Finn Orstavik

Constructing buildings — bridging worlds

1. Introduction

The building and construction industry performs tasks that are essential in society. The sector makes up a very significant part of any national economy. In spite of this, or indeed because of this, people – not excluding academics – often need to be reminded of this particular industry's size and significance. Building and construction is huge in terms of employment, value creation and resource consumption. But beyond this, activities in the sector have spreading consequences in terms of influencing significantly health, productivity, culture and individual identity. Presently, as efforts to develop a more sustainable economy are considered to be of critical importance in most countries, this industry needs to be placed center stage at the attention of policy makers. Improving products and processes in building and construction is of critical importance, since the sector plays a decisive role in determining society's "environmental footprint".

It can be argued that the actual state of building and construction today represents a mismatch with the industry's huge significance for development efforts of this kind, that is, for innovation taking place on the societal level. For example, statistics show that the industry is "low-tech"[i] and lacking in innovativeness. Initiatives such as the British *Construction Task Force* established by the Ministry of Trade and Industry and the Task Force's «Rethinking construction» effort, «Det Digitale Byggeri»[ii] in Denmark, and «Byggekostnadsprogrammet»[iii] in Norway, all indicate that quality problems and the difficulty in creating significant and cumulative improvements over time are significant facts pertaining to this industry. (See, for instance, Lepatner 2007). In Norway, reports on spectacular building failures and huge project cost overruns are a recurring feature of national media. Research

Corresponding author:
Finn Orstavik
NIFU STEP
Wergelandsveien 7, 0167 Oslo, Norway
Phone: +47 22595127
Mobile: +47 995 24 773
Email: finn@nifustep.no

has shown that quality problems continue to create significant additional costs for many of the parties involved in the value chains of building (Ingvaldsen 1994; Ingvaldsen, Lakka et al. 2004).

One particular lacuna in the knowledge about building concerns *project management*, or in more abstract terms, effective mechanisms of dynamic process control. Koskela and colleagues have argued that there is a general lack of sound theory as for project management in building (Koskela and Howell 2008). More specifically, they have argued that the underlying ideas in engineering about project management in building are inadequate. Their main point is that the established methods of planning, monitoring and control are inadequate for managing building projects. They claim that the obvious difficulty in improving productivity and quality of building is related to this lack of sound management theory. In a recent empirical study of productivity in building, several factors were found to correlate positively with efficient building (Ingvaldsen and Edvardsen 2007). Most important was found to be competent project management. The researchers, however, could not in a convincing way show what competent project management actually entails.[iv]

A recent survey of literature in the field leads us to conclude that the scientific understanding of the inefficiency and ineffectiveness of building still is incomplete.[v] There is a broad literature on a wide variety of issues related to the management of building and construction, such as project planning, cross-disciplinary collaboration, communication, and partnering and alliances between different firms. We have, however, found particularly interesting the early study by Foster, in which the issues related to coordinating efforts of craftsmen, architects and engineers in building are analyzed from a participant observer's point of view (Foster 1969). What we have not found, however, is qualitative and case oriented study of a more recent origin pursuing a similar line of argument, focusing on the work process and on how *relevant knowledge* is actually being applied in the process of building, across professions and crafts. In our view, not enough has been done to explain what people in building actually are doing in the operations of building, and in terms of the specific application of knowledge that is involved in operations. Effective building must rely on effective bridging of the diverse worlds that the arts, crafts and sciences of building, and their respective knowledge bases, represent. We think this an important issue also from a practical and political point of view, as quality and safety issues in building can be seen as simply consequences of *inadequate exploitation of existing knowledge, and insufficient development of new, relevant knowledge.*

In case study research that we have been undertaking in building and construction projects in Norway since late 2007, the basic idea has been to map the actual processes in which relevant knowledge is mobilized and actual knowledge use is determined. Among our many initial observations is an intriguing discrepancy between actual practices in building and the "applied theories" of management that are considered valid, by the participants themselves. What managers in building do and what they say about management tend in some significant cases to be quite different things. Arguing the case for the need for planning, process monitoring and control, personnel in building projects tend to rely on established hierarchical and linear models of management. But in most of their practice, they do not act accordingly. We observe a chasm between ideals and realities of process control and project management, and as researchers and sociologists we are naturally intrigued by this. Why is it that this discrepancy arises? What are the underlying dilemmas that this reflects?

