Technology Transfer in Construction: a View of Algeria

M SAAD and M GREENWOOD
The School of Business Systems Management
Bristol Business School, The University of the West of England
Frenchay Campus, Coldharbour Lane, Bristol, BS16 1QY, U.K
Mohammed.Saad@uwe.ac.uk

Abstract

Algeria has been striving to achieve significant and rapid economic development. The seventies saw the flow of ‘petrol-dollars’ from the significant rise of the oil price in 1973 and ‘all-embracing’ contracts were encouraged. These, somewhat expensive, ‘turnkey’ and ‘product-in hand’ contracts enabled complex and highly integrated projects through the re-assembly of all project operations and transference of the entire responsibility for the project to the technology supplier. In the early eighties, the nation’s improving bargaining capability plus the drastic decline in the oil price (hence available investment) prompted a change in focus. Algerian organisations began to feel a vital need to disintegrate, or unpack, projects and Algerian managers were directed to participate in the whole process of technology transfer. Today however, it is increasingly recognised that this strategy has fallen short of achieving the ambitious objectives of exploiting the full learning potential of technology transfer. The outcomes have not reflected the high level of investments.

This development programme has led to a significant increase in building. However, construction projects in Algeria are characterised by high (and increasing) costs, poor quality and long delays. As an example, housing construction costs grew by 10% from 1975 to 1989, by 120% from 1982 to 1989 and by 285% from 1989 to 1998. These drastic increases can be associated with both the introduction of ‘structural reform’ and the devaluation of the currency (1987: $1 = DA 4.9; 1998: $1 = DA 61). The cost of labour, on the other hand, has decreased (1989: 34%; 1998: 20%).

This paper not only examines the strategy of technology transfer adopted by Algerian construction organisations but also seeks to evaluate its impact on the development of their technological capability. To achieve this it attempts to detect the pattern followed by these organisations as they develop and to determine any similarity to models previously identified by a literature review. The paper argues that learning is the most influential element in determining the success of technology transfer; the various mechanisms of learning and their impact on the development of learning capabilities are investigated. The importance of management capability in construction is also highlighted.

Keywords: Algeria, construction, developing countries, learning, management, strategy, technology transfer.

INTRODUCTION

In developing countries the basic source of industrial development, which in reality is knowledge and technological change, is the industrialised countries. The process is known as “technology transfer” or, as defined by Rodrigues (1985), the “application of new technology to a new use or user for economic gain”.
Technology transfer must involve a whole process whereby knowledge related to the transfer of inputs into outputs is acquired. Its effective management is increasingly associated with a continuous process of acquiring and mobilising knowledge and technological skills [Chen (1996), Tidd et al (1997)]. This paper argues that successful technology transfer depends on the subsequent generation of new knowledge (post-transfer application) and on the capabilities of the receiver of this application to react quickly and effectively to change. It considers the process of technology transfer as being more than the handing-over of new technological hardware and focuses on the vital issue of learning, that is learning to select, acquire, implement, adapt and manage technology.

The work here is based on field observations carried out in the developing country of Algeria. Particular observations of the construction industry are used. The paper comprises three main sections: a background describing the Algerian economic development; the Algerian model for technology transfer; and investigations into the impact of the Algerian model of technology transfer on the development of indigenous learning capabilities.

ALGERIAN ECONOMIC DEVELOPMENT

From its independence in 1962 until 1989, Algeria was a socialist country with an economy which was centrally planned and which had a strong and rigid state control. It strove to establish a significant and strong industrial base and achieve a high level of technological advancement as rapidly as possible through a programme of massive investment. The strategy for the necessary technology transfer was, essentially, a combined software and hardware model (with greater emphasis on the latter) and the use of packaged or highly-integrated contracts. Alternative strategies, the acquisition of technology through the capital model or through foreign direct investment, were clearly and deliberately disregarded for ideological motives.

