IDEAS

The Challenges in Teaching About Intelligent Building Technology

Joachim Dittrich & Ludger Deitmer

This article is based on a paper entitled "Bridging the Gap—Experiences and a Concept in Technology Education, Networks, and Regional Innovation in the Field of Intelligent Building Technology" presented at the International Conference of Scholars on Technology Education at the Technical University of Braunschweig, Germany, September 24-27, 2000.

Automation Technologies in Buildings—Benefits and Opportunities

The term automation technologies in buildings, or building automation (BA), refers to a continuum of applications involving buildings, information, and automation technologies implemented in buildings. This article starts with commercially used buildings, where the technologies are implemented for the following purposes: to reduce operating costs in terms of resource consumption; to centralize control of lighting, heating, ventilation, air conditioning, and the like; to conform with supplier contracts in terms of peak energy consumption; to ensure reliable operation of the systems; and to meet security needs with respect to operating hazards, break-in, fire, or flooding. It also discusses private homes, where comfort, security issues, probable energy savings, and the integration of alternative energies are matters of concern.

As indicated, modern information and automation technologies can contribute to the reduction of personnel costs to run a building, enhance the operational security of buildings, increase comfort, and ensure that limits on conditions such as temperature, air quality, and peak energy consumption are met. To a certain extent, modern information and automation technologies can also contribute to reducing the consumption of natural resources such as fresh water and energy by switching off lights when no one is in the room, by reducing energy input through solar radiation, and by coordinating heating, ventilation, and air conditioning systems. (In the building we work in, for example, we identified energy savings of around 30% for lighting thanks to automation using brightness sensors and motion detectors.)

Recent developments in the construction sector, namely the statutory restrictions (at least in Germany) of energy consumption for heating, have led to the emergence of so-called low energy buildings. Very little heat is lost through the enclosure, which is beneficial in winter. In summer, however, solar radiation penetrates the building through the windows, heating it up and making it necessary to provide for cooling since there is no heat transfer through the walls at night. Ventilation systems have to be installed because the impervious enclosure does not permit natural air exchange. Renewable energy sources are used to provide the small amount of energy needed for such things as hot water. However, solar energy is also used for heating and cooling (e.g., by means of adsorption machines). All these processes have to be coordinated. Photovoltaic systems produce electrical energy in a decentralized manner on the roofs of buildings, thus helping to avoid the use of nuclear or fossil fuel to operate power stations. They have to be coupled to the power net in terms of frequency and phase, and there must be a data capture system installed. Automation technology is frequently required to perform these functions in addition to the above-mentioned heat management. In these cases, some tasks cannot be performed by people because they would put too heavy a burden on the user; other tasks are carried out through automation for greater overall convenience.

These are the benefits, along with the necessities, of introducing automation technologies in buildings. Now we come to the opportunities. Instead of a lengthy discussion of added value concerning rental or sale, we wish to focus on regional markets, regional development, and employment. In these areas, BA technologies have the potential to supersede traditional electrical installations. The latter are normally supplied by regional small- and medium-sized enterprises (SMEs), at least in small- and medium-scale projects. But BA still is the domain of industrial suppliers, since work tends to be expensive and is therefore often subject to rationalization efforts. As we know from the construction sector as well as from process industries, calls for tender are published nationwide or even throughout Europe, thus removing economic potential from regional markets. If BA competencies existed at the regional level and if there were BA networks providing all the necessary services from planning and installation to operation and maintenance, a large share of the economic activities could be retained in the region. This could stabilize employment in the electrical trades, which nowadays suffer from declining orders as well as from falling prices in the construction sector (Deitmer, 1992).

Additional opportunities include: The competencies needed and acquired in the BA sector, which are of a systemic nature, may help to increase innovation potential in the building trades by demanding systematic and abstract learning processes and also by crossing the boundaries between trades. The competencies acquired and the structures generated in BA can support Agenda 21 processes (United Nations, 1999) because they require the same type of competencies and interactions between the actors to achieve extensive results. In public buildings and residential housing, energy conservation and reduction of CO_2 necessitate both a systemic view along with concerted action in building and housing projects that roughly account for 30% of the energy consumption1 in Germany.

Obstacles to Technology Implementation

Several facts and attitudes have hindered development in BA applications. Some of them are described here to provide a clearer view of the concept presented in the following sections of this article.