As researchers of innovation, our imagination has been further triggered by the realization that a similar discrepancy is present in processes of innovation. Also here, the ideas about planning, process control and management by objectives that often are promoted by management consultants, are more normative and prescriptive than actually corresponding to real life innovation efforts. Normative theory and applied management theory (See for example Peters and Waterman 1982; Cooper 2001) tend to underplay the uncertainties and unpredictability of innovation processes, and overplay the ability of managers to plan and control, and to manage projects according to plans. Looking into «innovation journeys» in the manner of Van de Ven and colleagues, it is easier to see that the linear logic of the unfolding of the process is more of an ex-post construct and a rationalization, than a true history about the course of events (Van de Ven, Angle et al. 1989; Van de Ven, Polley et al. 1999).

Can this parallel between building and innovation be more than a coincidence? Can we learn something significant about the process of building, and the challenges of project management in building, by drawing on insights and theory from studies of innovation? This question is what we will address in the present paper. We find this question all the more intriguing, as building so often is disparaged as non-innovative and lacking in its ability to apply the full range of advanced knowledge available in modern, post-industrial knowledge societies.

2. Methods of research and structure of argument

«Why is knowledge underutilized in building and construction, even in situations where all parties involved would benefit from knowledge being exploited in a better way?» This is the lead question posed in a four year research project financed by the Norwegian Research Council, and with financial contributions also from partners in the Norwegian building and construction industry. (The program's full title is: *Plain building – plain sailing? Knowledge exploitation in the building and construction industry*.) A key element in this project is case study research carried out in building projects. Longitudinal data gathering is carried out by following a number of diverse building projects over time, from the explorative phase where ideas for building are gradually transformed into a real project, and throughout the phases of project planning, building. Data is gathered on two levels:

We map the firms and organizations that are participants in the project over time, either as members of the project team, or as significant actors in the environment of the project. We analyze the role of participants, their contributions in the building effort, and the kind of knowledge base that they exploit and maintain in the course of the engagement in the project.

Data on communication and knowledge use is gathered at key arenas in the building project. We participate in work group meetings where the overall design and project planning effort is done, and observe key members of project teams in their practical work. As building commences, we take part in meetings where short term planning is undertaken, and we participate in other important events, such as site inspections and meetings where site managers and project leaders meet with other involved parties, such as project owner, representatives of municipal authorities, etc. In addition to such observations, we do systematic interviews of the people involved, in one-on-one interviews.

We make recordings of meetings and events, and transcribe these recordings so that further analysis can be done, employing qualitative data analysis software such as QSR's Nvivo 8.[vi]

In the present paper, we do not detail data and nor present a systematic analysis of them. But we exploit our data in the general, empirical description of the building process that we present in section 3. This empirical description is intended to give a basic understanding of what kind of activity building and construction is. We try to show in an effective way how those who are involved in building make up heterogeneous sets of actors that represent diverse, but complementary resources in building. The point is made that the building can be understood as an aggregate of material traces of operations, and that these operations are what actually decide what kind of knowledge is "embodied" in the building.

In the subsequent section 4, we go on to point out how administrative decision influence knowledge use, but argue that actual work operations should be seen as what in the end is decisive. With respect to application of knowledge, actual work operations represent the ultimate, de-facto decision making. Finally, in section 5, we argue that the decision making carried out by the individuals and the groups that do the practical work in building, represents a complex and dynamic phenomenon that be cannot understood properly if it is analytically reduced to rational – or boundedly rational – individual action. The de-facto decisions, the actual work operations that add up over time to a completed building, and hence the overall application of knowledge in a project, are the outcomes of negotiations between individuals and groups, they are influenced by managerial decisions which are in themselves negotiated, and they result from a weighing of various issues and interests.

