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Evidence-Based Design in Learning Environments: A practical framework for project briefing

Matti Sivunen
Boost Brothers Ltd
matti.sivunen@boostbrothers.fi
+358 40 751 5710

Jere Viljanen
Boost Brothers Ltd
jere.viljanen@boostbrothers.fi

Suvi Nenonen
Aalto University
suvi.nenonen@aalto.fi

Juho-Kusti Kajander
Boost Brothers Ltd
juho-kusti.kajander@boostbrothers.fi

ABSTRACT

Purpose. The objective of this paper is to construct an evidence matrix, which can be used to analyse the correlation between learning outcomes and design strategies.

Theory. In this paper, a framework tool for a building briefing is presented as a potential solution to include Evidence-Based Design (EBD) in building design.

Design/methodology/approach. The research process was divided into three phases, namely a literature review, a workshop and a constructed model for linking EBD and a briefing process for further testing.

Findings. The main finding of this paper is that a building owner can utilize the presented evidence matrix to make key decisions in the building briefing phase regarding functional requirements and design parameters that support learning in the facilities. This article suggests that the EBD methodology can be implemented in the building briefing phase to support the benefits that the facility offers to its users. In the future, longitudinal and multidisciplinary studies are needed to assess the effects between EBD and briefing.

Originality/Value. Learning environment design at its best can have a significant positive impact on learning outcomes. Paradoxically, practical tools are rare for building owners to systematically manage the building design process to capture these productivity benefits.

KEYWORDS

Briefing, Design Strategy, Evidence-Based Design, Learning Environment, Learning Outcome

1. INTRODUCTION

Learning environment facilities have a strong impact on the learning outcomes of students. For example, Barrett et al. (2013) argue that school design has a 25% impact on students' learning rate. However, at the briefing phase of the construction management process, there is a lack of a systematic approach to link the building features and learning outcomes. Instead, the emphasis of briefing is often placed on standardized technical features and generalized user needs. Consequently, the utilization of research-based information on the documented benefits of

different design solutions, such as the Evidence-Based Design (EBD) results, is currently ad hoc based. Traditionally utilization depends on the personal interest and expertise of an individual designer.

The concept of EBD has been most widely discussed and examined in the context of healthcare facility research. EBD can be seen as a bridge for the gap which connects research evidence with operational design decisions. The Center for Health Design defines EBD as “the process of basing decisions about the built environment on credible research to achieve the best possible outcomes”.

Even though EBD is increasingly discussed and applied in practice, it has not been successfully integrated into the building briefing process (Elf et al. 2012). Briefing is the stage when owners define the requirements for their construction project (Ryd 2004). It has been recognized as one of the most important phases of a project (Tzortzopoulos et al. 2006). An effective EBD process in briefing helps designers to take into account the potential benefits of different, even unfamiliar design solutions for facility users. In contrast, without external information, such as evidence from research, there is a risk that the building solutions will be static, traditional and conservative (Higgins et al. 2005). Jensen (2009) claims that one of the problems in the building industry is the limited degree of learning from experiences of the use and operation of existing buildings.

The main research question of this paper is what are the potential correlations of design strategies and learning outcomes. Moreover, this paper examines how EBD can be utilized in a traditional construction project design process. This study proposes a potential implementation tool for facility projects in high school level educational buildings.

The research process was divided into three phases. First, earlier literature was reviewed pertaining to EBD and construction project briefing and a link between EBD and building briefing studies was established. Following this, the results from the literature review were reviewed and validated in an industry expert workshop. The participants of the workshop were 16 researchers and industry specialists from Architecture/Engineering/Construction (AEC) and real estate industry. The presented evidence matrix was confirmed and co-developed. Finally, the model to link EBD and the briefing process was constructed for further testing. The literature review includes an overview of earlier studies and introduces the constructed evidence matrix. The matrix is described more thoroughly in the following chapters. The article concludes with suggestions for future research.

