7 (restricted to PCs) Microsoft Office, Netscape Navigator, Adobe Photoshop, FormZ (modeller), AutoCAD, Adobe Pagemill.
Design brief	Different brief allocated to each team.	Same design brief allocated to all teams.	Same broad design brief allocated to all teams. Each team had to develop specific brief with 'client/tutor'.
Evaluation	<ul style="list-style-type: none"> • Pre/Post project questionnaires and interviews • Project diaries • Final presentation videos 	<ul style="list-style-type: none"> • Pre/Post project questionnaires and interviews • Project diaries • Final presentation videos • Continual monitoring • Observer's project log • Daily project videos 	<ul style="list-style-type: none"> • Observation of students • Review of student web logs • Final presentation & assessment of output in terms of project outcomes • Feedback from students on experiences

The methodological approach to the ICON projects and the IDP can be summarised as in Table 1.

TECHNICAL/ENVIRONMENTAL BARRIERS TO COMMUNICATION

Technological barriers were numerous during the ICON projects. As technology essentially *supports* such projects it is important that sufficient preparation goes into the purchase and testing of any equipment so as to minimise problems and resultant frustrations during the project. Technical problems during the IDP however were minor. This was perhaps due to the fact that audio and video conferencing were used in the ICON projects, placing far greater demands on the system than other computer tools. IDP did not use audio and video conferencing. Lessons had also been learned from the difficulties experienced by others. Every Internet-based course experiences a range of problems at the outset due to the unfamiliar environment but most of these problems are transitory [8] as students learn how to use the technology and find ways to work around the inadequacies of the system.

Unreliable software

Consistent ‘crashing’ occurred during ICON1 and to a lesser extent, ICON2 due to unreliable technologies. This seriously hampered project progress. Insufficient bandwidth for audio/video conferencing can badly affect performance and cause frustration; audio conferencing, particularly, is deemed crucial to effective communication. During the IDP many students expressed frustration at not being able to access or update their web log which contained a record of all communications, since the host server was often down; a stable server is essential. Some students also experienced problems with the university mail server and this led to a slowing down of communications. Whilst the majority simply accepted this, one group created a free web-based e-mail account to run parallel to their existing university account.

Inadequate software

During the IDP, some students found it ‘tedious and over laborious’ having to upload information using a web page editor before all members of group could see the communication. Students involved in communications from home found that some ISPs had limitations in this respect. Problems also occurred when ‘clients’ did not have suitable image viewing software, so a universal file format (JPEG) was adopted. Students also found that in real-time sessions Netscape Communicator had problems displaying information from image files without first being predetermined to fit window sizes. Sometimes text and images were displayed inappropriately on other platforms. One group added scale bars to drawings

to compensate for changes in their display across platforms and font choices were made carefully. Quality in line drawings was lost when viewed on the web and indeed the number of sketches which could be stored within the web log was low due to limited disk space.

Lack of technical training and support

During all these projects a high level of technical support was available to students by committed project staff. However the students had to learn how to use a range of new technologies as well as working on the core material for their projects. Adequate training and supervision is essential to avoid demotivation at an early stage. During these projects more training should have been given on the communications software in order for the tools to become ‘invisible’ and ‘effortless’ to use.

Poor physical environments

The right physical environment has to be provided to ensure effective work in the virtual one. Poor lighting and air quality as well as inadequate space were evident during some of the projects. During the two ICON projects students worked continuously in front of a computer screen in such environments from 9am to 5pm for periods of up to eight days. The resulting fatigue may have contributed to communication difficulties.

Hardware issues

During the first ICON project significant problems were caused because of hardware incompatibilities between the two institutions. Even when platforms are the same, there are other hardware issues to consider such as securing digital cameras and pens which are easily stolen from open access computer/design laboratories.

SOCIAL BARRIERS TO COMMUNICATION

The lack of experience in collaborative working is probably more problematic in most online design projects than difficulties in using the technologies. Students can in fact be remarkably tolerant of technical hitches, often failing to recall later precisely what the problem was—so long as it was fixed. The speedy and helpful resolution of such problems by the facilitator or support staff is essential [13].