3. Analyzing the building process empirically

In this section, we will describe the building process, as observed in case study research undertaken in the course of the ongoing project «Plain Building – Plain sailing?». We start out with a brief characterization of building as a specific form of production, and continue with describing the building project as «developmental constellation» (Orstavik 2008). We end the section with a preliminary discussion of issues related to planning and control.

3.1. The building process: The specificities of building as a form of production

Compared to other types of production, building is particular in several respects. The scale of operations and the physical dimensions of what is being built, as well as the fact that the product is geographically fixed and immovable, are all particular to traits of building as compared to most other kinds of goods production. Of particular importance as a distinguishing factor, however, is *time*. Compared to other human endeavors, building is a time consuming process, and buildings once completed are products of lasting value. They remain in operation for periods of time extending from decades to centuries. This is important with respect to knowledge use, both because what is considered relevant and up-to-date knowledge on issues relating to building will change over the life time of the building, and because effects of what is being done in building, and to the building, may appear long after, and affect completely different people than those who were involved in the first place. The effect of this may be that craftsmen operate on a building with other materials and other techniques than what was originally used. But the effect is also felt on a different level, namely on the level of the economy of building. What is invested and not invested at a certain point in time, might not affect the ones making the relevant investment decisions, but people and organizations that come in contact with the building at a much later stage. This may be a fact of great significance because of certain features of the markets for building and real estate objects. It is probable that a significant lack of relevant information in such markets makes transactions ineffective; omissions and defects that are built into structures will often not be taken into consideration, when market transactions take place.

The building process starts out as someone has an idea about a building, and sets out to realize this idea, or some derivative of it. The activities related to what is being built come to their final end only as the building itself is decommissioned and torn down. The one spawning the original idea may or may not be in a position to act as project owner, as *the builder* in legal terms. But in the most straightforward and simple cases of building, the one with the idea for a building may be a single person, who then goes on to realize the idea, and also takes the financial responsibility for the project. This person, then, is at the same time the builder, the project owner, and the one who will later own and use the property and accrue the benefits that derive from it. In such a simple case, the builder may himself or herself contact an architect, who can help develop plans for the building, and the two then can contact a carpenter, or a building firm, that can carry out the actual construction work. Even in this simplest of cases, all of those involved must be in a position to allocate resources and time to carrying out the project, and they must communicate between themselves in order to establish the effort as a joint project, with an common objective. Although each and one of them will put different things into the project, base their activities on diverse knowledge and competence, and have diverse personal agendas for what they want to achieve by carrying it out, they still have to work to realize the same ultimate goal; the building that is being built. And even in this simplest of cases, the heterogeneity of the involved actors may create problems, for instance as ways of thinking and talking might create obstacles to effective collaboration. Fundamentally, however, the heterogeneity is a precondition and a fundamental resource for the collaboration to be productive, and the building project to be viable.

No doubt, few building projects today are of this simple kind. Firms rather than individuals come up with ideas for building, and these firms might not be the same as that firm ending up taking on the formal role as responsible builder. Then again, this builder will usually be a different firm than the one or those several firms who become the owner or owners of what is being built, and the owner obviously does not necessarily need to be among those actually using the building for practical purposes once the building is completed.