2. LITERATURE REVIEW

The literature review includes two sections: the general theories of construction project briefing as well as a more specific review of the EBD concept.

Briefing and briefing tools

The main aim of briefing is to develop client needs to functional requirements, design parameters and constraints. Functional requirements are a minimum set of independent requirements that completely characterize the functional needs of the facilities. Design parameters are the key physical variables in the physical domain that characterize the design that satisfies the specified functional requirement. Constraints are bounds on acceptable solutions (Suh 1990). Pennanen

and Koskela (2005) noted that “during briefing the building as a solid object cannot be predicted”. Thus, the requirements set during briefing have many possible design solutions.

The briefing phase is highly important when aiming to achieve good value-in-use. According to Shen and Ann (2012), the strategic needs and functional requirements of users should be planted as early as possible in the briefing stages of a project to have a significant impact. It is inefficient and often expensive to include more functional requirements for facilities after the briefing phase. According to a broad literature review by Ryd (2004), there are four different strategic briefing tools that have been utilized in setting functional requirements. The tools are: problem seeking, strategic need analyses, strategic choice approach, and scenario planning.

Briefing can be seen as a problem seeking process and the design can be seen as a problem solving process. Peña and Parshall (2001) explain briefing as the pre-design activity that develops the considerations or design determinants that define a comprehensive architectural problem. The comprehensive method is a system called problem seeking and it consists of five phases: goals, facts, concepts, needs, and problems. The main sources of information in problem seeking are interviews and work sessions.

Strategic Need Analysis aims to define the needs of the client. According to Smith et al. (2003), the method aims to help stakeholders see projects from their own organisation’s true goals, objectives, needs, and requirements. The main sources of information in strategic need analyses are seminars and workshops.

The Strategic Choice Approach (Friend and Hickling 1997) is a Problem Structuring Method (PSM) developed as a methodological support for decision. Strategic choice is an incremental approach that recognises the need of an explicit balance between decisions to be made now and those that can be delayed. The main source of information in the strategic choice approach is workshops.

Scenario planning is a strategic briefing tool for medium to long-term planning under uncertain conditions to manage complexity. It helps clients sharpen their strategies, develop their strategic briefs for the unexpected, and focus on their goals. Scenario workshops can challenge existing paradigms and create shared perspectives on the future.

Even though there are several strategic briefing tools available, none of them systematically utilize evidence-based information, such as EBD, from outside the construction project. Instead, the main sources of information in briefing are usually interviews of the projects’ stakeholders, seminars and workshops and visits to similar buildings. Paradoxically, Kamara et al. (2000) and Ryd (2004) argue that briefing processes are often inadequate in considering the client perspective and often focus only on short-term problem identification.

Evidence-Based Design in healthcare

The concept of EBD is well-established in the context of healthcare facility research (Ulrich et al. 2008). EBD research has validated certain building design strategies to produce significant health benefits for building users. In particular, the EBD approach uses research evidence to forecast the desired outcomes for building users. The widely discussed review article by Ulrich et al. (2008) found rigorous studies that linked the physical environment to patient and staff outcomes in reduced stress, patient safety, improved outcomes, and overall healthcare quality.

First and foremost, providing of single-bed rooms, noise reduction, views of nature, wayfinding, ventilation, natural lighting and effective layout planning were identified as the most important design strategies that lead to desired outcomes. On one hand, Lundin (2012) claims that EBD is a “buzzword” in hospital planning, and that there are differing opinions on whether a correlation between the physical environment and healthcare outcomes exists at all. In addition, Stankos and

Schwarz (2007) criticise that EBD has been used several times only as a persuasive tool for decision makers to buy into suggested design solutions.

There are only a few studies that have investigated how frequently evidence-based information is utilized in the briefing phase. According to these studies, briefing practices in general lack EBD utilization. In fact, the most comprehensive study made on briefing practices so far indicates that knowledge from previous projects is moved into new projects mainly through designers' tacit knowledge (Kamara and Anumba 2000). In the area of Swedish healthcare projects, only a few of the studied 27 briefs mentioned evidence-based information (Elf et al. 2012).