Not knowing collaborators in advance

During both ICON projects collaborators had face-to-face meetings at the beginning and the end of the project. Synchronous communication and co-located collaboration helped reduce feelings of detachment. During the IDP students were allowed to meet up beforehand but were not necessarily able to physically meet the ‘client’. This proved extremely frustrating for one group; it was too easy to be ignored in this virtual world.

Communications could have been improved by holding an online desktop video conferencing session or at the least an audio session in real-time.

Students who knew each other prior to the IDP found that they could communicate better and express their ideas more openly than groups who had never met. Many students found holding face-to-face meetings at the beginning of the project beneficial. One group noted that communication within the group was good but poor with the client (the tutor) and demonstrated how there was a direct link between good communications and good interpersonal working relationships.

Not having clearly defined roles and responsibilities

It has been noted that most synchronous technologies such as 'chat' and video conferencing facilitate communication, not necessarily collaboration [14]. Effective collaboration requires goals and working procedures to be specified and agreed at the outset of the project. Groups which agreed early on a sub-division of tasks during the IDP created more harmonious working relationships, aiding communication significantly. Those who appointed leaders also performed more successfully. Communications over a distance can be particularly difficult to sustain and it is significant that the most successful groups were those that kept up enthusiasm and worked co-operatively.

The support of the educator is essential in helping students to allocate roles and responsibilities among the group. Defining the overall group objectives, identifying and prioritising the tasks necessary to achieve these objectives and specifying the group working procedures are essential activities. The instructor may wish to lay down rules of group working at the outset [15].

Difficulties in conveying design ideas

The use of e-mail only has limitations in conveying design ideas. Textual communication during IDP had to be precise and self-explanatory and tended to be verbose in order to achieve this. The ability to attach drawings and sketches (as files) was extremely useful as these could often describe much more. Real-time desktop conferencing offered a better level of communication. Images and drawings could be altered interactively and discussed using whiteboard and chat facilities. The pilot study concluded that audio communication in conjunction with the whiteboard offers a very effective means of communicating visual designs as this could convey some of the expression and meaning so often misinterpreted in text-based conferencing. Video capabilities on the other hand were felt to be rather crude and speech lagged behind the image causing dissatisfaction. The quality of drawings viewed via the video camera was also extremely poor.

Students had to establish 'new rules' for working in this environment particularly associated with

the visually intensive field of architecture. When using the whiteboard some groups agreed upon a colour coding system for textual clarity. Codes were established for ending messages in chat sessions in order not to waste too much time anticipating a longer response.

An additional barrier found during ICON regarded the *capability* of the technology, the extent to which current tools and applications can support the design process. The students felt that the conceptual design stage was adequately supported but detail design tended to fall down; it was difficult to argue or debate with their partners and most issues were just accepted rather than discussed in detail. Adequate training for project participants may minimise these effects in future as well as creating design-specific materials such as online specifications and design methods.

Misunderstandings

There is always the possibility of being misunderstood when engaging in virtual communications such as these. Students overcame difficulties in strategic wording of correspondence during the IDP by using humour and adopting a more informal approach to communications. Gestures readily understood during face-to-face interaction do not have the same impact when video conferencing. It is easier to ignore, cut-off or dominate the other person in a virtual setting. As well as adopting new practices in using the tools students need to give more thought to their actions. Progress was halted in ICON, for example, when collaborators would disappear from their stations without giving notice.

Frustrations of asynchronous collaboration

Asynchronous technologies enable 'any time, any place' interaction, which offers many advantages to individuals who cannot find mutually convenient times to meet. True collaborative work, however, necessitates a high level of feedback; asynchronous communication methods such as e-mail undermine the essential ability for team-workers to speedily renegotiate goals and procedures [16]. Although e-mail allows the attachment of diagrams and other graphics, the inability to discuss these in real time can also hamper the collaborative design process. Synchronous collaboration occurring 'same time, any place' provides a sense of immediacy, the ability to plan and solve problems and make decisions more quickly [17].