The adopted strategy required a massive investment programme, which was indeed evidenced in Algeria from 1967 to 1984. Investment funding rose between 1967 and 1979. However this was followed by a downward trend between 1980 and 1989 with a complete decline after 1990. With this decline there was a growing recognition that this strategy had fallen short of achieving its ambitious objectives for exploiting the full learning potential of technology transfer. The outcomes did not reflect the very high level of investments and debt increased more rapidly (multiplied by 30 fold between 1973 and 1993) than national production and wealth (multiplied by 5.5 fold).

In 1987, the country began a radical program of macroeconomic stabilisation and structural reform; this is still ongoing. Aimed at establishing the conditions for sustainable long-term growth it includes correcting macroeconomic imbalances and price distortions, containing inflation, promoting private sector development, reforming and restructuring public enterprises and reviewing the performance, the learning and the managerial capabilities of construction.

This development programme has led to a significant increase in building activity. However, construction projects in Algeria are characterised by high cost, poor/unsatisfactory quality and long overruns. On top of this, most large construction projects, such as the Algiers underground, the motorway linking the east to the west of the country and the housing programmes, suffer from significant delays which also impact hugely on costs. This is in spite of the decrease in the cost of labour: in 1989 it dropped by 34% and in 1998 by 20%.

An example of rising costs specific to housing construction are:

(i) 1975 to 1982: a rise of 10%
(ii) 1982 to 1989: a rise of 120%
(iii) 1989 to 1998: a rise of 285%.
These drastic increases can be associated with the introduction of the structural reforms in Algeria and the devaluation of the local currency (in 1987 US$1 = DA 4.9, in 1998 US$1 = DA 61). In the main however, they are essentially related to poor project management and the low level of technological capability.

From 1967 to 1994, the objectives and the strategy for Algerian economic development were set by the Central Plan. The allocation of resources and the investment programmes covered four periods: 1967-69, 1970-1973, 1974-77 and 1980-84. Tables 1 and 2 describe this.

Table 1: Programme of investment from 1967 to 1984

<table>
<thead>
<tr>
<th>Investment</th>
<th>Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.6% of the GNP</td>
<td>1967/69</td>
</tr>
<tr>
<td>46% of the GNP</td>
<td>1970/73</td>
</tr>
<tr>
<td>55% of the GNP</td>
<td>1974/79</td>
</tr>
<tr>
<td>60% of the GNP</td>
<td>1980/84</td>
</tr>
</tbody>
</table>

Table 2: Percentage of investment allocated to industrialisation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of national investment allocated to industry</td>
<td>43%</td>
<td>43%</td>
<td>61%</td>
<td>39%</td>
</tr>
</tbody>
</table>

Fifteen national state companies were charged with achieving these objectives, five of which were associated with construction and/or producers of building materials. It was anticipated that this strategy, known as “industrialising industries” (after the theories of French economist Gustave De Bernis (1966, 1968)) would, by creating industrial and sector interactions, help integrate the whole economy. Specifically, construction was meant to play a significant role. By creating a considerable number of jobs it would contribute to the GDP as well as to sustainable development and growth.

One of the key objectives of this plan was to reach a certain level of economic growth in a relatively short period of time. To do this Algeria had to rapidly acquire a high level of advanced technology conducive to sustainable development. This implied the purchase of complex and costly systems of technology and the use of highly integrated mechanisms of technology transfer. Unfortunately, as their level of production capacity utilisation is around 50%, most state-owned organisations were not able to manage this effectively [Saad, 2000].

This challenging but ambitious approach, driven by the need to achieve self-sufficiency as rapidly as possible, is considered as the chief cause of the ultimate failure of the Algerian strategy for technology transfer.

THE ALGERIAN MODEL FOR TECHNOLOGY TRANSFER

During the 1970s, the desire for rapid and heavy industrialisation led to a significant thrust of all-embracing contracts as illustrated in Table 3. This was made possible by the flow of ‘dollars-dollars’ resulting form the significant rise of the oil price.