Even managers of major providers of BA systems admit that the development of BA components and systems has not been sufficiently targeted to customer needs (Schneider, 2000). The same often applies to the planning and implementation processes that are insufficiently adapted to end-user requirements (Dittrich & Ritzenhoff, 2000). Further reasons for the stagnation of the market are seen in high prices, few benefits for the customer, an almost exclusively vendor-driven market, few service providers, and, hence, little competition in developing services. Schneider (2000) stated that now the time has come for a rapid development of BA markets: Users are well acquainted with information technologies; producers, vendors, and service providers have discovered the customer; the technologies can now provide surplus value by integrating various technical services; and the opening of the energy market brings in additional players (the energy industry), resulting in augmented competition in the BA service market and thus higher quality and lower prices.

But there is another reason that keeps small enterprises, such as craft trade businesses, away from the BA market. As we learned from several discussions with SMEs, there is a certain disinclination on the part of SMEs towards cooperation with large industrial firms, which still dominate the market of BA applications and installations. Indepe-ndence being one of the key values in the craft trade, small firms are afraid of becoming dependent on the large global players. As a consequence, there is little cooperation between large companies and the craft trades. Small firms are rarely engaged in carrying out large-scale BA projects,[2] a significant number of which are carried out for large commercial facilities, so the small enterprises are unable to gain experience and know-how in this sector. Therefore, it is difficult for them to become familiar with the technologies in order to offer them in smaller scale projects, such as for private homes or small commercial buildings. However, small firms could be competitive because of their proximity to the end user along with the lack of interest of large companies in small orders.

The same pattern applies to architects and technical planners involved in standard, smaller sized buildings. Because of lack of experience with the new technologies, they tend to advise their customers to order the proven, traditional technologies in the knowledge that they are less expensive and because they cannot assess the potential added value provided by modern automation technologies. Insufficient experiences might also cause uncertainty concerning guarantee issues as well as potential future customer satisfaction. In addition, it is still difficult, even for experts in the field, to give advice on a specific system that must also meet future requirements, be it European Installation Bus (EIB), Building Automation Control Network (BACnet), Local Operating Network (LON), European Home System Bus (EHS), or one of the DDC solutions.[3] The "convergence" initiative, which brings EIB, BACnet, and EHS together (Penczynski, 2000), the Process Field Bus (PROFIBUS) standard, which has been adopted by the majority of DDC manufacturers, as well as the new ISO 16484-5 standard (International Organization for Standardization, 2003), will most likely defuse part of this problem. Furthermore, there is little knowledge on the issue of amortization of investment in the new technologies. The key issue, however, is that in the past, planners in the sector comprising small buildings seldom advised their customers to buy and use modern BA technologies;[4] as far as we know, the same conditions exist today.

Another obstacle is the manner in which innovation and learning take place in the craft trades, especially in the construction sector. Here learning is incremental, linear, reactive, and by no means theory driven, as pointed out by Gann (1996) or specifically for the German situation by Brüggemann and Riehle (1996). This topic is discussed in detail in the following section.

Networking and Reflexive Innovation in and for Technology Education in Building Technology

Installation engineering is carried out after the innovation process itself takes place elsewhere: Innovations are implemented by the system developers of the building technology vendors (new supply technologies and new building management system [BMS] and building control system [BCS] products). Innovation is therefore disseminated following a linear model. Small enterprises in the electrical and the heating and plumbing trades have a more or less reactive role in the production chain. They receive much less formal technology training and education than the supplying system industry. They are organized in small workshops with little planning capacity and strong informal learning attitudes. Many new scientific and engineering methods have not yet diffused across the entire sector. Know-how continues to be transmitted through methods of apprenticeship, on-the-job peer group learning, or the study of examples found in existing buildings. Besides formal initial vocational training, the learning opportunities are very limited because of learning through practice. This "learning by doing" can be described as a process of repetition and continuous improvement on the job at the building site. Knowing that construction is a project-based activity, which produces the previously mentioned products—which are individual and hardly standardized, firms build their competencies on the provision of specialized and often quite narrow skills[5] and on resources that rely on expertise accumulated over many years.