Constructing an evidence matrix of learning outcomes

Correlations between learning outcomes and design solutions can be identified in several studies. According to the literature, better learning outcomes can be gained through attainment, student well-being and personal fit, student engagement, student attendance, affect, user satisfaction, and student behaviour.

Academic achievement is linked to learning components that facilitate learning. The main learning components are the student's motivation, engagement, and academic emotions (Pekrun 2006). It is argued that students experience a wide range of emotions while studying (Pekrun et al. 2002). These academic emotions refer to emotions that are linked to academic learning activities. In addition, academic emotions are closely related to motivation, engagement and achievement in learning situations (Pekrun 2006). Thus it is relevant to study how different design strategies improve the learning motivation and engagement indicators such as student well-being besides attainment.

Attainment

Several factors have an effect on student attainment, i.e., improvements in curriculum attainment measured by standardized tests or exams, or as monitored by teacher observation. First of all, the temperature affects human performance, for which Maula et al. (2013) and Earthman (2004) have found evidence. Moreover, indoor air quality has been shown to be associated with attainment. For example, Satish et al. (2012) studied indoor air quality (IAQ) and provided evidence that human productivity varies by different levels of carbon dioxide, CO₂, in the air. Haines et al. (2001) and Evans & Maxwell (1997) studied chronic noise exposure and cognitive functioning. Their studies discovered noise-related reading problems and deficiencies in pre-reading skills. Lercher et al. (2003) found evidence with more general cognitive deficits.

Student attainment also depends on the classroom layout, arrangement and furniture choices. Knight and Noyes (1999) studied differences of attainment between traditional classroom furniture and ergonomically designed furniture. They found significant improvement in on-task behaviour when using ergonomically designed furniture with correct installations. In addition, Nash (1981) found evidence that the classroom layout and arrangement facilitated learning and enhanced cognitive development.

Interestingly, a design strategy that enhances daylighting availability has been shown to improve human performance. In fact, standardized tests showed that better daylighting conditions lead to better human performance (Heschong 2002). Earthman (2004) also proved positive effects between daylighting and attainment. Barrett et al. (2013) examined the relationship between school building design and pupils' learning rates in primary schools in the UK. The study comprising an empirical setting of 34 varied classrooms with 751 pupils showed that design solutions related to colour, choice, connection, complexity, flexibility and light were connected to 25% better learning progression.

Student well-being and personal fit

Several design solutions affect student well-being, i.e., impacts on the physical self, relating to discomfort as well as minor and major ailments. For instance, bad indoor air quality and importance of ventilation have been linked to poor well-being (Undin et al. 2003). According to Norbäck (2001), irritants and allergens decrease air quality and thus wellbeing. Thus, “fleecy” furnishing and open shelving should be avoided and the frequency of cleaning should be increased.

Moreover, noise is a stress factor that will have a negative effect on students’ wellbeing. As a matter of fact, noise might increase blood pressure, which leads to helplessness in learning (Cohen et al. 1980). According to Stansfeld and Matheson (2003) predictability, control and judged necessity determine how annoying particular noises are for students. Furniture also has its role in the well-being that students perceive. According to Troussier (1999), students feel more comfortable in ergonomically designed furniture, thus it is likely to be correlated with perceived wellbeing.

Student engagement

Engagement refers to increased attention and decreased distracted or disruptive behaviour of students. A key factor for engagement is noise. However, the interactions between engagement and noise are complex. When a student is performing a high concentration task, for example, silent reading, external noises are very distracting (Shield and Dockrell 2004). Observations of teaching pauses have been studied and results show that noise bursts lead to significant (11%) reductions in teaching time (Rivlin and Weinstein 1984).

