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SHARING EXPERIENCE IN ENGINEERING DESIGN EDUCATION: HISTORICAL BACKGROUND AND FUTURE PLANS

Chris McMahon, Bill Ion and Pat Hamilton

Abstract

The organisation Sharing Experience in Engineering Design (SEED) was formed in 1979 as an informal forum for engineering design teachers to meet and to share their experience. In 2002 the organisation has terminated its activities and the members have agreed to help in the formation of a new Design Education Special Interest Group (DESIG) of the Design Society. This paper presents a history of the activities and achievements of SEED, and suggests how its work will be continued in the DESIG.

Over nearly quarter of a century SEED has pursued four main activities. The first has been the holding of an annual seminar/conference on engineering design education topics. Each event has been on a specified theme, such as creativity, assessment, quality and qualification, computer-aided learning and so on, and many have involved extensive discussion by delegates, recorded in the proceedings of the event, on the topic of the conference. The second activity has been the recommendation of a standard curriculum for engineering design and an integrated series of preparation material monographs on engineering design teaching, directly related to topics identified in the curriculum. The third activity has been publication of a comprehensive set of Design Procedural Guides to support engineering students in design project work. These guides cover a range of topics including power transmission, mechanical positioning and control, structures and other subjects. Finally, SEED has published an extensive collection of tried and tested engineering design projects.

The DESIG shares SEED's aim of providing a forum for the identification, sharing and dissemination of best practice in engineering design education. In order to achieve this aim, the DESIG will carry out such activities as organising Design Education conferences and workshops, promoting working groups to develop key engineering design education issues, promoting special design education issues of journals and maintaining a engineering design education resource web site. The paper reviews the main continuing challenges in engineering design education as we enter the 21st century, and in particular sets out a draft agenda for the initial development of the DESIG.

Keywords: engineering design education, special interest group, curriculum

1. Introduction

In June 1979 about forty people attended a Seminar at Hatfield Polytechnic with the objective of informally sharing experience of engineering design education and providing an opportunity for discussion. The meeting was held at the invitation of the design staff at Hatfield – mostly recruited recently from industry - who floated the idea of a seminar to discuss ideas, opinions and problems in engineering design teaching. The emphasis was to be on informality, small discussion groups and non-competitive sharing of experience. Particular issues at that first meeting were project work and teaching facilities. Those present felt that it would be worthwhile repeating the event and it was proposed that further meetings

be held annually or bi-annually, with the continued aim of facilitating the informal sharing of experience in engineering design education. The designation SEED, referring to Sharing Experience in Engineering Education, was chosen and in this way SEED was born [1].

In 1986, a formal Constitution for SEED was approved, and the organisation was incorporated as a company limited by guarantee in 1988. In the constitution the aims of the organisation were stated to be [2]:

1. To encourage the sharing of experience in engineering design education;
2. To facilitate the viewing of various engineering design teaching departments;
3. To provide a forum for the ventilation of matters of concern in engineering design education;
4. To represent the collective and informed view of members in the pursuit of a better understanding of design and improvement in the quality of engineering design education.

SEED has pursued these aims over nearly quarter of a century by holding an annual seminar/conference and through the publication of monographs and guides in support of several aspects of engineering design teaching. But although SEED had a number of members from outside the United Kingdom, the organisation was perceived to reflect very much a British perspective. In recent years there has been a very significant growth in international interest in engineering design education, and therefore at a Special General Meeting held in September 2002, the membership of SEED resolved to bring the organisation to a close, and to merge its efforts with a new Design Education Special Interest Group (DESIG) as part of the Design Society. This paper has the objective of recording and reflecting on the achievements of SEED over the years, and using this as a starting point for a proposal for an agenda for the DESIG.