Learning at the workplace and in the organization is therefore usually informal with many breaks and little feedback in the highly complex construction business process. Tasks often vary from project to project, and the site environment does not correspond to that in factories; examples include the seasonal nature of the work and building regulations that vary by region. The use of information technology in buildings (intelligent buildings) makes it clear that this systemic technological concept conflicts with professionalization, codes of practice, and the traditional craft trade demarcation lines upheld by trade unions and employees. On the one hand, we have an all-encompassing systemic technology that integrates all craft trades and on the other we have a "locked system" (Nam & Tantum, 1988), which has severe difficulties in coping with radical technical changes in construction. Traditional approaches to the transfer of know-how assume linear continuity of learning with minor changes and adaptations. However, continuity and linear models of technology education in vocational education and training (VET) institutions and in companies are called into question when radical changes occur, as was experienced with the need to install digital microelectronic technologies in buildings during the 1980s (Deitmer, Ritzenhoff, & Sproten, 1998). New competencies are required to exploit such technological opportunities. But construction firms in the craft trades are unable to respond by means of traditional, informal processes of innovation. The companies in the electronics and telecommunications sector have to move into the construction arena to fill the gap and, as argued here, in close cooperation and collaboration with the traditional construction firms. A networked approach is needed to strengthen both informal and formal processes of change and learning. Changes occur very frequently at interfaces between the specific craft trades. Therefore, a narrowing to a particular sector (such as solely for electricians) might be a mistake. Greater fluidity in the transfer of know-how between one business process activity and another is required.

Organizational changes have to be looked at and learned because many of the important innovations developed in the construction sector have taken place in organization rather than in technology (fast-track construction process management techniques, overlapping design and construction phases, and learning for each actor involved in the building construction process). Despite competition, the role and function of cooperation is found in the modern construction industry, especially in building up a learning culture facing new challenges of the market. This necessitates a re-consideration of companies as learning institutions (Lundvall & Borras, 1998). Craft trade institutions have to view themselves as learning organizations characterized by a capability of systemic reflexive learning: This refers to the ability of the company employees to reflect on core values of the organization and operate on the basis of cybernetic thinking and an organizational paradigm changing hierarchy to heterogeneity, which can provide multiple skills and experiences to cope with a problem. Such innovative learning behavior has to be enhanced by an innovative production cluster (Porter, 1990). These clusters encompass building users/investors, architects, technology planners and engineers, and system developers and providers, from software houses to technology component firms, construction companies, craft trade companies and their associated organizations such as chambers and craft trade guilds, regional R&D institutes, higher educational institutions such as polytechnics and universities that educate building engineers, and—last but not least—the vocational education institutions, both in initial and further training. For this reason an analysis of the production chain[6] is important to understand how technology education and training have to be based and initiated.

The structures described above are based on more hierarchical relationships. The point here is to develop heterogeneous structures in which regional networks act as loosely coupled information and dialogue-based networks. The relationships are based on trust, reciprocity, openness to learning, reliability, and a behavior that is inclusive and empowering rather than exclusive and disempowering. Obviously, these networks have to be moderated and somehow initiated by moderators and promoters. In our example, we argue in favor of the VET institutions, formerly known as competence and demonstration centers, as agents for this.

Regional networks are needed to define the training requirements, based on information from their members. Here we advocate a responsive and more interactive innovation model in which the specific conditions of these small enterprises are taken into account. In this respect qualified training and research institutions face the challenge of assuming their role as regional innovation and know-how centers and act as moderators between large building technology vendors (e.g., Landis & Staefa, Johnson Controls, Honeywell) and the many small enterprises in the installation engineering business. Sectoral innovation centers as part of these networks can furnish colleges with analytical background information on new developments and their energy effects on buildings. For more interactive innovation processes, which are very necessary for the successful implementation of BMS, the regional competence centers must create learning networks and innovative structures with their local companies.

In summary, we pointed out that companies still have great difficulties with these technologies because they are used to increment change and have problems coping with radical changes as those introduced with these new building technologies. They lack a comprehensive technical learning concept that helps them to adapt their view of their business. Raising awareness through information and demonstration of possibilities, as well as advice-oriented training models, is missing. Vendors offer scattered courses on specific technical problems or even courses on areas such as marketing, but integrative concepts that lead the firms directly out of their traditional learning situation do not exist. A modular training course concept that encompasses all the stages for full establishment of this technology in business is needed. Companies concentrate on the installation of new systems with little attention paid to the provision of services such as maintenance or to integration between design, system installation, and operation. Viewed from the standpoint of an existing craft trade company, the following requirements should be met:

- Determine potential/advantages/cost benefits of building management services and facilities.
- Provide technical know-how on the new systems from a comprehensive vendor-independent view and thus the ability to combine and develop new skills among the employees in an installation enterprise.
- Establish competency guidelines for these companies in establishing a new service organization.

