STRENGTHENING ASIAN ADVANCED DESIGN AND MANUFACTURE EDUCATION THROUGH A FRAMEWORK APPROACH

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ABSTRACT
The rapid industrial growth of some Asian countries demands to bridge the gap between Europe and Asia for mutual sharing and exchange of knowledge and cooperation in Advanced Design and Manufacture. A European Commission funded project provided a new platform for not only strengthening Asian education in design and manufacture but also helped in creating strong ties between European and Asian academic institutions for exchange and sharing of knowledge through joint course material development, delivery of MSc course in advanced design and manufacture and joint supervision of PhD training of Asian students. This paper introduces the project, key activities implemented during its duration, achievements and the impact it had regarding the introduction of world class engineering design and manufacture education in Asia through the up gradation of knowledge and skills of postgraduate Asian students. The project's implementation also built strong partnerships between European academic institutions and Asian industrial sector as well as laying foundations for the development of numerous research and education based projects between Asian and European academic and industrial sectors.

Keywords: Design and Manufacture, Asian Higher Education, Network, Collaboration

1 INTRODUCTION
Due to stiff competition, globalization of world economy in the last two decades, many industries in the developed world have outsourced majority of their operations particularly manufacturing in Asian countries to take advantage from cheap labour and infrastructure availability [1]. This resulted in collaborative and geographically distributed working of many operations (particularly design and manufacturing) of majority of globally operating companies such as Microsoft, IBM, Intel, Airbus and Boeing etc. However engineers and scientists working in South East Asia still lack far behind in terms of advanced knowledge about cutting edge technologies in the fields of Advanced Design and Manufacture due to obsolete curriculum and lack of properly trained faculty staff [2]. Therefore in order to compete with the developed world and work in geographically distributed environment, it is necessary that engineers should be trained with competencies necessary to achieve global engineering excellence [3, 4]. However due to obsolete curriculum of the undergraduate/graduate programs as well as non availability of skilled trained faculty staff in Asian universities, many Asian students go overseas in Europe and US for further training under Masters and for research in PhD programs[5].
European Commission in the past has funded many projects in design and manufacture education thereby establishing a Euro-Asia network [6] under their Asia Link program [7]. Some of these projects [8, 9, 10] were aimed to provide a framework solution for EU-Asia cooperation in higher education; to promote mutual exchange and sharing of knowledge in Design and Manufacture; to promote Europe as a centre of excellence for higher education and research as well as creating new and strong ties between Europe and Asia for future collaborations in science and technology. This paper introduces one of these projects [10] managed by University of Strathclyde, Glasgow in UK within a consortium of seven partner academic institutions from Europe and Asia. The project provided a total solution framework in strengthening Asian Higher Education in the fields of Advanced Design and Manufacture by implementing various activities throughout its three year of duration. The project was very well received by the targeted audience, which was Asian postgraduate students, members of Asian faculty teaching staff, industrialists and researchers. The second section of this paper explains further about the structure of the project, its aims and objectives. The

implementation of various activities of the project is explained briefly in the third section whereas results of implementation are discussed in fourth section. The impact of the project on its target groups in terms of its achievements is discussed in fifth section where as the final section of the paper concludes the paper with the discussion about the importance of executing such type of projects in promoting design and manufacture education and research in Asian through curriculum development, institutional development and human resource development by sharing and exchange of knowledge among European and Asian academic institutions.

2 STRUCTURE, AIMS AND OBJECTIVES OF THE PROJECT

The FASTAHEAD project [10] was lead by University of Strathclyde, Glasgow UK and is based on the success of previously completed Asia-Link project [8] titled as "Promoting and Assisting Engineering Design Education in China" (PAEDEIA). The PAEDEIA project started in 2002 and finished in 2005 and involved three European (UK, France, Denmark) and one Asian (China) academic partner institutions. This project achieved its proposed targets and deliverables. Three short courses were developed in the topics of Advanced Ceramic Material Design and Manufacture [11], Advanced Product Development [12], and Advanced Mechatronic System Design [13]. Seven Ph.D. students from China have been successfully recruited and trained through Split Training at the Universities in the UK, France, and Denmark. Two international conferences were held successfully in April 2004 and November 2005, respectively, i.e., the Europe-Asia Symposium in advanced Engineering Design and manufacture for globalisation (EASED) 2004 [14, 15], and the Seminar on China-Europe Engineering Education (CEEE) 2005 [16]. Due to the success of this project, University of Strathclyde decided to extend this partnership to other Asian partner countries particularly some least developed countries such as Pakistan and Bangladesh to improve their higher education in fields of advanced design and manufacture.