Table 3: Types and number of “integrated contracts” adopted between 1970-1978

<table>
<thead>
<tr>
<th></th>
<th>Turnkey contracts</th>
<th>Product-in-hand contracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970/73</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>1974/78</td>
<td>31</td>
<td>16</td>
</tr>
</tbody>
</table>
These complex and highly “integrated contracts”, such as turnkey and “product-in-hand” contracts, were based upon the idea of assembling and co-ordinating all the project operations, from conception through to implementation and installation, into one package and transferring the entire responsibility to the technology supplier. Specific descriptions follow:

The Turnkey Contract

In this form of contract, the foreign partner (the technology supplier) takes complete responsibility for the concept stage, machinery and process choice, civil engineering and construction, delivery and installation. He is required to deliver a plant in working order.

However, this contract does not include the sourcing or training of local skills and therefore implies either a continuing reliance on outside assistance for management and skilled operations or an inefficient operation by local management due to a lack of understanding and skill. Tlemcani (1983) argues that this form of contract often leads to difficulties such as breakdowns, delays in the delivery of spare parts and repair facilities which can only be completed by experts located abroad. The knock on affect for the construction industry is delays in the production of building materials and hence buildings.

The turnkey contract puts an emphasis on the “acquisition of hardware”, suggesting that this is the only condition of technology transfer. Such an approach would probably be successful in an environment containing adequate levels of skills, experience and knowledge. However, in Algeria at the time of the implementation of the first integrated contracts, none of these factors were available. As a consequence, the hardware acquired was too complex and not compatible with the local framework. Indeed, Said-Amer (1978) and Tlemcani (1983) reported that the technology imported was perceived to be difficult to understand and to use and did not match with the local context.

To facilitate compatibility and to reduce complexity as much as possible, the process of successful technology transfer needs a substantial level of “in-house” technological capacity [Bell (1982, 1984), Fransman (1986)]. In investigations during 1973/74, Dahmani (1985) found that there were no more than 250 engineers in the whole country. He therefore argued that the pre-requisite for success was not available in Algerian firms. As a consequence of this lack of local, technical skill, the technology imported in turnkey contracts were too “complex and difficult to monitor”, resulting in less involvement of local managers and local organisations.

The “Product-in-hand” Contract

This type of contract is designed to include the procurement of labour force training to enable the production system to operate at desired rates of output and to the specified product quality levels. This integrated package has one technology supplier who is in charge of the whole project process, from the design, construction and commissioning of facilities, through to the provisioning of the necessary skills, organisation structures and training inputs.

The philosophy underlying this somewhat expensive contract system is:

(i) the need to speed up the learning mechanisms so that local firms could use the imported technology as rapidly and efficiently as possible; and
(ii) the importance of making the foreign partner feel committed to the long-term impact of the investment in terms of economical and technical achievement, the same as he would feel for a direct investment.

The entire responsibility for the ‘product-in-hand’ project rests with the (usually foreign) technology supplier who inevitably carries out practically every activity associated with the transfer. Consequently, this contract fails to give local managers and construction organisations hands-on experience of project
design and implementation. Cooper and Maxwell (1975) explain that such contracts can have serious negative impacts on local involvement opportunities. In the extreme, when every activity is completed wholly abroad, local managers are not given any opportunity to participate in any of the project decisions or key activities such as choice, feasibility studies, installation and project management. Hence they often lack motivation and they miss important learning opportunities [Said-Amer (1978), Perrin (1983)].

This lack of involvement of end users and local managers is considered to be one of the main inhibitors to successful transfer of technology and implementation. Leonard-Barton and Deschamps (1988), Tidd et al. (1997), Cooper (1980) and Yachir (1983) go further and suggest that this type of contract is unlikely to promote learning and technological change in developing countries.

By allocating greater responsibility to the technology supplier, this type of project has been successful in significantly reducing delays in project completion. However, what may have been saved in terms of time has been lost in terms of learning to operate, adapt and manage technological change [Saad (2000)].