All this notwithstanding, the builder has to establish a working relationship to an architect firm, and to one or more architects doing the actual work of drawing up plans for the new building. This architect will play a very central role in the planning and designing process, as it is the responsibility of the architect to consider implications of the project of the many kinds that can be of interest for a broad range of government agencies, both local (municipal) and central (regional, national). Among the issues involved are the municipal level efforts to regulate the use of land, and to influence the nature of building projects in relation to where building is taking place, in relation to transport infrastructure, availability of childcare, schools, hospitals, etc. The architect, however, also has to consider agencies at a national level, focusing for instance on environment protection, cultural heritage, etc. In addition to all this, the architect obviously also has to take into consideration issues of a more purely technical nature, when designing buildings. For instance, designs have to be made in such a way that the structural properties of the building are sufficient for the building to withstand strains and loads originating from the environment and from the activities going on inside and around the building. There are also a number of requirements that are important for the functioning of the building, many of which are actually also found as legal requirements made explicit in laws and regulations. Among such issues are fire protection requirements, energy consumption requirements, and noise level requirements.

3.2. The building project as a developmental constellation

To deal with all these issues, more people and enterprises than the architect and the architect's firm have to become involved. Who actually coordinates the complex process of involving people and groups with the necessary technical competence varies with projects, and depends on the overall structuring of contractual arrangements. The system of roles, responsibilities and contractual arrangements is ultimately anchored in laws, regulations and standards. There are usually several alternative basic layouts of such schemes, and these vary somewhat both between nations and over time. Currently, a common form of contractual arrangement is based on the idea that one firm, often a Building Contractor Firm, take the overall responsibility for the whole project on behalf of the builder (In Norway, this contractual form is called a "*totalentreprise*"). In other cases, responsibility for building is distributed between several contributors in the project.

In the early phase of the building project, the design of what is to be built is developed in a collaborative set-up where the builder, the architect and municipal authorities, and often many others, negotiate the design of what is to be built, and some of the main features of the building process itself. The builder may or may not involve the future owner, future tenants, or others who have an interest in what is being built from a financial or user-value point of view. The builder *has to* involve experts in a significant number of technical fields, as the involvement of such are prescribed in the building code and required by law, and in regulations and conditions set up for building by the authorities. The obvious task of these technical experts is to make sure specific solutions chosen are viable. Practically, they also relieve the builder of specific responsibilities with respect to the solutions that are selected. The experts may be technical contractors that are later to be involved in the actual construction of the building (for example making installations of electrical systems, ICT infrastructure, fire protection systems, water piping and sanitary installations, etc.), or they may be involved solely in the planning and design work, on the basis of their expert knowledge in their respective fields.

3.3. Building design, process planning and control

Actual building operations start out with preparatory work being done to establish proper conditions for building, removing mass to make place for sub-terrain parts of buildings, to connect the building to systems for warm and cold water, electricity, gas, sewage, etc. Then, the actual building is commenced. In this, the construction work – the operations related to joining of materials, elements, and subsystems – constitutes a major part of the overall effort. But this physical and mechanical effort is anchored in a complex set of logistical operations, involving the supplying of materials, components and equipment, removing surplus materials, securing that preconditions for effective work are met, and that workers' health and safety requirements are fulfilled, etc. Obviously, communication and information processing are major issues in this logistical effort. The processes of planning, designing, building, and handling logistics are closely related, and are carried out in a collaborative effort in which management and coordination is a critical issue. We are particularly interested in this collaborative effort and its relationship to the use of knowledge in building, and will return to it in the analysis below. As pointed out earlier, the whole process is initiated the moment efforts to realize an idea about building are set in motion. The process starts out with discussion and paperwork, but may also involve physical work on a potential building site. Gradually, it transforms into a practical effort in which manual work with and transport of materials becomes overriding concerns. Planning and design is an ongoing activity, as practical solutions have to be found to emerging issues throughout the course of a project. Many problems are solved by craftsmen in their daily work operations, but some issues unavoidably involves others and the interests of others, in such a way that work on solutions have to be carried into the "drawing room"; that is, in meetings where the different parties affected by the potential solutions to a specific problem can be confronted with the alternatives. In this way, an agreement can be made on what is to be done and how those affected will solve any new problems arising as a consequence of what is being done.