2.1 Structure of the Project

From January 2006 to December 2008, a three-year project entitled "A *F*ramework *A*pproach to STrengthening *A*sian *H*igher *E*ducation in *A*dvanced *D*esign and Manufacture" (FASTAHEAD) funded by European Commission under Asia-Link programme has been implemented. The total funding of the project was approximately 1 million Euros. The project aims to develop a framework solution to engineering higher education demands in Asia, by developing a new curriculum in Advanced Engineering Design and Manufacture for Asian and European MSc education, upgrading the skills of university teaching staff in Bangladesh, Pakistan and China, split training Asian PhD students in European Institutions, comparing educational policies / systems / programmes among various countries, and enhancing the overall management of Asian Universities. There are seven universities from six countries participating in this project, namely the University of Strathclyde (SU), in UK; GIK Institute of Engineering Sciences and Technology (GIKI), Pakistan; Huazhong University of Science and Technology (HUST), China; Islamic University of Technology (IUT), Bangladesh; Northwestern Polytechnic University (NPU), China; University of Malta (UOM), Malta; and Troyes University of Technology (UTT), France.

2.2 Aims and Objectives of the Project

The core problem to be addressed in this Asia-Link project was the shortage of well-educated engineers and teaching staff at the postgraduate level with advanced knowledge on Engineering Design and Manufacture in least developed countries and developing countries in Asia. The proposal was to develop a framework to address the above problem. This project aimed at developing human resources and new curriculum, and improving administration within institutions. The overall objectives of the project were to:

- Contribute to the postgraduate training provision in Advanced Design and Manufacture in Bangladesh, China and Pakistan and increase partner institutions Postgraduate population;
- provide short-term training for Asian teaching staff by attending intensive courses, lectures, Asia Link Seminar, research collaboration, and thesis supervision etc;
- Split train Asian PhD students through study/research abroad;
- Promote technology transfer between engineering design and manufacture and economic development in Europe and Asia through the academic activities conducted in the project;
- Enhance and exchange the skills and knowledge between teaching staff members of Asian

partners and European partners;

- Introduce broader higher education opportunities within partner Universities to promote reciprocal access to higher education and increase postgraduate mobility;
- Contribute to the development of sustainable engineering design and manufacture in Asia;
- Upgrade the skills of people working in the engineering design and manufacture;
- Promote regional and multilateral networking among Engineering Design and Manufacture education Institutions in Europe and Asia;
- Increase the quality and number of MSc courses offered on engineering;
- Promote and strengthen collaboration between European Engineering Design academic departments with their counter partners in Asia;
- Research labour market needs further for each of the modules to be developed based on the market research reports and surveys;
- Introduce Asian students to a wider choice of postgraduate training opportunities in the UK, France and Malta;
- Expand existing ties between the partner institutions to enhance the understanding of and information on higher education;
- Promote the exchange of experience and encourage mutual knowledge and the recognition of study programme;
- Review project progress, disseminate collaboration results, and discuss the further collaboration activities to sustain future collaboration;
- Enhance the knowledge and skills of teaching staff and postgraduate students by introducing the latest skills and methods in engineering design and manufacture;

The specific objective was to develop a framework solution to engineering higher education demands in Asia, by developing a new curriculum in Advanced Engineering Design and Manufacture for Asian and European MSc education, upgrading the skills of university teaching staff in Bangladesh, Pakistan and China, split training Asian PhD students in European Institutions, comparing educational policies / systems / programmes among various countries, and enhancing the overall management of Asian Universities.

2.3 Project Activities

The flow chart of project core activities, techniques and approaches applied, results, beneficiaries and time scale has been summarised in Figure1. This chart represents the key activities of the framework solution proposed for the project to address both short and long term needs identified. The short-term framework solution was to develop a flexible pilot MSc/Pg European style course in Advanced Design and Manufacture as a common framework, which each partner institution could adopt. This structure provided flexibility for students to choose which institution they wish to study based on their own preference. The long-term solution proposed was the training of PhD candidates.