Another important weakness of this type of contract follows the ardent desire of the technology providers to reduce risk as much as possible. They are more likely to deal with well-known foreign subcontractors rather than less experienced local ones. Hoffman and Girvan (1990) report that "foreign consultants responsible for preparing feasibility studies often recommend a package of foreign techniques and suppliers".

The use of these two types of contract has not achieved the economic integration and rapid industrialisation as targeted by the Algerian policy and as anticipated by the Central Plan. The existing body of literature on the analysis of Algerian industrial development is quite unanimous as to the failure of this experience. The analysts are, however, divided on the reasons for this negative assessment.

- Boutaleb (1980), Benachenhou (1980), Yachir (1983), and Perrin (1983) hold that the Algerian Central planning mechanisms have been inefficient. Nellis (1980) wrote that "in an increasingly regulated, increasingly supervised and increasingly inefficient world, the Algerian bureaucracy maintains its standing as one of the most difficult with which to deal and one of the least productive in terms of output". For these reasons, Benachenhou (1980) suggests reinforcing and decentralising the planning system.
- On the other hand, Benissad (1982), Bouzidi (1986), and Bouyacoub (1987) argue that the failure is mainly the result of the non-existence of a market orientation policy. They recommend the use of the market as the major economic parameter and suggest that state firms should be run on a financial profitability basis.
- A more recent body of literature questions the role of the state and the strong interaction between the economic and political systems. This is seen to have inhibited efficiency, initiative and competitiveness [Goumezian (1994), Hassan (1996), Saad (2000)].

This non-achievement of the anticipated objectives in terms of production, as well as in terms of assimilation and understanding of the acquired technology, has given rise to the emergence of a new way of acquiring technology, whereby local skill is fully integrated into the process of technology transfer.

The “decomposed” or “design and installation supervised” contract

- As a result of the improvement of bargaining capability through information, acquisition, diversification of partners and technical training programmes, Algerian organisations have started requiring:
  - the disintegration, or unpacking, of projects to enable and encourage local participation in the process of technology transfer and
  - greater participation in co-ordinating the overall activities of the project.
- The result however is a multiplication of contracts, specialities, partners and therefore responsibilities. The project is now more fragmented, co-ordination is complex and the success of the project is more demanding in terms of the capability and availability of indigenous skills.
The phases prior to installation, such as knowledge awareness, exploration, selection, and planning, previously left to the technology supplier in the integrated contracts, are now taken charge of by Algerian users in order to reduce implementation uncertainty. The choice is currently motivated by the need to acquire a technology which is competitive, can be assimilated, is adaptable and is compatible with local requirements. For this, the supplier is required to provide Algerian firms with technical documentation, technical assistance and supervision in order to facilitate the acquisition of knowledge by local firms and hence improve their technological capability.

This form of contract is designed to improve the process of learning for local organisations whilst projects are correctly and efficiently implemented under the supervision of the technology suppliers. It is a less costly approach since the completion is carried out by local managers and organisations (Dahmani (1985) argues that the cost of a foreign engineer in Algeria is five to ten times the cost of a local engineer). It is, however, important to acknowledge that although this approach develops indigenous capability, it involves several suppliers, processes, machines and systems which makes assimilation, organisation, maintenance and integration a complex matter.

This development is motivating the need to opt for simple technology and efficient personnel training to enable assimilation, adaptation and the eventual improvement of technology. This appears to be in line with theory advocated by:

- Bell (1982, 1984) and others that organisations from developing countries cannot mature unless they accumulate the capability for technological change through learning processes; and
- Hoffman and Girvan (1990) who support the concept that unpacking is very attractive for firms from developing countries as it can result in financial savings and, above all, in increased local learning opportunities.

The impact of the Algerian model of technology transfer on the development of indigenous learning capabilities.

This section, which considers Learning as the most influential element determining the success of technology transfer, attempts to identify the pattern followed by Algerian companies in the development of their technological capabilities. It also investigates the various mechanisms of learning acquisition and their impact on the development of local capabilities.