With the asynchronous nature of e-mail there was uncertainty during the IDP as to whether e-mails had arrived. To alleviate this one group sent messages to their client's mobile to inform him to check his e-mail. There was however no guarantee that the recipient would read the e-mail and reply immediately. In some instances, when response times were not fast enough, communications began to break down and 'time was wasted in waiting for replies'. To counter this the majority of the groups communicated online several times a

day thus avoiding missing e-mail messages. Some groups requested e-mails to be directed to home and workplaces as well which allowed working to continue into the evening. Another group designated one person's user area as the communications contact 'host'. Using a password each of the group was free to respond and everyone had the chance to view incoming and outgoing communications.

A few students experienced difficulty in brainstorming and reported that 'the buzz when the ideas are flowing is impossible to get over the Internet.' Text-based communications, the main method used in the IDP, do not allow for such expression. Real-time communication using Communicator on the other hand was much faster in discussing issues and students found that they could resolve design problems immediately. Design proposals developed at a greater rate during these communication sessions. The whiteboard with its ability to import images (JPEGs) proved 'a highly effective and user friendly method of communication'. But at times even this caused problems: some students found that chat was 'much faster—too fast! We kept sending messages at the same time'.

Conflicting institutional cultures and methods

When more than one institution is involved matters of conflict can include staff and equipment resources, timetabling and project objectives. Increases in the number of personnel involved, allied to their different locations can also cause significant problems.

When so many different aspects of work have to be considered and managed effective project management is crucial to the success of such projects. Problems were encountered in ICON when an additional tutorial was given to students at one institution. This had serious repercussions for the rest of the project by altering the students' perceptions of what was required and the relationship between the institutions. A project champion may be necessary to control, manage and supervise all elements of a project at all participating sites. Particular attention should be paid to the input of different personnel, the availability of support and the meeting of deadlines in setting up the project.

Differing student backgrounds and personalities

Although ultimately a positive effect, the result of students working together from different backgrounds can cause problems at the beginning of a project in terms of understanding. A good supervisor can successfully integrate different areas of knowledge and ensure that students can work towards a common goal.

During ICON and the IDP it became clear that the teams progressed at different rates due to the respective relationships between personalities. These relationships ranged from professional to antagonistic. A common problem in any collaborative venture is the feeling that one partner

may be contributing more than another. It can be even harder to overcome such difficulties if people do not have face-to-face contact. The setting of roles and responsibilities early in the project can again go a long way to alleviate such problems.

CONCLUSIONS AND FUTURE DEVELOPMENTS

The ICON and Internet design projects at Strathclyde have allowed students to work collaboratively on design projects using a range of Internet-based technologies. Now that some of these technologies have matured, many of the initial problems experienced by students have been overcome. Software is becoming increasingly stable, cheaply available and easier to use. However all students using unfamiliar technologies should be given adequate support and time to practise using them in advance of scheduled project work. Groups are likely to find that collaboration is easier if they are given a chance to meet in advance of the project. The IDP scheduled a face-to-face seminar on the subject of group working prior to running the project, a practice definitely to be repeated in subsequent projects. Ideally, students should allocate roles and responsibilities at the start of the project with a clear set of working practices, specified with the help of a tutor.

Participants are likely to find that designing with the use of asynchronous technologies is a frustrating process but that video conferencing and other forms of real-time communication such as chat can make the design process come alive, particularly when designs can be viewed and discussed synchronously. Students need to develop new methods of working together, particularly as problems due to differing backgrounds and personalities can be exacerbated through the lack of face-to-face contact. When projects take place between collaborating institutions, the staff involved must ensure that the project is managed effectively and students given similar guidelines as to what is expected of them.

The Internet design project is an attempt to emulate to some extent the communication within architectural practice. More and more practices are using the Internet and in particular e-mail (and attached drawing and image files) to communicate with the other consultants in a design team and their clients. The architectural students on Strathclyde's programme will all be faced with these technologies when they graduate; they will have a distinct advantage in having already been introduced to the technologies and the problems involved in communicating with them.

The Clyde Virtual Design Studio provides a supportive environment for product development complete with design and communication tools. At present however it does not incorporate company and business constraints; these need to

be addressed separately by the design team. To provide a realistic simulation of 'real world' design it is important that business constraints such as manufacturing and resource capabilities are addressed by the supporting environment. Within such an environment a student or team of students would be able to experience a realistic simulation of the design activity within a business context. The Virtual Development Enterprise for Europe (VIDEEO) project, funded by the Socrates ODL programme and started in 1998, aims to develop such an environment. VIDEEO is being developed jointly by Glasgow Caledonian University and the University of Strathclyde.

