THE EFFECTS OF SUSTAINABLE DESIGN OF EDUCATIONAL SETTINGS

By

TOM PAGE

Senior Lecturer, Loughborough Design School, United Kingdom.

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ABSTRACT

Sustainable design when used in educational building design has large effect or features the buildings possess and it also effects the users interaction with the building. This effect needs to be determined whether it is positive or negative one. Multiple case studies and a main case study of The Loughborough Design School were researched and analysed through questionnaires, interviews, and library resources. This was carried out to discover varied opinions and reviews of a range of educational buildings that have taken a slightly different approach for the sustainable design. 50 people, a mixture of Loughborough student, other students and other users, completed a distributed online survey focusing on their personal experiences with the educational buildings they spend time to achieve an understanding of day to day living with different buildings. Three people were interviewed on the topic of sustainably built educational buildings, all users differing in profession and age to provide a more diverse amount of data to be analysed. Key issues appeared throughout the study, which consisted of natural light issues, noise pollution, and temperature regulation problems within the buildings. These findings show that the introduction of sustainable design over recent years drastically effects the technological techniques and user interaction of educational buildings, but there is still a long way for technology to progress before sustainable design will be problem free and second nature.

Keywords: Sustainable Design, Educational Settings.

INTRODUCTION

The primary area of focus of the research is how users interact within educational buildings. These buildings are constructed and used with sustainability as the main focus. Therefore the technological features will be modern and very different to those in the previous, older buildings. This relatively new method of building design has much to be improved upon, as Berkebile (2008) states, "We have only begun to tap sustainable architecture's potential for strengthening our social, economic, and environmental vitality." Sustainable design is becoming increasingly apparent and important throughout the world, forcing designers to meet demands, which can sometimes compromise the overall quality of the finished product. Educational buildings still have to be places that students and teachers can benefit from, providing technological features that help their teaching and learning ability. Technology is a great influence in the way educational buildings are being designed and greatly changes the way users interact with them as well as drastically altering the aesthetics. Bokalders and Block (2010) explain "It is clear that no move towards sustainable development can go ahead without radical changes in architecture, construction and spatial planning". Sustainable design affects a large range of issues within the buildings, such as temperature, sound, and workspace. Some user feedback suggests that certain buildings built in recent history with sustainability as a main focus, are not as effective at delivering the primary goals than a building should. So in these cases, some sustainable technologies do not move design forward in the right direction and steps back will have taken. A main case study will be the main issue, being covered in detail to achieve a good understanding using primary research methods. The

study aims to address technological features of educational buildings through user research and case studies so to receive an overall conclusion on whether the positive effects outweigh the negative effects by focusing on sustainable design. Qualitative and quantitative research methods will provide insightful evidence helping conclusions to be drawn. The research will also consist of questionnaires and specific interviews with users chosen to achieve a good understanding of the topic covered producing a range of mixed results.

To investigate, though a various and a main case study of Loughborough Design School, how building user's interactions can effect sustainable technologies effectiveness.

- A literature review was undertaken to locate and analyse sustainable educational building designs, focusing on the use of sustainable technologies.
- Using Loughborough Design School as the main case study, primary data will be collected from building users (staff, students) to understand their experiences of interacting with sustainable technologies.
- To explore the reasons why sustainably built educational buildings around the world either have, or have not, been successful at achieving their targets.
- Conclusions will be drawn as to the effectiveness of sustainable technologies within educational building design in relation to user interactions with them.

1. Literature Review

Sustainable features will be covered and users; interactions were discussed to establish a well-rounded basis to draw conclusions upon. A main case study and various other case studies will be mentioned throughout and they will relate the main focus of assessing their effectiveness of being purpose built educational buildings. Educational buildings are buildings in which persons are taught and learn in. University and college buildings are great examples, especially ones built in recent years, and they are built to meet certain targets. Educational buildings will include; computer laboratories, lecture theatres, design studios and workshops. Libraries and study areas are not to be included. More often today, educational buildings are obliged to consider sustainable factors if not forced to make this the main focus.