The Kick-Off Workshop was to set-up the project management structure, establish a common understanding of the proposed project, assign the responsibilities of each partner, agree and allocate funds to and contribution from each partner, and agree detailed timetable. Project Publicity Days proposed to be held at the four Asian partner Institutions respectively, to publicise the Project programmes at the beginning of the project. Labour market surveys at the early phase were proposed to help the project implementation in the right direction. Each module was designed to reflect the recent research and technology achievements of the related fields and the needs of the current labour market. Each module was proposed to be designed by at least two different country partners. The students were selected for the course hosted by the Asian local partner institutions. All modules were delivered in English. These modules were delivered using suitable modern teaching methods, such as interactive teaching practised and proven in the Current Asia Link Project, e-learning, web based learning support and presentation, shared workspace, and virtual team working, net-meeting discussion, email communication and CD based interactive learning. In the end of the project, a “Review and Plan Workshop” was organised to review the whole implementation of the project, to evaluate the modules development, to consolidate the cooperation between partners, and to discuss the plan for future.

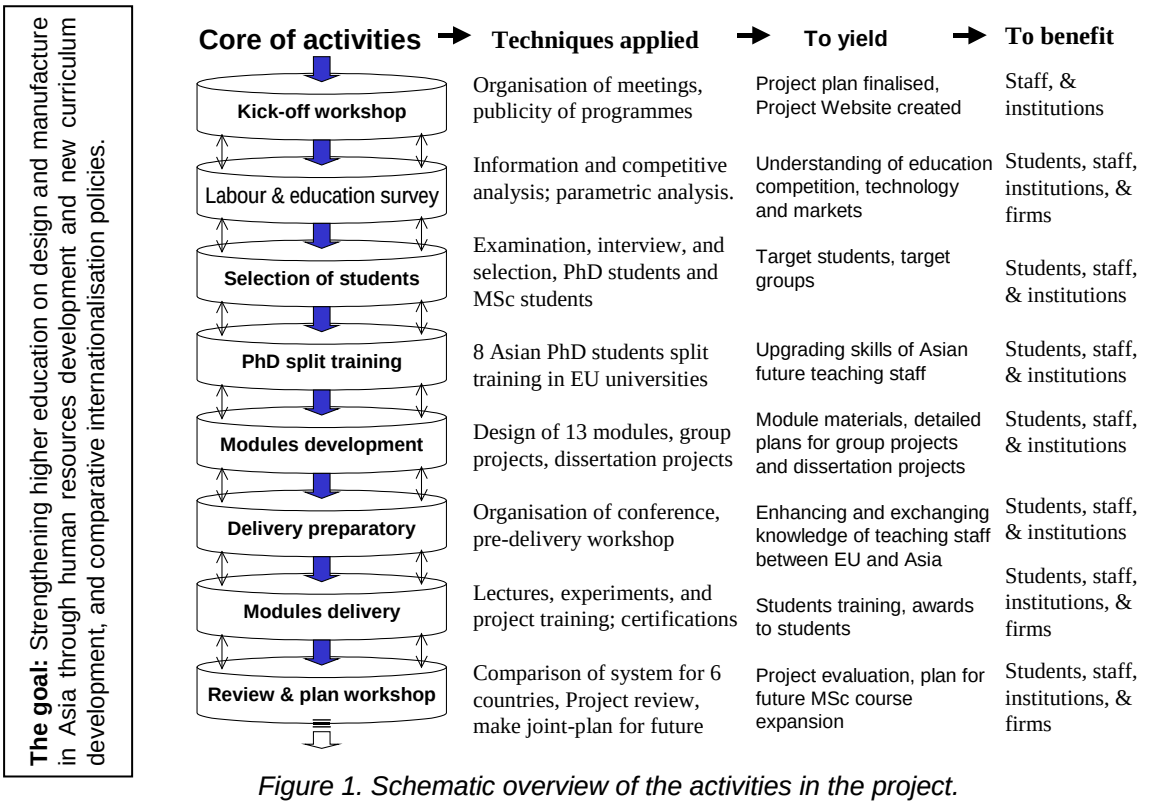

Figure 1. Schematic overview of the activities in the project.

3 PROJECT'S IMPLEMENTATION

The project was completed and implemented almost all its activities as per planned and scheduled according to its proposal throughout its three year duration of the project. Following is the brief overview of the main project activities which were implemented at all seven partner institutions in Europe and Asia:

3.1 Project Publicity & Development of Communication Structure

- An overall as well local project management committee was established to ensure a collective and responsive decision making mechanism in place and to communicate effectively among different partners. In addition, a dedicated online project repository has been established to upload and download important data for massive information sharing, which was in the form of emails, forum discussions, teaching materials, course notes, data and videos/pictures among different partners;
- Fourteen Publicity days were organized by four Asian universities in the three Asian countries (Bangladesh, China, and Pakistan). 144 students, 100 teaching staff & 28 industrialists attended these events;
- Six local and one main project websites linked with each other were setup to carry out the publicity of different activities of the project through the internet to its targeted audience. In addition, three project brochures with 3000 printed copies and one poster were also designed and sent to different organizations in different institutions in all three partner Asian countries to promote and publicize the project and its activities.

