Supporting the introduction of design automation tools into very small manufacturing companies

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Very small manufacturing companies make up an important element of the UK’s manufacturing economy. However, relatively few of these companies make any systematic use of design automation tools. This paper outlines two case studies of very small companies introducing such tools through the agency of formal technology transfer arrangements with a collaborating university. The paper presents a discussion of the issues to be considered by universities and colleges when assisting such companies in the implementation of systems for design automation. The paper also offers an assessment of the effectiveness of the particular technology transfer and training processes used in the studies.

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A substantial element of the UK manufacturing industry is made up of very small companies. A survey in 1990 showed that 95% of the three million businesses in the UK employed fewer than 20 people, and, in Wales alone, two-thirds of manufacturing firms employed fewer than ten. In 1993, the European Commission’s White Paper on Competitiveness concluded that the contribution of these small and medium-sized companies was critical to the success of the economy, and so their performance is of paramount importance.

Of the factors that help to ensure commercial success, good design is of paramount importance. Research indicates that in the UK an increase of one-third in in-house design capability is directly related to a rise in the growth rate of manufacturing output by 0.3% a year.

In the manufacturing sector, the most effective design processes are becoming increasingly reliant on the application of design automation tools. Indeed, new products are now being developed without any physical prototypes being produced; the process relying instead upon the creation of virtual prototypes via computer-aided design (CAD) software.

Within very small companies two factors continue to hamper the effective application of design: first, a failure to recognize the value (and nature) of an effective product design process, and second, the limited application of appropriate design automation tools. These issues have been widely recognized by a number of bodies, including the UK Department of Trade and Industry (DTI), which states that "UK companies still tend to look only to manufacturing productivity for growth, ignoring design’s potential for achieving product competitiveness".

Technology transfer in support of product development

The focus of this paper is on the application of design automation tools in support of the product design process within very small manufacturing companies.
The UK DTI College Business Partnership (CBP) and TCS (formerly the Teaching Company Scheme) have as their aim the effective transfer of technology from academia to industry and, in consequence, many CBP and TCS programmes frequently focus on the application of such tools. The CBP scheme is aimed at improving the competitiveness of small companies by accessing proven technology and skills in partnership with colleges in the further/higher education sector. Programmes run for twelve months and are delivered through the appointment of a new graduate as a CBP Associate to work at the company under the guidance of the academic partner.

In contrast, TCS operates for a minimum two-year period and is based on partnerships between companies and research and technology organizations such as universities. Its focus is on the transfer of leading-edge technology and skills from the research-based organization to the partner company. Leading graduates are appointed as TCS Associates to work within the partner company to deliver projects designed to realize predefined commercial benefits. Over 300 new TCS projects were launched in the UK in 1997/98.

The National Centre for Product Design and Development Research (PDR) at the University of Wales Institute, Cardiff, is a leading provider of research in the areas of product design and development and has been an academic partner in a number of CBP and TCS projects. FDR is particularly committed to supporting small manufacturing companies and the case studies presented here are drawn from among the CBP and TCS projects that FDR has undertaken with very small companies.

Case studies

The two case studies outlined in Table 1 are chosen from a large group of such studies carried out by PDR over the past four years. All of these relate to the product development process in small companies. The studies presented here focus specifically on cases that involved the introduction of design automation tools to support the process. The company characteristics and planned outcomes are shown in Table 2.

Case study A

This one-year CBP project involved supporting a very small company through the introduction of up-to-date product design and development technology. The focus was on the development of a CAD-based resource capable of automating the design, costing, and quoting of bespoke cardboard box products. An Industrial Design Honours graduate undertook the project with PDR delivering support in the areas of CAD and project management.

As the project developed, the main issue of interest to emerge was the difficulty in persuading the company to embrace the new technology to its full extent. In terms of design automation, the agreed project outcomes were delivered with some ease, but the company remained reluctant to build upon these outcomes and to use its newly-acquired knowledge and skills base to make further process and product improvements.