The building design process and *cumulative work operations* lead to a building with a particular structure. This structure can be realized economically only taking proper care of logistics and the many dependencies between operations. Only if operations that depend on each other are done in their proper sequence and with appropriate timing, is economical building possible. And only if planning is done in such a way that real dependencies are actually considered, is it possible to establish what this proper sequence actually is. The traditional engineering approach to the process of building consists in decomposing the structure into basic elements, assigning work operations and workers to the realization of the many elements, and structuring the sequence of the operations in such a way that dependencies are taken care of. (To use a trivial example, the planning is done in such a way that walls are set up before painters start doing their job.)

It is important to note that while trivial examples of dependencies abound, not all dependencies are trivial. Furthermore, buildings are *complex* in Luhmann's sense; everything is depending on something else, even though everything does not depend on everything else. The complexity of dependencies is also dynamic, in the dual sense that dependencies between operations change over time, and operations themselves influence on the nature of dependencies between operations.[vii] What this means, is that there are non-linear systems properties in building.

4. Knowledge processes and decisions in building

We have considered the process of building, and have detailed the developmental constellation of actors that together form the vehicle for carrying out the endeavor. We have pointed out how the roles, responsibilities and knowledge bases of the actors involved make up a heterogeneous set of resources, complementary with respect to the building effort, and we have briefly touched upon the challenges related to coordination of efforts; to the actual "bridging of worlds" that building and construction efforts entail.

The complexity and the non-linear dynamics of building create conditions under which it is extremely costly to do detailed planning in an all-inclusive way. There is a trade-off between investing resources in up-front planning and in using resources in the course of the project to fill in where up-front planning has been omitted. Realistic, detailed planning up-front is demanding, because information on critical issues is scarce. In some cases, relevant information cannot be obtained. The project involves a large number of independent actors, some commercial, other political and governmental, and it is not possible to predict what the outcomes will be in all important decisions. At times, only rough estimates can be made of what future situations will be like. Hence, it would not only be very costly to get rid of the uncertainty inherent in the process. In reality, uncertainty is unavoidable, the possibility to make it go away no more than a theoretical option.[viii]

4.1 Knowledge application and efficient building

Herbert Simon used the term "bounded rationality", claiming that striving for something more than "good enough" is meaningless in administrative behavior (Simon 1976). This general idea no doubt can be applied to building. Project management is essential for economic and effective building, even if coordination of efforts is destined to remain incomplete and the rationality of the overall process bounded.) Knowledge about the issues involved, and competence in managing the process and the people involved is essential.

Efficiency in building, or that building is economical in a general sense, means that little waste is created and that relatively little energy is consumed throughout the project. The period of time from when the idea about a building is formulated, to the point when the building effort as such is completed, and even further, to the point in time when the building is decommissioned and torn down, is the relevant period in which we should judge what knowledge is used and what resources are consumed, and what benefits the building has rendered. This is the life cycle of the building, and for a building project to be economical in the broad sense, this is the time period over which adequate economic calculations have to be made. Relevant knowledge has to be employed at all stages, in all the operations that are done during the construction effort. Operations have to be done in such a way that the desired result is obtained as economically as possible, not for the single operation in itself and in isolation, but for the aggregate sum of operations that cumulatively add up to the completed building.

Returning now to the question of application of knowledge, we may first remark that managing the building process in such a way that it becomes economically adequate in the sense just discussed, presupposes what we here would characterize as adequate exploitation of knowledge. As stated earlier, the efforts of project leaders to handle the complexities of building, to influence what operations are done, how they are done and when, go on throughout the project. But this is only the very beginning of an analysis of knowledge application in building.