3.2 MSc Course Material Development

One of the key activities of the project was to design and develop state of the art MSc course in the Advanced Design and Manufacture on the basis of findings of survey of labour market demand and education in Asia.

3.2.1 Labour Market Demands & Education Requirements Survey

In order to design a new state of the art MSc course in the fields of Advanced Engineering Design and Manufacture, it was necessary to understand precisely the current state of higher engineering education systems as well as the labour market demands in terms of skilled workers across the whole

world, especially in the target Asian countries. This was achieved by conducting surveys on global MSc programs in engineering, global needs of engineering education, Asian needs of engineering education and skilled worker/labour market demands. A comparison of policies of existing MSc programmes in all partner countries of the project was also made and this also included leading and typical countries. The results of all these surveys were analysed and compiled into individual reports. An overall collated report was produced to present an overall summary of all conducted surveys and highlight important areas which needed to be considered to address the needs of engineering design and manufacture in the new proposed MSc course of the project. Some interesting results of these surveys are:

- There is a strong need of improvement in the ability to use the techniques, skills, and modern engineering tools necessary for design and manufacturing practice in industry. Therefore technical knowledge of the students in different fields such as Product Modelling and Visualization Techniques; Industrial Design Engineering; Design of Biomedical Systems; Systems Engineering and Integration; Design for Product Life Cycle Phases; Composite Materials; Computer Aided Manufacturing and Laser Processing needs to be improved.
- Strong Managerial/Administrative skills are needed to manage the whole design and manufacturing process of a product cost effectively and efficiently. Survey results indicated a strong need of adding the course contents related to the management of the design and manufacturing process such as Team Based Interdisciplinary Design; Design & Project Management; Global and Distributed Design and Process Modelling, Monitoring and Improvement Techniques.
- A strong participation of and link to the engineering industry is recommended and suggested by all surveys in order to better equip the students with the knowledge of solving real industrial world's problems. At the same time, they should be able in identifying solutions so that they are not only familiar with the theoretical knowledge of design and manufacture but also knowledgeable about the current practice and procedures of the industry to design and manufacture a product in a real fast growing competitive world.

3.2.2 Designing an effective structure of Modules of MSc Program

MSc course consists of 11 instructional modules, 6 related to the fields of advanced design and 5 to advanced manufacture, whereas the remaining two modules are Students Group Project and Final MSc Dissertation project. Based on survey results, module leaders who were experts in those modules were chosen from the project staff of all partner institutions. Module leaders designed the structure of all 13 modules of the MSc programme in consultation with other partners involved in the project using a standard template named as Module Descriptor Form (MDF). Each MDF describes in detail the learning objectives, list of topics and topics development allocation of a module among different partner countries. This structure was designed to provide a clear indication of the module contents as well as for the management of the module development, e.g. what topics are to be produced in each module and who is going to prepare these topics and what students would learn after completing this module. Each module course material consists of power points (teaching material) and course notes (learning material) for 10 topics. The procedure adopted in developing the course material is shown below:

- Development of Module Descriptor Form (MDF) for each module by the corresponding module leader and allocating topics in consultation with other partners
- Development of each topic of module by corresponding module developing staff and sending (using project repository) it to module leader for review/feedback
- Incorporating comments from module leader to refine the course material;
- Finalizing the course material after rechecking/feedback;

The project staff of all seven partner institutions jointly developed course material for 11 instructional modules, 1 group project module and 1 final dissertation module. These modules are Design management and prediction; Design methodology, techniques and tools; CAD and product data management; Modelling, simulation, and visualisation; Digital manufacture and rapid manufacture; Robotics and manufacturing automation; Materials design and materials processing; Advanced laser processing; Process planning & computer aided manufacturing; Design optimization and analysis techniques; Advanced heat transfer and computational fluid dynamics; Group project and MSc final dissertation. Altogether 110 topics for teaching material for tutors in the form of power

point slides and 110 topics for learning material in the form of course notes for more comprehensive learning of students developed by different experts of seven partner institutions. The project staff also published two text books [17, 18] in addition to teaching materials developed for two instructional modules.