A few studies have investigated the correlation between student participation and time on task and furnishing and classroom arrangement. A renovated room with soft furnishings and an aimed friendly and attractive feeling seemed to lead to increased student participation (Sommer and Olsen 1980). In a layout study, Galton et al. (1999) found that rows of desks (instead of, for example, pairs of desks) increased time on task and seemed to be appropriate for individual work.

Matthews et al. (2011) studied social learning spaces and their potential impact on student engagement. The researchers conducted over a hundred informal interviews and found out that “social learning spaces can contribute to enhanced student engagement by fostering active learning, social interaction and belonging amongst tertiary students.” Such social places are often informal by their nature and represent something else than formal space types at school.

Student attendance

Earlier research has examined the correlation between student attendance (i.e., fewer instances of lateness or absenteeism) and facility condition, poor indoor air quality, and inadequate lighting. For instance, Durán-Narucki (2008) have studied the role of school attendance as a mediator of the relationship between facilities’ condition and student grades. The study showed empirical evidence that a poor school building correlates with student attendance, which led to decreased academic achievement. Rosén and Richardson (1999) linked poor air quality to absenteeism. They found that reducing the number of particles in the air resulted in reduced child absence. Hathaway (1992) argued that absenteeism and inadequate lighting correlate with each other.

Affect

In essence, affect is improvements in self-esteem for teachers and learners, increased self-esteem and identity and improvements in mood and motivation. Earlier studies have found that noises, the visual environment, ergonomically designed furniture and an open layout plan seem to be positively correlated with student affect. Lundquist et al. (2002) linked annoying noise to children’s level of mood in their study of the visual environment and concluded that it “affects a

learner's ability to perceive visual stimuli and therefore affects [a] student's mental attitude. In addition, Troussier (1999) found that students have a preference for ergonomically designed furniture. Rivlin and Rothenberg (1976) stressed that students wish to perceive some privacy, which challenges the advantages of open plan classrooms.

User satisfaction

Learning is no more only knowledge distribution where a lecturer distributes his/her knowledge in auditoriums. Learners are requiring more dynamic and interactive methods of learning (Poutanen 2012). To meet this requirement of interactivity, the physical facilities benefit from having different layout options so that a sufficient level of flexibility is achieved. "It has been discovered that users appreciate possibilities to control their environment and it increases user satisfaction" (Nenonen et al. 2013).

Student behaviour

Air quality, temperature and the school layout have been found to correlate with student behaviour. For example, Fisher (2001) and Schneider (2002) argue that air quality and temperature affect student behaviour. Moore (1986) claims that the layout arrangement of pre-school environments affects children's behaviour. Social cohesion is easier to achieve in a comfortable indoor environment because it does not cause e.g. tiredness. This also seems to imply that basic physical variables have to meet the minimal requirements before it is possible to change other requirements.

Based on the reviewed literature, considerable evidence for correlations between indoor environment elements and specific learning outcomes exists. Table 1 sums up the findings and presents the evidence matrix of learning outcomes. The correlations are indicated by applying the method of Ulrich et al. (2008).

Table 1. Relationships between design strategies and outcomes

Indoor environment elements	Air quality and temperature	Noise	Daylighting	Lighting and colour	Facility condition	Furniture	Arrangement/ layout	Informal areas at school
Learning outcome								
Attainment	**	**	**	**		*	*	
Wellbeing	**	**				*		
Engagement (Study commitment)		**				*	*	*
Attendance	*		*		*			
Affect		*				*	*	
User satisfaction							*	*
Behaviour	*						*	
<p>* indicates that a relationship between a specific indoor element and a learning outcome was indicated, directly or indirectly, by a one empirical study reviewed in this report. ** indicates that there is strong evidence (converging findings from multiple studies) that a specified indoor element improves a learning outcome.</p>								

3. UTILIZATION OF THE EVIDENCE MATRIX IN BRIEFING

The evidence matrix (Table 1) can be utilized by building owners as a tool in the building briefing process. Both Pennanen and Koskela (2005) and Alexander et al. (2013) emphasize dialogue in briefing between owner, user and other stakeholders. The dialogue should include:

1. User activity description
2. Workplace requirement description
3. Performance requirement description
4. Use-of-resource description.