A Programmatic Concept for Technology Education and Implementation

Small enterprises, in particular local craft trades, have great difficulties in developing innovation despite the advantages of flat hierarchies and barely formalized communication structures. They suffer from little know-how regarding new building technologies, restrictions in terms of time and finances, and lack of business and market information, which impedes the diversification of products and processes as well as the necessary adaptation of organizational structures. To overcome the above-described deficits within the construction sector, it is necessary to provide specifically designed programs for technical education and develop cooperative approaches. In northern Germany some of the ideas are conceptualized in several competence and demonstration centers.[7] They are aimed at bridging the gap between technology developers/vendors and users from the construction trades. The central focus of these regional initiatives are network-like partnerships between craft trade enterprises and research and vocational institutions (Deitmer et al., 1995; Ritzenhoff & Deitmer, 1999). These regional initiatives use the support provided by regional, national, and European development and demonstration projects. All these projects[8] deal with specific problems concerning effective utilization of new technologies within buildings. The goals pursued by such projects can be summarized as follows:

- To build up new training infrastructures within selected regions in Europe in order to address know-how deficits and to remove innovation barriers erected by technical and social challenges. Product and process innovations in SMEs rely heavily on organizational and technical conditions and on the competence of managers and employees.
- To provide an environmentally sound technology. Minimizing use of energy and water resources in buildings, for example, should help to protect the environment through reduction of CO_2 emissions.
- To provide perspectives for new employment. The introduction of BCS/BMS systems offers a significant new area of work for the craft trades and for SMEs throughout the European Union. These companies are of particular importance for generating new employment opportunities in regional economies. Monitoring of buildings offers new perspectives in addition to classical installation work. BCS/BMS systems can provide data that may be analyzed to allow energy management, and these systems are the basis for technical facility management.
- Additional aims include improvements in several aspects of building security, thus enhancing user comfort.

Overall the activities are targeted at enhancing the skill base of SMEs in the installation and engineering sector in three dimensions.

1. The business dimension addresses the following competencies:
   - To design, install, and apply technology for customer benefits.
   - To handle quality standards for installation and design work.
   - To manage the technology based on contractual cooperation with planners, building construction, and other trades.
   - To create efficient management services for public and private buildings.
   - To assess the potential of buildings concerning the optimal utilization of technology and actively offer advisory services to potential customers.
2. The technical dimension addresses the functional and practical aspects for competent technology design, implementation, and service. Key subjects include the following:
   - Sensors and actuators, function, handling, and integration.
   - Signal transmission, bus systems, and related tools.
   - Management, control, and analysis software.
   - BA system setup and control software.
   - Technical equipment of buildings, function, handling, and integration.
   - Systemic behavior of buildings, including overall and subsystem dynamics.
3. The work-oriented dimension focuses on work processes going on in craft trade enterprises. The central aim is to

enable company personnel to interact with each other, with the customer, and with other trades and also to undertake various work activities to guarantee maximum appropriateness during technology implementation. Learning in the work process is an important issue and should be supported.

The methodological approach to training should be based on the following principles:

- The actual system is always the subject of the learning and innovation process.
- Learning situations are placed at different locations: regional demonstration houses as examples of good practice, regional competence and demonstration centers, and the company itself.
- The learner is instructed in taking planned autonomous action (selecting, applying, and reflecting on information).
- Projects are used to structure learning and teaching processes.
- Cooperative teamwork is supported through supervision and advice.

The tasks of the regional competence and demonstration centers include:

1. The networking of relevant local bodies and SMEs to provide research and development facilities and to encourage cooperative approaches to market development.
2. The provision of business information, cost benefit analyses, case studies on improved environmental benefits, and technical demonstrations.
3. The initiation of further development of technology and systems in direct contact with developers, planners, installers, and end users.
4. The development of new training programs for skilled workers in close cooperation with the regional actors from the BA field.
5. The development of learning material and concepts for different learning locations (center, work, home, Internet).
6. The provision of consulting services for individual small- and medium-sized enterprises and for consortia of companies in order to install adapted work systems that can perform these new tasks.
7. The provision of detailed marketing information material.
8. Promotion and awareness raising of SMEs, local authorities, and customers through planning and execution of promotional activities (e.g., exhibitions, seminars, regional trade fairs, and conferences in the partner regions).
9. Development of transnational networks (including SMEs) in order to stimulate technology transfer, know-how exchange visits, and cross-fertilization of ideas, including the publication, distribution, and dissemination of project results among European countries and regional enterprise networks.