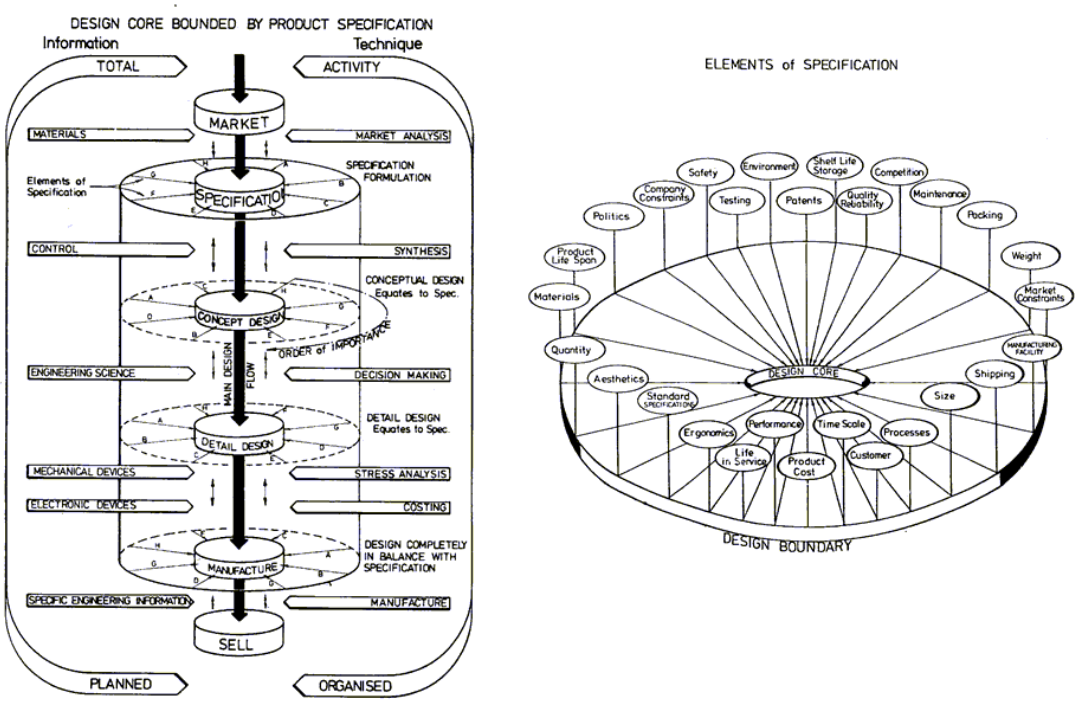

Figure 1. The SEED Design Activity Model [7]

2. History of SEED

In the UK and elsewhere in Europe the 1970s were a period of growing interest in the teaching of engineering design. The engineering student population was growing - the 1960s had seen the creation of 31 new polytechnics and ten new universities in the UK with a further ten universities arising from the upgrading of former colleges of advanced technology and two Scottish institutions [3]. Many of these had a strong focus on design. The Moulton report on "Engineering Design Education" of 1976 [4] and the Finniston report of 1979 on the formation of engineers [5] both laid great emphasis on design as a central focus of engineering education. The Design Research Society was founded in 1965, and the ICED conferences began in 1981, growing out of a strong Design Science movement in continental Europe. Yet there was little consistency in the design curricula of different educational institutions, and although textbooks were beginning to appear, many teachers of engineering design in the UK felt the need to share experience to clarify the direction of the curriculum.

2.1 The Curriculum for Design

The need to clarify the approach to teaching engineering design was central in the early discussions of SEED. A tentative suggestion was floated at the conclusion of the 1982 seminar at Huddersfield Polytechnic, and subsequently enlarged upon in 1983 at Southampton University, that the best practice from around the UK should be collected and distilled into a 'recommended curriculum'. A working party was formed and a draft was presented to and modified by the 1984 meeting at Coventry. The Curriculum for Design was accepted by the members, published in 1985 and widely circulated [6]. This document presented a view of engineering design based on the design activity model shown in Figure 1. This model emphasised the core phases of engineering design, techniques, information and management, and also identified the place and importance of the product specification. The curriculum included proposals for definitions of terms, teaching strategy, time requirements and detailed areas and topics to be taught.