In a classical Italian account of the art of building (Alberti 1988 [1486]) the architect-author sought to assemble all the most relevant knowledge on building, based on codified knowledge found in texts and books published up to his own time, and based on his own extensive knowledge both of the history and of contemporary practices of building and construction. In his "ten books on building" he deals extensively with handling and use of building materials, such as wood, stone, glass and metals. He furthermore discusses issues that should be considered when locating buildings, such as climate, the exposure to sunlight and shade, and implications of this for those living in the planned buildings. Also, issues related to the nature of the ground upon which buildings are erected are considered important, and knowledge about implications of this for the way buildings should be constructed and how robust and durable they can become, ought to be a major concern of those undertaking building. Beyond this, Alberti, being an architect, is naturally concerned also with both static and esthetical aspects of how the basic structures and the outer shell of buildings are designed and made, as well as esthetical and functional aspects of internal organization of space. All this, he argues, must be handled while also taking economical issues properly into consideration. All in all, building as a whole is a very complex task, and a task in which high demands are put on the architect in terms of knowledge:

Him I consider the architect, who by sure and wonderful reason and method knows both how to devise through his own mind and energy, and to realize by construction (…). To do this he must have an understanding and knowledge of all the highest and most noble disciplines (Alberti 1988, p. 3).

It is striking that the considerations by Alberti of the core issues of building and building's reliance on both established craft knowledge as well as on creativity, artistry and innovation, rings true even today: At the heart of building is the joint effort of people to create structures serving specific functions for the practical issues of daily life, satisfying esthetical criteria, and doing this in reliable an economical way, both in the short term and the longer term.

4.2. Knowledge, decisions and work operations

Our most basic idea about knowledge application in building is that the actual use of knowledge in building is reflected in the building itself. *We consider the building the material trace of operations which all have exploited knowledge in their own particular way.* The building, then, is the trace of a cumulative aggregate of work operations. Not all operations are represented by material traces present in the building, present in the way bricks are present in a brick wall. A large share of all the operations of building is aimed at intermediary results, some of which are material and specific, such as scaffolding. Other intermediaries have a different form. Drawings made by the architect, calculations done by the structural engineer, drawings with sub-systems designs for ventilation, water and energy supply, all are examples of intermediary items that are utilized during the building process and contribute to their shaping, but which do not in themselves end up being part of the completed building.

Such items function as declarative statements, as *administrative decisions*, and it is obvious that a large number of such decisions made throughout the process of building influence operations and the building that results, without such decisions necessarily being easily traced in the material results of activities. (Think for example of administrative decisions about logistics.) Classical organization theory and theory on decision making in administration tend to focus in particular on the *communicative* aspect of activities. In fact, some organization theory tends to limit attention exclusively to this communicative level of activity, implying that all decisions of significance are taken on the level of language (See for example the discussion of organization as rational systems, in Scott 1987). This linguistic approach in organization science is carried over into sociological systems theory by Niklas Luhmann. Of course, Luhmann proposed to position analysis of human communication as the core concern in sociology in general (Luhmann 1988). We would argue that his approach is comparable to – and even inspired by – the development of information and communication theory in engineering science, where the level of information and communication is abstracted completely from – and dealt with as logically independent of – the actual material "layers" of information systems. Luhmann ventured to develop a sociological theory of social systems by focusing on human communication and information processing (in the form of operations of meaningful symbolic interaction), abstracted from and independent of human bodies and all other material realities. His paradigmatic approach to sociological theorizing was then carried over into organization theory. This is the explicit objective of his work *Organisation und Entscheidung* (Luhmann 2000).

The great relevance of Luhmann's ideas for organization theory have been pointed out several times, for example by Hernes and Bakken (2003). We are interested in Luhmann here, not least because he in his organization sociology is crucially concerned with *decisions*. Consistently with his theoretical interests, he concerns himself exclusively with *the communication of decisions*. He sees decisions as a particular kind of operation in the information and meaning processing taking place in the organization, and not as phenomenon concerning human consciousness and the free will of human beings:

Was immer eine Entscheidung ‚ist': innerhalb von Organisationssystemen kommt sie nur als Kommunikation zu Stande. Für uns ist demnach die Entscheidung ein kommunikatives Ereignis und nicht etwas, was im Kopf eines Individuums stattfindet (pp. 141-142).