The VIDEEO environment aims to provide an educational and training tool for not only designers but also for other disciplines with an involvement in the design process such as marketing and manufacturing. The environment has been created utilising modern computer and network technology as appropriate to provide a complete teaching and learning experience for the participants. The programme involves staff, from engineering and business disciplines, from eight educational institutions from across Europe.

The VIDEEO project represents the next step in the development of a fully integrated product development environment for education. It enhances and develops the CVDS and ICON concepts in the following manner:

- Wider geographic spread of users—the users of the VIDEEO system are based in various HEIs in a number of European countries. The system

provides a web-based environment accessible using TCP/IP connections. ISDN is used as a back-up means of connection.

- Wider range of user degree disciplines supported.
- Provides direct access to all the tools/applications and information required to complete a design project online e.g. design, financial and marketing applications.
- Supports both remote and local multidisciplinary team-based design projects.
- Incorporates a number of company/business scenarios and project outlines which can be used by tutors in developing team-based projects.
- Incorporates a project and business scenario creation tool used by tutors.
- Tutorials covering the operation of the VIDEEO system and topics relevant to the project are included.

The barriers to communication identified in the ICON and IDP projects are compounded in the VIDEEO approach. Barriers of culture, discipline, distance, network and technology are all at a much higher level. These aspects have been addressed in developing the enhanced system and ways of overcoming them considered. The development phase of the VIDEEO project is now coming to an end and pilot projects between different institutions are about to commence. The pilots will be fully monitored and evaluated to measure the effectiveness of the system in terms of teaching and learning, staff efficiency and technology robustness and capability.

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Niall Sclater is Manager of Educational Systems at the University of Strathclyde in Glasgow. He has been involved in implementing technology in Higher Education since 1990 and teaches modules in Web-based Teaching and Internet Communication on the University's Postgraduate Certificate/Diploma in Advanced Academic Studies. He developed and manages the Clyde Virtual University initiative. He also leads the multi-site Scottish Computer Assisted Assessment Network which is promoting the use of computers for assessing university students across Scotland. His current research centres around online continuing professional development. Further details are at www.sclater.com.

Steven MacGregor is currently conducting research into distributed working within the engineering design industry as part of an EPSRC funded PhD. The project aims to effectively utilise knowledge to maximise the potential of the distributed design process. He graduated with an MEng in Product Design Engineering, also from Strathclyde University in 1999. The development of the ICON series of academic projects represented a major part of the latter year's study. He has published related work on similarities between education and industry in the field of Computer Supported Cooperative Work (CSCW) and the link between CSCW and Knowledge Management within engineering design industry.

Hilary Grierson studied at the University of Strathclyde, Glasgow and the Graduate School of Design, Harvard University. She has worked as a practising architect in both the United States and in Glasgow and now tutors the postgraduate Computer-aided Building Design programme and 1st year architecture design studios at Strathclyde University. Her recent research work has focussed on the implementation of Internet technologies in architectural projects, both in education and practice, and the use of new technologies in relation to Continuing Professional Development for architects.

Bill Ion is a Senior Lecturer in the Department of Design, Manufacture and Engineering management at the University of Strathclyde. He graduated from the University of Glasgow in 1979 with an honours degree in Mechanical Engineering with specialisation in Production Management. Prior to appointment to the Department of Design, Manufacture and Engineering Management (DMEM), University of Strathclyde in 1985 he spent periods with Barr and Stroud Ltd and Yarrow Shipbuilders Ltd. In both these positions he was responsible for a wide variety of design projects principally for the MOD. He has been actively involved in the development of design and design management education at secondary school, undergraduate and postgraduate levels. He is currently Director of Teaching and Learning in DMEM and Course Director of the undergraduate degree programme in Product Design Engineering. He has been an investigator on research projects with a value in excess of £1.7M in the areas of design tools and techniques and computer supported working in design and design education. His current funded research programmes focus on the field of virtual prototyping, rapid prototyping and CSCW in European design education.