The aim of the centers is to enable the regional craft trades to develop a new service infrastructure in the building management technology field. The project will encompass the whole range of activities related to the innovation process including human resource development, training, marketing, and the development of innovation centers.

Joachim Dittrich is a senior researcher at the Institute Technology and Education (ITB) at the University of Bremen, Germany.

Ludger Deitmer is a senior researcher at the Institute Technology and Education (ITB) at the University of Bremen, Germany.

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Footnotes

1. In 1997 German energy consumption of households amounted to 30%; trade, commerce, and service consumed another 15.8% (BMWi, 1999), but not all of it was used for heating, lighting, and ventilation.
2. Small electrical companies usually perform the cabling and installation of traditional electric devices as subcontractors, but they are rarely involved in planning and programming a BA system.
3. DDC: Direct Digital Control. These are powerful, freely programmable automation units that are available from various manufacturers. A drawback is that they are largely based on proprietary standards and therefore interoperability with systems of other manufacturers may not be ensured.
4. The situation is likely to change. Building contractors are beginning to offer pre-planned residential buildings equipped with BA systems and other modern technology, such as solar energy systems.
5. Skills are specified in occupational profiles that are centrally defined within the dual German VET system and negotiated between the union and employer organizations. Problems in this connection are discussed in Heidegger and Rauner (1997), that is, the borderlines of these profiles that conflict with market flexibilization and dynamism.
6. Analysis of the production chain includes the relationship between producers and suppliers and between producers and users, the role played by the government in setting standards and regulations and sponsoring R&D, and the way in which know-how is acquired through different learning processes.
7. Under the auspices of the Institute Technology and Education, University of Bremen, Germany, several centers have been developed. The Center for Building Automation (ZGA), Bremen, based in a VET school, is aimed at supplying the Bremen region with training and advice for regional SMEs to assist them during the introduction of BMS/BCS technologies. They concentrate on initial training in this field. The intention is to provide vendor independent training in a laboratory that provides facilities from different systems providers. The Center for Energy Management in Neumünster shows local enterprises and other institutions how to make use of environmentally sound technologies. Similar processes have taken place in Rostock in the technical training bodies of the Chamber of Craft Trades. All in all a network of different actors from industry (important vendors of this technology), model demonstration houses, craft trades with building management technology experience, and university technical education institutes form a network of different institutions interested in opening up the market through a training, education, and innovation dialogue.
8. One example of such a national research project is EcoSol: construction and evaluation of a new solar-optimized office and administration building in Bremen. The demonstration building is evaluated and optimized in terms of energy consumption (Ritzenhoff, Bräuer, Limberg, & Niemeyer, 1998). Transfer activities are conducted in connection with the local building trade as well as building investors, architects, and house users/customers. The project is carried out under the BMBF (Federal Ministry for Education and Research) program in solar architecture (see, for example, http://www.solarbau.de).

External Challenges to Classroom Technology First-order barriers to the successful integration of technology into the classroom are factors external to teachers implementing technology. External barriers must be addressed at the.Â Intelligent tutoring systems such as those detailed in this book can individualize instruction to student progress within the system, but consistent 1:1 computer access is highly desirable given this pedagogical approach. With limited federal, state, and local funding, schools may often need to pursue unconventional funding options for obtaining classroom technologies.Â countless new technologies will be developed during their teaching careers, and they will need to undergo additional training to keep their skills current. 1 INTRODUCTION Building intelligent open-domain dialog systems that can converse with humans coherently and engagingly has been a long-standing goal of artificial intelligence (AI). Early dialog systems such as Eliza [151], Parry [18], and Alice [142], despite being instrumental to significantly advancing machine intelligence, worked well only in constrained environments.Â In this paper we focus our discussion on three challenges in developing neural-based open-domain dialog systems, namely semantics, consistency and interactiveness. The rest of the paper is structured as follows. In the rest of Section 1, we compare open-domain dialog bots with traditional task-oriented bots and elaborate the three challenges. Whilst there is some maturity and great case studies from other Microsoft partners in intelligent buildings (optimising them once they are built), the challenge of digtialising construction remains. We saw some impressive demos of drone-based surveys combined with augmented reality to visualise the as-is and to-be of a construction site.Â I foresee two types of Kainos engagements: first, working with IOT innovators who understand the problem space and capabilities of sensor technology in construction but need a cloud engineering partner to deliver solutions that scale and meet data processing and insight needs.