This was partly due to the owner-manager's unwillingness to continue with the appointment of the Associate (or a replacement for the Associate) beyond the life of the CBP project. This stemmed in part from a failure to understand the importance of the...
continued application of design automation tools within the development process. In consequence, there is now a real danger that the impetus gained as a result of the technology transfer project will be dissipated and the benefits offered by the introduction of design automation technology will not be fully realized by the company. This tendency towards 'short-termism' has been a feature of a number of such case studies and represents a challenge for technology transfer organizations in the context of working with very small companies.

Case study B

This TCS programme involved PDR working in partnership with a small family-owned company that designed and manufactured playground equipment. The project was designed to assist the company in the development of an integrated computer-based design and manufacturing system. The ability to create accurate 3-D visuals of the company's products within a client setting was also an important element of the project. An Honours graduate with a background in 3-D design was recruited as the Associate. PDR staff provided expertise and technology in the areas of computer-integrated manufacture, rapid prototyping and virtual prototyping.

The issues that emerged as the project developed related principally to:

- the need to locate the introduction of design automation tools within a clear, long-term vision of the company's future;
- ensuring that the company remained focused on the agreed project outcomes and did not become diverted by other short-term priorities; and
- the need to provide effective support systems for the TCS Associate.

An early challenge here was to ensure that the company grasped the full significance of the programme in which it was engaged. In particular, senior managers needed help to understand how the new resource could provide a lasting stimulus to growth. In turn, this vision needed to be aligned to a shared common purpose (as shared by the company and the higher education partner) in ensuring that the introduction and implementation programme was not disrupted by issues of short-term expediency. Both these factors were sources of concern during the first phases of this TCS programme.

Support mechanisms for the TCS Associate were of particular importance in this study. The company was located some 200 km from PDR. Consequently day-to-day support for the Associate by PDR staff was limited. There was heavy reliance on telephone and electronic communication media, particularly for the communication of progress reports, design concepts and other data. Without robust communication media (and, by implication, the finance to install them) the programme would soon have been in difficulty.

Generic issues

The two case studies presented here (together with other such studies carried out by PDR) identify a number of generic issues relating to the application of design automation tools within very small companies. These issues have less to do with the features of the tools themselves and more to do with the characteristics of owner-managed micro-companies - in other words, the company culture.

The principal issues identified through the case studies are:

- recognizing the need for change;
- recognizing the potential impact of design automation tools;
- understanding the product design and development cycle;
- adopting effective planning and monitoring procedures; and
- having the vision and commitment to carry through and capitalize on the technology transfer process.

The need for change

Micro-companies often appear unwilling to accept change in any form, particularly when the change implies the need to employ new and unfamiliar tools and techniques. This can be seen particularly clearly when the activity is design-related. This uncertainty and unwillingness to accept change may arise for a variety of reasons, including lack of understanding of what design and design automation tools can provide, fear of losing control over a vital process, lack of time, fear of incurring unnecessary cost and, in many cases, an existing 'do it ourselves' culture. (In addition, very small companies may also resist external advice being offered on the design of a product they have successfully manufactured for a significant number of years.)

Case studies undertaken by PDR have demonstrated repeatedly that many companies are simply unaware of the need for disciplined design input to their product development process. Micro-companies often do not recognize the need to embrace change (particularly in the shape of new tools and techniques) as a means of maintaining their position in the marketplace. Thus technology transfer schemes have a key role to play in helping micro-companies understand and accept the need for change. However, this must be done in context. It will be little use to offer examples of good practice...
Supporting the introduction of design automation tools into very small manufacturing companies

Based on the activities of large companies — exemplars must be sought within the micro-company macrocosm and must focus on the tangible benefits (particularly profit improvements) that the successful application of design automation technology can bring.

Understanding design automation

The case studies demonstrate two primary reasons why very small companies need to invest in design automation: first, to become more proactive in attempting to increase market share and aim for market leadership; second, to construct a fall in market share as a result of increased competition. Other reasons (also identified through the case studies) prompting a company to invest in design include: to review present practices and reduce manufacturing costs, to expand on existing markets and to take account of new legislation. Unfortunately, however, even when very small companies invest in design automation as a proactive move, they often fail to appreciate what can be achieved beyond simple cost reduction in product manufacture. Such companies are rarely design conscious and as a result seem unable to accept that design automation can also be used as a tool to increase perceived value (and therefore sales) of a product to the targeted customer. In addition, the companies were often unable to understand that design (and technology) could bring benefits to the company in general as well as to individual products.