A REVIEW OF THE MAIN MECHANISMS OF LEARNING

Bell (1982,1984) submits that learning refers to the various processes by which skill and knowledge are acquired by individuals or perhaps organisations. Lall (1982,1992), focusing on developing countries, suggests that learning is based partly on the experience of production, partly on importing ready made knowledge from industrialised countries and partly on a deliberate process of investing in the creation of knowledge. Various forms of learning are identified by the literature. A summary of their key features is outlined in Table 5.

In most studies of technology transfer emphasis is placed on production capability and on the acquiring of imported technology for passive consumption. Dahlman et al (1982) show that detailed information on how and why the technology works are ignored; hence there is little understanding.

This learning mechanism, the understanding process, is relatively passive and automatic in the sense that it will occur at some rate with the passage of time or with increasing accumulation. It is based upon observation which is usually inactive, and participation in production tasks which, if/when imported technology is regarded as a consumable item, can run for years without generating any kind of understanding. In this case, learning is minimal. Indeed, researchers such as Gold et al. (1980) and Lall et al. (1994) have convincingly demonstrated that passive forms of "learning-by-doing" have, in fact,
contributed very little to productivity growth. If a form of learning does emerge, it occurs after a long period of trial and error. Thus, the concept of cost and time in the “learning-by-doing” mechanism must be considered.

Algerian construction companies have typically “learned-by-doing”. Observations have shown that most of these firms have demonstrated some learning over time. However, the output of the industry is still characterised by high cost, long project delays and very poor quality. The “learning-by-doing” then is not, as scholars suggest, “costless”. Indeed, it is demonstrably costly and time consuming with little pay back.

Bell et al (1984) and others argue that learning in a production setting only occurs if there is a feedback of information. This flow of information enables an understanding of the process, be it manufacturing or construction, and it can be used to improve the overall production (or construction) system. Thus, the perception of possible improvements depends essentially upon the prior availability of skills and knowledge to analyse and interpret the information generated. Knowledge and understanding, then, is acquired through mechanisms requiring a deliberate allocation of resources. Bell et al (1984) argue this point further and suggest that firms cannot rely on “learning-by-doing” in order to develop their technological capacities; they must invest in training and other knowledge creation.

**Table 5: A presentation of the major mechanisms of learning and their main impact on capabilities development**

<table>
<thead>
<tr>
<th>Type of Learning</th>
<th>Positive Impact</th>
<th>Negative Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning by operating or learning by doing</td>
<td>Improvement of execution of production tasks</td>
<td>Passive consumption of imported technology and passive role of users. Low impact on learning curve.</td>
</tr>
<tr>
<td>Learning by changing</td>
<td>Acquisition of knowledge and understanding of technology used. Acquisition of confidence in manipulating the imported technology</td>
<td>Limited to the execution of production tasks. It is based on observation which can be passive if local capability does not exist</td>
</tr>
<tr>
<td>Crude copying</td>
<td>Low cost activity. It can lead to simplification of imported technology.</td>
<td>Essentially limited to the development of ‘know-how’ and does not lead to the generation of new technology.</td>
</tr>
<tr>
<td>Adaptive copying</td>
<td>Accompanied by adaptation of product design to improve quality or marketability. It develops ‘know-how’ and is based on disembodied technology.</td>
<td>Costly and requires higher level of skill and greater depth of manufacturing experience.</td>
</tr>
<tr>
<td>Learning by exporting</td>
<td>It can arise from acquisition of ‘know-how’ and ‘know-why’</td>
<td>Requires incorporation into the firm of a large number of professional and technical personnel of different specialities.</td>
</tr>
<tr>
<td>Training</td>
<td>The major source of technological capacity</td>
<td>Cost and time consuming. Success is reliant on strategy of learning. A production orientated form of training limits the development of technological capacity.</td>
</tr>
<tr>
<td>Hiring of foreign Management</td>
<td>Helps to complement the local technological capacity by adding the missing components of experience and knowledge</td>
<td>Costly. If this approach is mainly orientated to execution of production tasks, the impact on learning is not positive</td>
</tr>
<tr>
<td>Searching</td>
<td>Increases the knowledge-base</td>
<td>Time and cost consuming. Requires a high level of skill.</td>
</tr>
</tbody>
</table>