We do not doubt that decision making of this kind, or in Luhmann's sense, is important in building. But we ask: How are all these "decisions" transformed into tangible realities? Managers make written or oral statements; technical experts such as architects and engineers at least produce some tangible intermediate materials. But even these have to be taken into consideration by those who actually do the physical work of producing materials and joining materials together, into what is being built. It may be tempting to reduce conceptually the role of the workers into so-called "slaves" (the unfortunate way too many academics today label junior members of their project teams). But as has been shown in-depth study of organizational work, the efforts of workers go far beyond mindless execution of operations designed and decided by others (Wenger 1999).

5. Knowledge usage and innovation as systemic outcomes

Our thesis, then, is that the total of *knowledge used* in building is the cumulative sum of knowledge employed in all the operations that are carried out during building, on end products (such as walls and floors) as well as intermediary products (such as scaffoldings and drawings). Operations are the outcome of decisions. However, such decisions are of different kinds. Decisions are neither exclusively explicit, nor are they only linguistic, or "administrative".

Perceiving a risk of being unjustly attacked for confusion over basic concepts, we propose to make a distinction between *de facto* and *communicative decisions*. In building, the work operations of craftsmen, engineers and architects cannot be reduced into mere executions, or simple "mirror images" of administrative decisions. Work operations are undertaken in complex situations. They are sequenced and given specific content with reference to a multidimensional reality and to a reflexive positioning of the worker inside the reality where the worker operates. In our view of the realities, acting by realizing specific solutions in building does not depend in principle on prior communicative decision-making, in this sense, producing *is* deciding. Although talking is most often part of what is going on, and although Vygotsky may well be correct in his argument that work operations and language use psychologically are inseparable (Vygotsky 1978), we maintain that decisions can be made and power exerted in building without the use of *explicit* language. Similarly, and the other way around: *Explicit decisions* can have little say over real events: Communicative decisions are only effectively influencing the outcomes of building efforts if the "*de facto decision makers*" heed what is being uttered, and manage to transform instructions into relevant work operations.

Making the work operations the functional core of knowledge processes, the human beings involved in this work are placed center stage in our theoretical analysis. However, we wish to avoid a reduction of this issue to a question of individual, rational – or boundedly rational – decision making.

Also avoiding the interminable sociological discussion of the relationship between social structure and individual choice, we base our reasoning here on the idea that operations (whether done by craftsmen, architects, or engineers) are carried out as part of individuals' acting in a role, under circumstances that are significant for their way of operating, and in lived situations in which diverse sets of complexities have to be handled concurrently.

In order to make more concrete what is meant by these general considerations, many observers of building would start out with economic arguments. People doing work have to consider what is profitable. They may be concerned with how much risk ought to be accepted, and how long terms gains should be balanced against short term profits. Others might emphasize non-economic arguments, for instance concerning professional issues and in terms of technical knowledge and quality norms, or in terms of social issues such as status and the proper division of tasks and sequencing of work. We wish to introduce a simple model that takes into consideration all such examples of the multidimensional complexity that the people in building need to tackle. The structure of this model is shown in figure 1.