The product development cycle

All the technology transfer operations described here focus on a greater or lesser degree on the product development process. The micro-companies involved in the case studies had already undertaken a variety of product development. However, in all of these companies the design and development processes were either carried out by or had been devised by their owners/managers. As such the processes employed were largely idiosyncratic and/or ad hoc and owed more to the preferences and instinctive approaches of the individuals involved than to a systematic approach to product development. (In this context, a characteristic demonstrated by more than one company was a 'system' of constant incremental changes throughout the product development process — and after launch — without any predefined plan of action.)

In few of the case studies undertaken by FDR was there any real understanding of the totality of issues that needed to be addressed in a modern design and development process. This applied particularly to the place (and potential) of design automation tools within that process. In consequence, this frequently meant that the owners/managers (and therefore the chief drivers of change) failed to understand the scope and implications of both the technology and the technology transfer process itself.

An example of this was the failure on the part of an owner/operator to understand the need to test products functionally and structurally at an early stage in the design cycle (case study B). Similarly, in case study A, it was difficult for an owner/operator to accept the need to allow time to develop and evaluate a variety of solutions for a particular design problem before selecting an optimal solution. Paradoxically, however, all the companies were looking to the technology transfer process as a means of improving productivity and profitability. The difficulties arose when managers began to realize that the ad hoc processes previously employed had to be abandoned, to be replaced with a more systematic approach for which they felt little ownership.

Planning and monitoring

The need for accurate product development planning is well understood. Equally important is the planning and monitoring of the technology transfer process, particularly in respect of micro-companies in which, as one owner put it, a 'seat of the pants' approach is often taken in relation to planning.

A feature common to both case studies was the need to re-focus the project on the planned objectives and outcomes at regular intervals. A clearly defined project plan is a necessary prerequisite for all CBP and TCS projects. However, once micro-companies had grasped the nature of the technology transfer (and, by implication, the potential of the graduate undertaking the project) they were tempted to use their graduate Associate for a wide variety of tasks (such as designing marketing and publicity materials) not covered by the original project plan. This tended to divert effort and thus to impede the delivery of the agreed outcomes. Case study B was particularly prone to this problem and in several cases university staff had to intervene directly to withdraw the Associate from work that was not part of the agreed project.

In consequence, successful technology transfer in micro-companies requires detailed project planning allied to a rigorous monitoring process. A failure to satisfy either of these requirements is likely to lead to a dissipation of effort on jiffy issues and a consequent under-performance in terms of project outcomes.

Vision and commitment

A chief characteristic of micro-companies is the overwhelming influence wielded by the owner/operator. As a result, the vision and commitment shown by these individuals are critical to the success of the technology transfer process. In particular, owner/managers need
both the vision to realize the nature and potential of the
long-term benefits that technology transfer can bring
and the commitment to sustain the transfer process over
the full period of the project.

That owners/managers have the necessary vision
would appear to be implicit in their recognition of the
need for technology transfer support at the outset.
However, managers often see technology transfer as
offering a solution to immediate problems and enter the
process seeking only short-term gains. This failure to
see the long-term potential of technology transfer is a
shortcoming that the university partner needs to address
as a matter of priority. If this potential is not realized,
there is a danger that the benefits of the transfer will not
outlive the project itself.

Allied to vision, owner/managers need the
commitment to sustain what can seem a lengthy
process of introducing and integrating design
automation tools, and to remain focused on the agreed
project plan and desired outcomes. Lack of
commitment often occurs not through any want of
enthusiasm for a project, but through owner/managers
becoming distracted by the variety of day-to-day
company problems that only they (by virtue of their
position) can address. Case studies provide
evidence of this. In both cases, owner/managers were
having to spend extended periods as operatives on the
factory floor in order to prevent production shortfalls
through staff shortages. Paradoxically, an enthusiasm
for the project can also bring dangers if it is not
channeled effectively.