The teaching strategy presented in the curriculum was for a progressive build-up of knowledge, techniques, skills and experience via a three-stage presentation of topics, with the first stage comprising a general introduction with emphasis directed towards the acquisition of basic knowledge and skills, the second stage introducing the model of the design activity together with core phases, techniques and information, and the third stage being that at which students carry out projects and work on their own initiative. The topics to be introduced at each stage are shown in Table 1.

2.2 Preparation material for engineering design teaching

The Curriculum for Design led to one of SEED's three publishing activities - the first of an integrated series of preparation material for teaching was a set of monographs based on the topics of the Curriculum. The monographs were produced to a uniform style and peer reviewed. Each monograph typically comprised a topic definition, a rationale for teaching the topic, educational aims and objectives, a syllabus, teaching and assessment suggestions, further reading and references. Over a period of some 15 years, 12 monographs were produced on the topics underlined in Table 1 (Market Investigation and Specification formulation were combined), and further publications on the remaining topics were planned. Many were popular and sold widely at home and abroad generating interest in the whole area of study and providing a basis for quality teaching. In due course they received the Yale and Valor Partnership award for excellence and innovation in engineering design. Library editions of the monographs, comprising all in the series, were introduced in the mid-1990s.

Table 1. Stages of the SEED Curriculum for Design

AREA	STAGE 1	STAGE 2	STAGE 3
Total design activity	1. Introduction to design 2. Engin'g organisations	3. Design activity model 4 The designer	——————→
Core phases		11. Market investigation 12. Specification 13. Conceptual design 14. Detail design 15. Manufacture 16. Sales	——————→ ——————→ ——————→ ——————→ ——————→ ——————→
Techniques	21. Information retrieval 22. Communication	——————→ ——————→ 23. Market analysis 24. Spec'n formulation 25. Ideas Generation 26. Evaluation 27. Decision making 28. Analysis 29. Modeling/simulation 30. Costing 31. Economic analysis 32. Computing 33. Aesthetics 34. Ergonomics	——————→ ——————→ ——————→ ——————→ ——————→ ——————→ ——————→ ——————→ ——————→ ——————→ ——————→ ——————→ ——————→
Information	41. Engineering science 42. Manufacture 43. Materials	——————→ ——————→ ——————→ 44. Components 46. Specification elements	——————→ ——————→ ——————→ ——————→ ——————→ 45. Product liability
Management			51. Time/ resources 52. Budgeting 53. Design review
Assignments and Projects	61. Assignments	62. Assignments	63. Project

2.3 Project compendium

A further working party began work in 1986, with the aid of a grant from the Department of Trade and Industry (DTI), to produce a series of Project Compendia, in association with the Design Council. Three Compendia were published, in 1988, 1989 and 1991, and included 66 projects and assignments for use at all stages of undergraduate courses. The projects and assignments were intended to integrate with the Curriculum. Each Compendium contains project briefs and guidelines to facilitate effective implementation, including the stage of the course for which the project is recommended, the resources required, the educational objectives, information and resources to be made available to students, suggested method of assessment and so on. Comments for teachers and details of the source of the exercise are also given.

2.4 Engineering Design Procedural Guides

While the preparation material for engineering design teaching and the project compendia were firmly aimed at use by teachers, SEED's third publishing activity, the Engineering Design Procedural Guides (DPGs), was aimed at providing assistance to students in the course of projects and exercises. The guides consider the selection of components or devices that are typically bought out from specialist suppliers, the design and validation of components to be manufactured in-house, and the selection of materials, manufacturing methods or systems components. The production of the guides was one of SEED's first activities. Work was commenced in 1981 with early support from the Design Council, and continued for a number of years with support from the DTI and Smallpeice Trust.