3.3 Organization of International Conference on Advanced Design and Manufacture (ICADAM 2008)

An International Conference on Advanced Design and Manufacture (ICADAM 2008) was planned, organized and held by project staff in Sanya, China in January 2008 under this project. The organizing committee received over 500 papers in the first round. 174 papers were finally selected based on the comments of the reviewers for presentation in the conference and publication in the proceedings. The conference proceedings were published by a UK based well known science and engineering publisher Springer in two separate books titled as *"Global Design to Gain a Competitive Edge"*[19] and *"Integrated Design and Manufacture to Gain a Competitive Edge"*[20].

3.4 Delivery of MSc Course Modules at Asian Partner Institutions

A new MSc course in Advanced Design and Manufacture was approved by university authorities (syndicate/senate) in Pakistan's and Bangladesh's partner institutions whereas in two Chinese partner institutions, the designed modules were incorporated in different existing MSc courses of Engineering. This provided flexibility for Chinese students to choose from a wide range of newly developed advanced design and manufacturing related modules in addition to the existing available modules. Expert project staff form European partner institutions delivered various modules at Asian partner institutions to impart their knowledge to Asian postgraduate students and junior faculty staff while delivering course modules at four Asian partner institutions. 137 postgraduate students studied the MSc course; 13 members of teaching staff; 92 industrial engineers; 47 scientists/researchers and 945 optional postgraduate students who took only couple of modules were benefited from delivery of various modules at both European and Asian partner institutions in one year as shown in the following table.

Table 1. Distribution of Participants of MSc Course Modules Delivery in Different Institutions

Details of Modules' Delivery Participants

		NPU					HUST					GIKI					SU					UTT					UOM				
No.	Module	MS	OS	IE	TS	SR	MS	OS	IE	TS	SR	MS	OS	IE	TS	SR	MS	OS	IE	TS	SR	MS	OS	IE	TS	SR	MS	OS	IE	TS	SR
G1	Design management & prediction				3			23						10	2	6		99													
G2	Design methodology, techniques, and tools		9					14										71										18			
G3	CAD and product data management		21					2															260								
G4	Modelling, simulation, and visualisation		23		4	5		1			3			12	2	8		45					77					14			
G5	Digital manufacture and rapid manufacture		11					4																							
G6	Robotics and manufacturing automation	61				24	68	25			3	8																13			
G7	Materials design and materials processing		20					9					5	28	1								103								
G8	Advanced laser processing							19	28																						
G9	Process planning & computer aid manufacturing (CAM)		9					7		1	8																				
G10	Design, optimisation and analysis techniques		5					10					8	9																	
G11	Advanced Heat transfer and computational dynamics (CFD)		0					9					11	5		1															
	TOTAL	61	98	0	7	29	68	123	28	1	11	8	24	64	5	7	0	215	0	0	0	0	440	0	0	0	0	45	0	0	0
G12	Students Group Projects			15					16					5																	
G13	MSc Final Dissertation Projects			61					68					8																	

LEGENDS:		MS	OS	IE	TS	SR
	Total Number of Students for Instructional Modules	137	945	92	13	47
MS - MSc Registered Students						
OS - Optional Students						
IE - Industrial Engineers	Total Number of Group Projects			36		
TS - Teaching Staff	Total Number of Final MSc Projects			137		
SR - Scientists Researchers						

3.5 Project Review and Evaluation

Evaluation of the project was carried out led by University of Strathclyde in the last two months of the project involving all project partner managers. Two separate project meetings were held in Asia and Europe to carry out the detailed evaluation of the project at all partner institutions and both quality and quantity of evaluation were assessed at these meetings. Project Management Committee oversaw this evaluation and external experts were invited to be panel members to assess the overall implementation of the project from the independent point of view. A review report was generated by the external experts.

4 RESULTS OF IMPLEMENTATION

The implementation of project's activities produced important results which are briefly explained below:

- **Introducing Asian students and academics** to a new state of the art MSc course in the field of "Advanced Design and Manufacture" based on European standards of quality. This was evident from the overwhelming responses received during the publicity days of the project in Asian partner countries. The participants showed great interest in knowing more about the project and appreciation to introduce high quality engineering post graduation in developing Asian countries specially in Bangladesh and Pakistan;
- **Identification of needs of global design and manufacture in higher education.** In order to design a new state of the art MSc course in the fields of Engineering Design and Manufacture, it is necessary to understand precisely the current state of higher engineering education systems as well as the labour market demands in terms of skilled workers across the whole world, especially in the target Asian countries. This was achieved by conducting surveys on global MSc programs in engineering, global needs of engineering education, Asian needs of engineering education and skilled worker/labour market demands and comparing policies of existing MSc programmes in all partner countries of the project and as wide as possible to include leading and typical countries. The results of all these surveys were analysed and compiled into individual reports. An overall collated report was produced to present an overall summary of all conducted surveys and highlight important areas which need to be considered to address the needs of engineering design and manufacture in the new proposed MSc course of the project. All together eight reports have been produced for this activity.
- **Introducing Asian students and academics** to a wider choice of postgraduate training of opportunities in the field of Advanced Design and Manufacture in UK, France and Malta. This has been accomplished through the start and completion of PhD training at SU (UK) and at UTT (France). The PhD training equipped students and academics from targeted Asian countries not only with the advanced research topics in the fields of Design and Manufacture but also helps them generally in learning doing research and problem solving techniques in an organized and structured method thereby contributing in their professional development;
- **Training Asian students to do research** in the fields of Design and Manufacture. This has been accomplished by arranging a two week PhD training summer school in China. An overwhelming number of more than 80 PhD students applied for and nearly 60 participated in the summer school from different institutions of China and Pakistan. Teaching staff from SU, UK and NPU, China delivered lectures on various topics in the fields of Design, Manufacturing, Control and Mechatronic. Short lectures about the latest developments and research were also given regarding important subjects of the aforementioned fields.
- **Extending the impact and scope of the project to the industrial sectors** by arranging industrial seminars. Two Industrial Seminars were organized one each at Beijing (China) and Glasgow (UK). Decision makers regarding Chinese industry at national level as well as different industry representatives attended these seminars with overall attendance of 160 participants. Good discussions and exchange of research results by European and Chinese industrial and academic participants were held during these seminars. Success stories of Chinese industry as well as new industrial developments were exchanged among the participants of the seminar. Several key areas were identified during these seminars and it has been agreed that new collaborative research and development projects will be initiated jointly by European academic institutions and Chinese industrial companies;

- **Enhancement and exchange of skills and knowledge** between teaching staff members of Asian partners and European partners by completing the design and development of all the modules of the MSc course in Advanced Design and Manufacture. This has been evident from the composition of each developed module where different topics in each module are developed by different module developing staff from all seven participating institutions. The exchange of skills was further implemented by thoroughly reviewing the course material and positively suggesting changes/improvements in the course material development during the pre delivery workshop, as well as other communications within each module led by the European module leaders. In addition, latest books and references were also provided for Asia project staff to help them develop the teaching materials;
- **Sharing and exchange of knowledge** related to the fields of advanced design and manufacture through the organization of an International Conference on Advanced Design and Manufacture (ICADAM 2008) in China. The conference provided excellent opportunity for leading researchers of the world and local industry in sharing, updating and exchange of knowledge related to the fields of advanced design and manufacture. The conference proved to be a very successful event and due to popular demand of participants of the conference, the organizers have decided to make it a regular biennial event. In this regard a special track of ICADAM was held in IDMME 2010 virtual concept conference at Bordeaux in October 2010 whereas the following year it will be held at Malta in 2012 (ICADAM 2012);
- **Enhancement of the targeted individuals' skills** through the delivery of MSc course in Advanced Design and Manufacture. More than 1200 postgraduate students, teaching staff, scientists/researchers and industrial engineers benefited from the different module deliveries of MSc course in European and Asian partner institutions. The deliveries of these modules introduced new trends/developments in the field of design and manufacturing technology to the audience particularly the Asian audience through the expertise of the delivery staff;
- **Dissemination of Project progress** to a wider international audience through internet about the project aims and objectives, selection of PhD students, PhD split training opportunities, development of MSc course modules, PhD summer school, industrial seminar and MSc course modules delivery. The impact of this dissemination was evident from several enquiries received from different persons in target Asian countries by the project management committee to attend the delivery of different MSc modules as well as enquiring about the possibility of joining European partner institutions as PhD candidates and attending PhD training summer school.

5 IMPACT OF PROJECT ON TARGET GROUPS

The target groups of this project were Asian postgraduate students, members of teaching and industrialists. The project had great impact on the proposed target groups as shown in the following subsections.