A further issue to be considered within micro-
companies is their susceptibility to periodic (and
sometimes dramatic) shifts of priorities. These can
occur through particular external pressures (such as a
major new contract) or through new internally-
generated initiatives (or entusiasm). Given the small
scale of the micro-company, any change of priorities
can spell danger for the technology transfer process and
can lead to the 'yesterday's good idea' syndrome.

Implications for technology transfer
organizations

Because of the high levels of research done by
universities and higher education organizations, they
have a good grasp of the new advances in technology in
their specialist areas, but, in contrast, micro-companies
see little relevance in these advances and their potential
to deliver tangible benefits at company level.

However, by gaining an understanding of what a
micro-company is trying to achieve and through the
development of a mutually agreeable plan, the
university can 'tune in' to the company's wavelength.
This process of 'tuning in' to the micro-scale is
particularly important in relation to the introduction of
design automation (inasmuch as universities have
traditionally directed much of their efforts in this area
towards larger companies. However, larger companies
exhibit very different characteristics and operate with a
very different culture from micro-companies.
Assumptions and approaches that may be commonplace
and supportable in dealing with larger companies
will be inappropriate, even damaging, when dealing with
their micro-sized counterparts.

On an operational level, the location of management
responsibility for these projects with the university
requires a high level of trust between both parties. This
can be gained only by close collaboration within a
regular framework of meetings and progress reviews
with both parties mutually committing to deliver real outcomes for the company. In the TCS and
CIB programmes, an added level of direct interaction is
created, with the graduate Associate operating in full-
time contact with the company. However, there needs to
be recognition that the process of 'tuning' to the micro-
company culture will be as necessary for the Associate
as it is for the university.

Furthermore, without close support from the
university there is a danger that the Associate will
become isolated, with the concomitant risk that he or
she will be diverted by the owner/manager or other
company staff into tasks peripheral to the technology
transfer project. It can be very difficult for a young
Associate to demur when pressed by a senior company
member (with whom the Associate is in daily contact)
to undertake a particular task. The university needs to
provide mechanisms that the Associate can
invoke at such times – intervention at an early stage will
remove pressure points and avoid undermining the
technology transfer project.

Conclusion

Various forms of academic-industry technology transfer
projects have been established in industrialized
countries. The emphasis of many of these projects is on
providing support for small and medium-sized
companies. However, micro-companies have very
individual characteristics and can exhibit highly
idiographic corporate behaviour. Technology transfer
projects in support of such companies need to take these
characteristics and behaviour patterns into account if the
potential benefits of the transfer are to be optimized.

In particular, in the context of the product
development process, a successful technology transfer
project will have the following features:

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- it will be born out of an acceptance of the need for change on the part of the micro-company;
- it will have an ability to impart to the micro-company an awareness of the nature and potential of design as well as an understanding of modern product development processes;
- it will encourage mutual ownership of the transfer process and a common commitment to the delivery of meaningful outcomes;
- it will include robust and effective systems for planning and monitoring the transfer process; and
- it will provide close support for the individuals delivering the technology transfer.

There is much evidence that the TCS and CBP programmes provide an excellent framework for technology transfer. Nonetheless, even the best regulated schemes cannot always easily accommodate the particular attributes and ways of working found in micro-companies. This is where the role of the university or other technology transfer organization becomes critical as a determinant of success. These organizations will need to be sympathetic and responsive to the culture and characteristics of micro-companies. They must also be capable of maintaining an output-oriented approach through the life of the project and be able to deal effectively and quickly with any circumstances that threaten to divert the transfer process.

The benefits of successful technology transfer are widely accepted. The challenge for universities and other organizations is both to reveal and realize these benefits within the context of potential micro-company partners.

Notes and references

8 A. Lewis and R. Hopkinson, 'Some key issues in implementing concurrent engineering within SMEs', paper presented at the CEED 90 Conference, Poole, 1996.