The overall programme of production of DPGs was guided by a topic matrix, with, in one dimension the domains to be covered, and in the other the design level – ranging from system considerations to component design and production. Table 2 shows the classifications used in these two dimensions, and Table 3 shows the guides produced, together with a cross-reference to their location in the matrix (e.g. the DPG on Belt Drives is a level 4 book – Unit Design – in subject A – Mechanical Power Transmission). Note that some topics could legitimately appear in more than one location in the matrix.

Table 2. Dimensions of the DPG Matrix

Dimension 1		**Dimension 2**	
A. Mechanical Power Transmission	B. Fluid Power Transmission	Level 0 Problem abstraction, prime mover sel'n	Level 1 System Considerations
C. Electrical Power Transmission	D. Structural Systems	Level 2 Sub-system Considerations	Level 3 Unit Selection
E. Mechanical Positioning and Control	F. Fluid Transmission and Control	Level 4 Unit Design	Level 5 Component Selection
G. Electrical and Electronic Control	H. Heat Transmission and Control	Level 6 Component Design	Level 7 "Production"

Table 3. Topics of the Design Procedural Guides

Mechanical Power Transmission	**Electrical and Electronic Control**
Rotary Power Transmissions – A1	Operational Amplifiers – G5
Electric Motor – A3	**Structural Systems**
Shaft Coupling – A3	Static Structures – D1
Gearboxes – A3	Threaded Fasteners/ Bolted Joints – D4/5
Clutches – A3	**Mechanical Positioning and Control**
Shaft/Hub Connections – A3	Planar Mechanisms – E2
Belt Drive – A4	Cam Mechanisms – E4
Chain Drives – A4	Springs – E5
Seals – A5	**General**
Rolling Element Bearings – A5	Limits and Fits – Level 7
Standard Gears – A5	Manufacturing Processes – Level 7
Shaft for Strength and Rigidity – A6	
Shaft with Fluctuating Load – A6	

The DPGs were again offered as library editions, and, in 1994, McGraw-Hill published the set of guides dealing with rotary power transmission as an integrated book [8].

2.5 Electronic Publication

By the late 1990s it was clear that paper publication of a large number of booklets was becoming less viable financially for the organisation, and therefore it was decided to move the publication of SEED's teaching material to the Internet. A number of DPGs had been converted to HTML by David Mole and colleagues at South Bank University and these, together with other material from the DPG and Curriculum Guides, are being incorporated at the time of writing into a Web site [9], with support from the Institution of Engineering Designers, the Royal Academy of Engineering and a number of higher education institutions.

2.6 SEED Seminars

As was noted at the beginning of this paper, the holding of an annual seminar was the initial reason for SEED's formation, and seminars have been held every year since 1979. Each seminar was held in a different institution of higher education, and the format was deliberately chosen to allow the local organisers some say in the choice of topic and an opportunity to show others their way of working in engineering design. The format also allowed time for discussion – plenary sessions were interleaved with group discussion sessions on topics raised by the presenters, and a record of the discussion was incorporated in the published proceedings of the seminar.

Each seminar followed a theme, and speakers were invited to address issues within the theme. Topics that were considered by the seminars included the design curriculum (1983-85), project work and industrial links (1988), engineering design across the disciplines (1990), student assessment (1991), creativity in design (1992), quality and qualification (1994) and computer-aided learning in engineering design (1996). Very often, as has been seen, resolutions arising from the Seminars led to the establishment of working parties. The outcome of a number of SEED seminars has been reported at ICED conferences (e.g. [10]).

It is interesting to note the cyclic appearance of some discussion topics in conferences, amongst which are project assessment; the continuum of design education; interdisciplinary design; the engineering design 'process'; design data; computer aids in engineering design; integration of design with engineering science subjects, with industrial design, with business studies etc and so on. These are clearly on-going matters of concern for design teachers.