5.1 Access to World Class Education in Design & Manufacture for Asian Students

Up-to-date knowledge and skills in engineering design and manufacture are one of the crucial factors for the future industrial development in developing Asian countries. This was the demand of local industry during the surveys conducted that there is a need to completely change and overhaul the existing higher education system and introduce a new curricula at postgraduate level so that the students emerging from have required skills and knowledge to contribute effectively in the development of the local industry. Therefore students in the past who wished to learn more and at advanced level in these two fields had to travel abroad to different European and American countries paying huge sum of moneys in terms of paying for travelling, fee and maintenance besides living far from homes. This project provided access to world class education in the fields of Design and Manufacture by introducing a postgraduate level course in Design & Manufacture for Asian students and local academic/industrial community at their doorstep. This is evident from the interest shown in the proposed course during the publicity of the project by project partners in Asian countries especially in Pakistan and Bangladesh. Participants of the publicity events which included prospective students, academics and industry representatives showed keen interest and appreciated local partner managers in bringing world class engineering educations to their respective countries.

5.2 Transfer of Advanced Knowledge about Design & Manufacture to Asian Partners

There was a dearth of knowledge availability in the fields of advanced Design and Manufacture especially in Design engineering in some target countries. To date only some basic modules related to design and manufacturing are being taught in Pakistan and Bangladesh. This project provided academia the facility and platform at no extra cost to have access to advanced knowledge about Design and Manufacture which European partners achieved through years of implementing research work and conducting/running courses on Design and Manufacturing Engineering. The transfer of knowledge has been implemented in the form of designing structure and development of course material of all modules in the form of topics and learning objectives as well as designing and development of teaching material for lecture delivery and learning material for comprehensive learning of students in the proposed MSc course by different experts in European partner institutions. The developed course material has been pilot tested at European partner institutions as well thoroughly reviewed during the Pre Delivery workshop to suggest improvements and bring its quality to world class standards.

5.3 Skills and Knowledge Improvement of Asian Students & Industrialists

One of the main reasons of lack of industrial growth in some targeted countries (such as Pakistan, and Bangladesh) is the lack of technical and managerial expertise of the industrial personnel in the advanced fields of science and technology such as design and manufacture. There is an immediate requirement of providing a mechanism for continuing professional development of industry personnel and training postgraduate students with advanced knowledge and skills of science and technology. This requirement has also been illustrated by the results of survey regarding labour market demand conducted by all Asian partner institutions during the first of year of the project. The demand of skills and knowledge improvement of Asian students and industrialists has been met by starting and completing the delivery of different modules related to Advanced Design and Manufacture by the skilled European faculty staff at Asian partner institutions. After the completion of delivery of all 11 instructional and 2 project based modules, postgraduate students and industrial personnel of targeted Asian countries have been equipped with the latest advanced knowledge and skills related to advanced design and manufacture fields. This is verified by the evaluation by Asian student and industrialists of delivery of various modules by European teaching staff as mentioned by their appreciation of European style of teaching and of module delivery staff by European experts in the following quotations:

"My experience with couple of European teachers suggests that they are more open and encourage two way participation more. That is way I prefer European style"

"European style because these assignments related to course are very good, also it is much better than Pakistani style as it is of course developed by most developed countries. This will increase the learning power of students."

"I like European style because of knowledge base, visual aided based, right to target and illustrate with examples, (Practical and common)" (During the delivery of a module in China)

"The courses were very good. Courses should also be arranged at other universities of Pakistan."

Table 2 shows some sample feedback from the attendees of Module deliveries of E1 (Design Management and Prediction) and E10 (Design Optimisation and Analysis Techniques) modules at three Asian Institutions. It is clear that the deliveries are success and liked by the students as shown from these statistical analysis.

Table 2. An Overall Comparison of Module Evaluation Forms for E1 AND E10 across 3 Institutions

Evaluation Forms	E1			E10		
	NPU	HUST	GIKI	NPU	HUST	GIKI
Quality of Power Point Files (Good +Very Good)	77%	94%	100%	72%	96%	100%
Speed of Delivery (Appropriate)	100%	84%	100%	76%	90%	82%
English as lecture Language (>70% can be understood + Too Easy)	85%	95%	100%	76%	79%	100%
Contents of Lectures	92%	100%	92%	80%	85%	91%

5.4 Introduction of Postgraduate Research Opportunities in Europe for Asian Staff and Students

Due to the unavailability of the proper infrastructure, software/lab facilities and lack of foreign trained skilled faculty staff in the target Asian countries, there are very few research opportunities available for Asian faculty staff and students in the fields of advanced design and manufacture. Therefore the only option left for these students and staffs is to enrol in foreign European universities. This is not possible for most of the students due to high European tuition fees and living costs. Through the start and completion of one year split PhD training in UK and France under this project, Asian postgraduate students and junior faculty staff were given an opportunity to do research under the supervision of experienced European faculty using most advanced tools of doing research in a proper scientific/research environment. By gaining the knowledge and experience of doing research in the fields of advanced design and manufacture for one year at European institutions has enabled these junior faculty staff to start imparting this knowledge to other students back at their home institutions thus contributing to the human resource and infrastructure development at Asian partner institutions.