Source: Saad (2000)

**Interactions between the mechanisms of learning and the various arrangements for technology transfer.**

Emphasis in Algeria has been essentially placed on developing capacities for operation of activities. The most important elements of management capability such as planning, organising, managing, gathering and interpreting data to cope with changes have often been neglected. The lack of focus on learning mechanisms is evidenced in the low allocation of resources to training and technical assistance. Although training has not been totally disregarded, it has mainly been of a narrow focus, aimed only at developing the level of skill necessary to operate the imported technology.
Foreign assistance has also been essentially devoted to operation activities. Dahmani’s (1985) findings show that as much as 93% of the foreign experts in Algeria were allocated to operation activities, and just 7% to co-ordination, monitoring and organisation of production.

In addition to the above two points, the responsibility given to the technology supplier regarding the whole project implementation (design, construction, commissioning of facilities, provision of some skills, organisation structure and training inputs) has failed to give local managers and construction organisations hands-on experience of project design and implementation.

These integrated forms of contract have failed to take into account other elements such as complexity and compatibility. Local staff have not been involved and have therefore not undergone the development which participation in the project would have permitted and which might have allowed them to adapt and modify the imported technology according to the local requirements. As a result, managers and workers in local firms are not well equipped to analyse and interpret feedback. The detailed information and understanding of how and why things work has simply been ignored and has not been viewed as an important element of the process of technology transfer. This lack of involvement of local managers in the initial phases of the project implementation, constitutes an obstacle to learning and to the acquisition of knowledge and understanding. Indeed Hoffman and Girvan (1990) argue that if local firms are “denied these opportunities over a sufficiently long term period, such skills as do exist are going to be seriously under-utilised and will become marginalized from the production system”.

The dependence on outside assistance for management and operational skills is still significant. Major new build construction projects are still being allocated to foreign firms. Repair/maintenance assistance is still being requisitioned from overseas: only foreign experts are capable of dealing with breakdowns, spare parts are only obtainable from overseas, local repair facilities are non existent.

OVERVIEW AND CONCLUSION

Learning within Algerian construction firms follows, to a large extent, the same pattern. Early on, learning was essentially restricted to developing the production and construction capability through the execution of repetitive construction tasks. This happened though the adoption of highly integrated packages of transfer of technology such as “turnkey” and “product in hand” contracts where the role of the foreign contractor was substantial and the involvement of local managers was largely ignored. Consequently, the detailed information and understanding of how and why things work was not acquired.

This learning was subsequently re-enforced by the use of “decomposed” contracts. These contracts led to the strengthening of the production capability through the acquisition of knowledge and information relating to the technology and the processes used. This new approach to technology transfer has also led to the development of investment capability as a result of a greater participation of local managers in the technology implementation.

Finally, by the mid-eighties, managers began developing an “independent attitude” and a third step of learning, concerned with management ability, commenced. This attitude is motivated by the need to use the imported technology efficiently to enhance the overall performance of organisations to allow them to be more competitive. However, this “independent attitude” is still impeded by the strong interactions between the Algerian political and economic spheres, the background of a strict state and bureaucratic control and the relatively low level of skills and qualifications.

The Algerian experience, then, of technology transfer is of suffering from the strategy set by the Central Plan. A strategy which focuses on the hardware, gives little attention to the software aspects of disseminating improved technologies, and neglects the learning and managerial capabilities in construction. Greater emphasis needs to be placed on effective and on-going learning. Organisational changes are also
needed to gain the full potential of the new technology; developed countries are showing that successful uses of new technology, such as 'advanced manufacturing technology', are convincingly related to organisational adaptations.

REFERENCES

15. Destanne de Bernis, G (1966) Industries Industrialisantes et Contenu d'une Politique d'Integration Regionale in Economie Appliquee No 3-4.