In 1999, SEED joined its Seminar series with the conference programme of the Institution of Engineering Designers to form the Engineering and Product Design Education conference. This conference has been held in each year since (e.g. [11]). In 2003 the conference will for the first time be held under the auspices of the Design Society, at Bournemouth in southern England.

2.7 An assessment of SEED's contribution

There are many engineering design teachers and students who have derived great benefit from the existence of SEED. For teachers the benefit has arisen especially in 'networking' with colleagues; in developing good practice and being able to debate developments in a non-competitive forum; in encouraging younger, less-experienced design teachers and supporting them with reasoned and well written texts; and for students in supplementing standard text books with easy to access guides to detailed design in a unique format.

SEED has been a presence in UK engineering design education for nearly a quarter of a century, while over this time a number of other initiatives have come and gone. This has been its strength, and also its weakness. As an organisation, it has been influential to a generation of engineering design educators in the UK, and to a smaller but nevertheless enthusiastic group from elsewhere in the world. The downside is that it has been seen as being confined largely to the UK and largely to mechanical/manufacturing engineers. It has also, although incorrectly in the view of the authors, perhaps been seen as taking a rather static and prescriptive line on engineering design education, based very much around the Curriculum for Design.

To a certain extent it can be proposed that's SEED's job is done. Design is very much established as central in engineering education in the UK, and its importance in research and industry is reflected in engineering design research centres and journals, the growth of the ICED conferences and the emphasis put on design by industrial speakers. The SEED membership nevertheless felt that there was important work to be done in an international arena – to share experiences between engineering design educators in different disciplines and in countries, to develop and share educational material using the powerful mechanism of the Internet, and to continue to promote the importance of engineering design education in industry, education and politics. For this reason SEED members have volunteered to disband the organisation and to devote their efforts to developing and promoting the Design Education Special Interest Group (DESIG) of the Design Society.

3. The Agenda for the DESIG

DESIG shares the central aim of SEED that it wishes to provide a forum for the identification, sharing and dissemination of best practice in engineering design education. In a number of ways it will have similar activities and functions. It will differ however in three key respects. Firstly, it will seek to be as inclusive as possible in the range of views on engineering design education that it seeks to embrace. It seeks membership from across the engineering disciplines and beyond, and from across the world. Secondly, it will not be prescriptive in establishing a curriculum, although it will seek to contribute to the development of an understanding of a structure into which topics and issues in engineering design may be allocated. Thirdly, it will seek where possible to exploit the Internet to promote and assist sharing – through electronic documents and also ultimately through electronic communication, webcast seminars and the like.

In order to achieve its general aim DESIG will seek to undertake the following;

1. Organise an international engineering design education conference every two years (in non ICED years).
2. Organise an international engineering design education workshop every two years (in ICED years).
3. Collaborate with national design education organisations in the organisation of national design education conferences.
4. Promote working groups to develop key engineering design education issues.
5. Promote special design education issues of journals.
6. Maintain a engineering design education resource web site (restricted to membership, download/upload, sponsorship).
7. Other activities as deemed appropriate.

3.1 DESIG Structure

The proposed organisational structure of DESIG is as shown in Figure 2.

The Management Board will comprise seven elected members and will be responsible for the organisation and day-to-day running of all DESIG activities. A representative from the Design Society Management Board will be an ex-officio member. The Board will be elected by affiliates every two years. Initially, the management board has been be formed by the SEED Executive plus two invited international members.

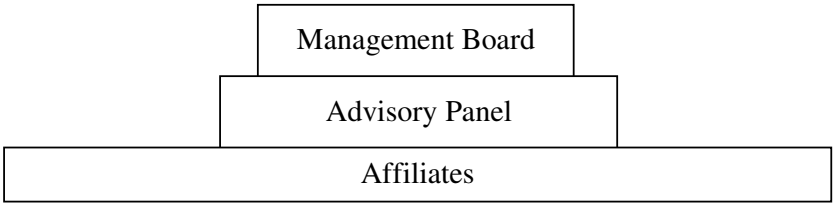

Figure 2. Organisation of the DESIG

The Advisory Panel will comprise 20 – 25 members, and it is aimed to have balance of membership in terms of country and discipline. It will advise on the nature and direction of DESIG activities, and will include working party chairs and representatives from national organisations. The period of membership is two years. Initially it is being formed by invitation from the Management Board, but ultimately it will be elected by the Affiliates. Working party chairs and national organisation representatives may be co-opted.