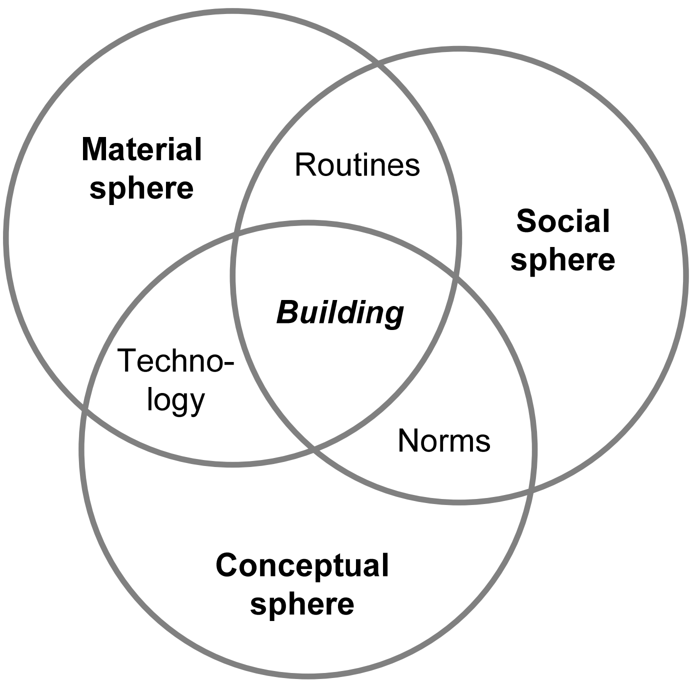

Figure 1: The multidimensional complexity of building

The knowledge being applied in building extends across all the basic domains of the model.

- The conceptual sphere involves the theoretical element in professional knowledge.
- The Social sphere involves knowledge of group specificities, relationships and status.
- The material sphere encompasses materials and technique – including knowledge and competence in handling tools.

In building, routines are developed in the cross section of the material and the social, as when the use of scarce resources is scheduled, and repeating operations standardized in content and sequencing. Similarly, we consider norms to be located in the overlap between the sphere of the social and the sphere of the conceptual, while technology is the field in which the material and the conceptual domains overlap.

All work operations are carried out in a situation where the persons and the social reality that these are embedded in, have to be taken into consideration. Applying knowledge in building extends beyond applying concepts and tools to work with materials, it also involves being able to handle the social reality of building. Hence, not only are operations reflecting dependencies between themselves in the material dimension (in the sense that what is considered adequate and economical will depend both on operations already having been carried out and operations that are to be expected later in the course of the project). Operations are done reflexively, also in the sense that they are carried out by people who are taking into consideration the preconditions and the repercussions of their operations also in the conceptual and the social realm, and in the overlaps between these.

6. Conclusion

This is but a preliminary and highly incomplete draft of a forthcoming paper. The key objective of the paper in its present form is to present a limited set of ideas for discussion, on a novel approach to analyzing work processes and projects in building. A main idea motivating our work is that building *and construction is both important from a societal and policy making point of view, and at the same time infinitely more interesting for social science than most academics today believe. Activities and institutions in building and construction provide a rich empirical field which we believe may be used as a fundament for substantial advances both in organization studies and in innovation theory.*

Notes

[i] "Low tech" is OECD jargon and means that the industry's expenditures on R&D are low compared to other industries.
[ii] "Digital Building".
[iii] "The Building Costs Program"
[iv] What was pointed out in the analysis was that projects in which participants rated the project manager as competent, did better economically than projects in which project leaders got a less favorable rating.
[v] If the Norwegian case can be used as an indicator for the state of affair in the industry internationally, superficial single-factor explanations of sub-standard performance abound, while there is a real lack of scientifically based knowledge. This is a problem and a challenge not only for researchers and academics; it is a serious challenge for firms that have resources to promote innovation, and even more a challenge for government and government agencies in the sector who must play a strategic role in structuring and financing an effective system of education, research and innovation.
[vi] For information on this product see: http://www.qsrinternational.com/products_nvivo.aspx
[vii] A simple example of the first order dynamics: The drying of a construction changes its properties and operations that make sense under dry conditions may be senseless under humid conditions (such as making parquet flooring, or painting a cement surface). An example of second order dynamics: Changing the quality of building boards used in walls may significantly change the sound insulation properties of the wall, creating need for introducing sound-proofing materials as filling in the wall, which again may influence how the internal structure of the wall has to be designed, what materials should be used, etc.
[viii] Hypothetically, one could do the project twice, first as a demonstration project to demonstrate its viability, and then the real project could be carried out. Only then could uncertainty be taken out of the equations. Industrial mass production exploits such a strategy, and attempts to industrialize building no doubt have a similar motivation.

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