These four steps can be both widened and deepened by applying the EBD process. In addition of functional requirements described as the user activity description also a functional requirements of the desired value-in-use for the user can be added to the brief. In addition of the design parameters of performance the brief can include EBD design parameters from the resulting evidence matrix. These two steps also include the seed for an evaluation of the outcome, which is not only based on evaluating the performance of the building but also on the evaluation outcomes of the performance of the users. This provides an approach that is closer to the usability appraisals developed in earlier studies (Alexander et al. 2013).

Table 2 provides an example of an EBD application in the briefing process. Building design is the next phase after briefing. The success of the design solution can be evaluated with the brief. For example, if the presented design solution achieves design parameters and constraints e.g. the requirement of workplace, performance, EBD, and use-of-resources in normal conditions, the design can be accepted.

Table 2. Example of EBD and brief implementation

Type	Briefing phase	Briefing content in the dialogue	Role of Matrix	Example of values
Functional requirements	User activity description	User vision User processes	Setting a context for a learning environment project	Classroom for 30 pupils
	Desired value in use for the user	User goals for the value of the solution	Providing examples and good practices	Improved student attainment by 30% during the first 5 years of operation
Design parameters and constraints	Workplace requirement description	User space needs	Providing new insights for the learning environment, for example, use flexibility	Classroom requires 45 m ² and the room must be divisible into 2 small work group spaces
	Performance requirement descriptions	Technical solutions	Setting a context to technical solutions	Load 5 kN/m ²
	Evidence-Based requirements from the resulting evidence matrix	Evidence-based choices	Providing recommendations	Attainment (requirements): <ul style="list-style-type: none"> - Air quality level: CO₂ level at 600 ppm (Satish et al. 2012) and - Internal temperature level: 23 Celsius degrees (Maula et al 2012) - Noise: Ambient noise levels under 57 dBA (Haines et al 2001)

				<ul style="list-style-type: none"> - Colour: Bright colours (Warm colour for senior grades and cool colours for junior grades) (Barret et al. 2013) - Lighting: High quality and quantity of the electrical lightings (Barret et al. 2013) - Day-lighting: Classrooms receive natural light from more than one direction (Barret et al. 2013)
	Use-of-resource description	Goals for evaluation of learning environments	Basics for long-term and short-term evaluation	The classroom will be in good use (utilization degree 70%), life-cycle costs of the classroom are 15 € / m ² / year.

4. DISCUSSION AND CONCLUSIONS

Correlations between learning outcomes and design solutions can be identified in several studies. According to the literature, better learning outcomes can be gained through attainment, student well-being and personal fit, student engagement, student attendance, affect, user satisfaction, and student behaviour.

The main finding of this paper is that the presented evidence matrix can be used by a building owner to set functional requirements and design parameters that support learning in facilities and to utilise EBD results during a building briefing phase in a more systematic way. This article suggests that EBD methodology can be implemented in a building briefing phase to support the benefits that the facility offers for its users. The presented briefing model is potentially valuable for building owners in all procurement models. For example, in a traditional design / bid / build model the brief can be utilized to monitor whether the design solution fulfils the design parameters. In the Design & Build model, the brief can be utilized to evaluate the design quality of tenderers' offers.

As the EBD results have been collected globally, the results of this paper in relation to the correlation matrix can potentially be generalised internationally. The correlation matrix was objectively constructed from the literature and, moreover, 16 industrial experts confirmed that the correlation matrix covers relevant aspects and literature. The briefing process is also potentially useful in other industries, for example in healthcare, as the construction management process is in general industry-neutral.

The results of this paper are only suggestive and thus the briefing process needs further testing. In future, longitudinal studies are needed to evaluate the effects that the EBD-integrated briefing has on construction management and value-in-use.

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