While concentrating on engineering design, the DESIG will aim to attract interest from a broad spectrum of design educators and practitioners, including the following: industrial/product design, mechanical engineering, manufacturing, architecture, electrical and electronic engineering, civil/structural engineering. Interested individuals will be encouraged to join the Design Society and to register their interest with DESIG. Registered members will be considered to be 'Affiliates' of DESIG and will be permitted to vote in DESIG Management Board and Advisory Panel elections.

3.2 DESIG's Future Agenda

It is planned that the future agenda for DESIG will be determined by the affiliate members and management and advisory boards during the next year, in particular through discussions at ICED03 and at the International Engineering and Product Design Education conference to be held at Bournemouth University in September 2003. Some suggestions for the issues that DESIG might address are as follows:

- To address the questions of how to reconcile the relentless demand for (commercial) efficiency in universities with the (inevitably) greater resources needed to teach design well, and of how to find better ways to integrate design activities with other parts of the engineering curriculum
- To provide a forum for comparison of national patterns and curricula in engineering design education, and comparing the approach to design education in different disciplines, with the aim of helping design education communities learn from each other. In this way aspects of commonality and best practice may be identified.
- To promote international collaboration, for example in joint projects with communication provided by groupware and other communication (for example [12]), in the shared preparation and delivery of teaching material and in research into design education issues.

- To address the question of what should be the nature of engineering design education in a "wired, learning society" – i.e. a society with extensive computer-mediated information access. What should the balance between primary, secondary, tertiary and life-long education be in engineering design?
- To help to define the need for learning material in engineering design, and in particular to set standards for reusable "learning objects" for design. For example this might include machine simulations for instructional purposes, audio and video clips, streaming video lectures, demonstration programs and Applets (Java programs executable by a Web browser) etc.
- Investigating special issues from the engineering design curriculum in some depth – for example how should issues of sustainable engineering or ethics be dealt with in design education?
- Promoting excellence in engineering design education, for example through design competitions and design prizes. Perhaps it might be possible to arrange for an international competition for undergraduate designs, maybe with different topical themes each year, to be sponsored by a prestigious sponsor?

The authors would welcome any further suggestions for issues that the DESIG might address in the future.

4. Concluding Remarks

The original intention behind SEED was that those involved in engineering design education should have an opportunity to share and compare their own experiences and problems with others in an informal, non-threatening forum, and maybe, thereby, even influence the course of developments. That need has not disappeared. It is vital to seek to improve the content and methods of engineering design education, both in preparing students for the challenges for industry and as a legitimate intellectual activity in its own right. It is, after all, the core of real engineering. In addressing this need, SEED has made a distinguished contribution to engineering design education over nearly quarter of a century, as has been reviewed in this paper. At a time when the importance of engineering design teaching is receiving even greater emphasis in a number of countries around the world, we hope that DESIG be similarly influential on a wider stage in the future.

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Chris McMahon
University of Bath
Department of Mechanical Engineering
Bath, BA2 7AY
UK
Tel: Int +44 1225 384026
Fax: Int +44 1225 826928
Email: c.a.mcmahon@bath.ac.uk
URL: http://staff.bath.ac.uk/enscam/

Bill Ion
Strathclyde University
Department of Design, Manufacture and Engineering Management
James Weir Building,
75 Montrose St.
Glasgow, G1 1XJ
UK
Tel: Int +44 141 548 2091
Fax: Int +44 141 552 7986
Email: w.j.ion@strath.ac.uk