5.5 Training of Asian Students and Researchers to do Research

Due to lack of proper training of Asian faculty regarding conducting and supervising research generally in the field of engineering and particularly in the fields of Advanced Design and Manufacture, it is very difficult for the Asian students and researchers to get trained in how to do research in engineering. This is one of the reasons due to which Asian students and researchers lack in producing high quality research work. Keeping in view of this lack of expert supervisory staff and availability of advanced research knowledge related to advanced design and manufacture, the project staff organized a two week PhD summer school where expert European academics interacted with Asian students and researchers and gave lectures to them on how to do research in Advanced Design and Manufacture. Short lectures about the latest developments and research were also given regarding important subjects of the aforementioned fields. All participating students also presented their research problems and initial research results to all the participants of the summer school; thereby stimulating interesting research discussions and getting valuable feedback from all the participants of the summer school. The participants confirmed the success of summer school in training Asian students and researchers to do research.

5.6 Involvement of Local Industry

Based on the publicity of the project and its applied nature, industry approached with queries to solve their real world problems related to design and manufacturing engineering. There was an increased demand from the industry to design student group and final projects on sheet metal work, reverse engineering, surgical and instrumentation, Mechatronic, modelling, simulation and analysis. Local engineering actively participated and involved in the project through following ways:

- Over 90 participants from the Asian industry in two countries have been trained through the delivery of various modules by European specialists. The industry showed keen interest in attending a variety of modules delivered by European project staff particularly in Pakistan. This overwhelming interest showed that industry is willing to be involved and get their engineers trained through the future delivery of MSc course modules at Asian partner institutions;
- The industry was also actively involved through co supervising the students' group projects and final MSc dissertation projects. Over 36 industry based group projects and 137 final MSc dissertation projects have been jointly conducted by academic and industrial supervisors to solve the problems of the local industry;
- Organization of two industrial seminars in China to ensure that the impact of the project is extended to the local Chinese industry as well as their continuous involvement in the form of future research collaborations with Asian and European academic institutions. An overwhelming 151 participants from different parts of China took part in the China seminar making it a very successfully activity. Officials and leading researchers in China participated in the Seminar and there are good discussions and exchange of research results by European and Chinese industrial and academic participants. Success stories of Chinese industry as well as new industrial developments were exchanged among the participants of the seminar. It has been agreed during the seminar that new collaborative research and development projects will be initiated jointly by European academic institutions and Chinese industrial companies.

6. CONCLUSIONS

The implementation and achievements of the project as mentioned in the preceding sections has been quite successful and productive in achieving the aims of Asia-Link theme of European Commission funded projects. The solution framework has been successful to address three key issues to fulfil the engineering demands in Asia which are curriculum development, institutional development and human resource development as follows:

- **Curriculum Development.** The course material for the proposed MSc course in Advanced Engineering Design and Manufacture has been systematically and completely designed, developed and reviewed using the survey results and learning objectives defined for each module of MSc course;
- **Institutional Development.** It is found that the successful implementation of this project which includes the new MSc course proposal approval from institution's governing body, joint curriculum development with European partners, delivery of the course and supervision of split PhD students have established a basic infrastructure for the transfer of skills and knowledge to the local target partner institutions to run and manage the proposed MSc course successfully on their own even after the completion of the project;
- **Human Resource Development.** Human resource development in this project has been accomplished by two means (1) Delivering MSc course by European partner institution academic experts; (2) Split train PhD students at European partner institutions;
- **Exchange of Knowledge, Skills and Experience** took place as more than 1200 persons directly benefited from the delivery of 13 modules of MSc course in Advanced Design and Manufacture at both European and Asian partner institutions. Out of these 1200 persons, 1082 trained postgraduate students, 13 members of teaching staff, 47 scientists and researchers and 92 engineers of industrial organization have been directly benefited from the project and the knowledge, skills and methods of engineering design and manufacture in general have been significantly enhanced and upgraded.

Due to the success of this project, both European and Asian partners jointly applied in various other research and education projects to various funding bodies during and after the completion of FASTAHEAD project such as a new MSc under ERASMUS MUNDAS programme between European partners, a couple of projects between Strathclyde University and Chinese partner universities funded by Ministry of Science, China as well as collaboration between Pakistani and Bangladeshi partner universities. All these projects were possible due to the development of strong and sustainable partnership during FASTAHEAD project.

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