There are companies, such as; BREEAM (2010-13, cited on http://www.breeam.org/about.jsp?id=66) that state as their duties to "address wide-ranging environmental and sustainability issues and enable developers, designers, and building managers to demonstrate the environmental credentials of their buildings to clients, planner, and other initial parties." Many educational buildings will be funded and purposely built through and by specific green companies promoting sustainability.

New technologies within the issue of sustainability have to achieve certain targets and goals to be considered successful. New technology means modern features can be added to a buildings design, which in turn, allows the user to have a greater bond with the buildings' environment as a whole. An obvious technology would be the introduction of solar panels on rooftops to provide electrical power for the building. However, the solar panels are not necessarily user related. The technologies and modern features inside buildings that users have to work with and alongside everyday are extremely important at judging the overall success of a green building. Some features may be considered to reduce the efficiency of the building regarding user interaction. This means that not all sustainable features will actually produce the best working environment, whereas a previous, less environmentally aware approach may have been more suitable.

Sustainable design is a great way forward, but there are negative effects within building design that need to be addressed and improved upon. A highly regarded topic is the amount of funds when making the buildings. Many buildings will be very cost efficient once they are in use, but the high use of technology and organic materials can outweigh the funds that will be saved later on in the building's life. Educational buildings will commonly appear impressive to look at, but great aesthetics can sometimes be coupled with expensive prices so there needs to be a balance of what buildings can actually

afford to visually look like.

Educational buildings will always have to be designed with the user's needs being met. Sustainability is promoted, but the user still needs to connect and comfortably use the building fulfilling their specific needs, dependent on specific user groups. Thorough tests and evaluations have to be conducted to gain maximum success with user. Baird (2010) covers detailed user research stating, "My overall mission in all of this is to provide an independent and unbiased evaluation of how the users perceive some of our recent sustainable building developments." Everyday use of buildings will discover successes or problems that would not otherwise been recognised purely from a designer's perspective so this is key for this discussion.

The main case study is the Loughborough Design School, built in 2011 by a sustainable architectural group and has received several awards (Wilkinson et al., 2011). It is a great example of a relatively successful project possessing various technological features with feedback from a range of users. Interviews and questionnaires have been conducted to gain an understanding of how well users interact with it on a daily basis. It consists of a variety of rooms, including workshops, studio rooms, lecture theatres, computer laboratories, communal areas, and staffrooms. This will provide evidence for an understanding of how sustainable buildings are used, regulated, and improved upon. Figure 1 shows an image of the school from the outside.

A range of case studies are to be analysed, which will provide helpful resources to reinforce one another and to compare architects' descriptions with user's perspectives. Using case studies from around the world will provide a good variety of weather condition, landscapes, cultural preferences, and desired aesthetical qualities. These case studies will be compared showing their downfalls and successes. User feedback from certain cases studies will also be analysed to strengthen levels of success.

Loughborough Design School was finished in 2011, designed by Burwell Deakins Architects and built by Shepherd Construction. It has been named Building of the Year in the regional ProCon awards. It has collected three Royal Institute of British Architects' (RIBA) East Midlands regional awards for Client of the Year and importantly it has been awarded, Sustainability and Building of the Year. The school as therefore been widely credited with a large amount of its initial design focused on sustainability. Colin Sargeant, Shepherd Construction's regional managing director who stated, "Not only does the Design School make a dramatic statement, but it is also an exemplar of how thinking outside the box can result in a building that meets the client's vision and provides an energy efficient facility" (Sargeant, 2012).

The Design School has a sustainable lighting system

Figure 1. Loughborough Design School – Outside View

resulting in lights that automatically switch off when there is no one in the area to save electricity. Full, large rooms will save a lot of energy when lights are completely switched off in times between, when the rooms are occupied. Continuing with electrical usage, there are water heaters at the staff tea points, which eliminate the need for individual kettles for the staff members further reducing the electricity consumption. This can be compared to the previous Loughborough Design Block, which consisted of individual kettles for each staff member, which is not very cost efficient. Large solar panels on the roof facing in the correct direction produce electrical power to cater for various electrical systems of the school including the temperature regulating system, which makes sure the temperature inside the school is comfortable all year round. The solar panels also provide electrical power for the dust extraction system, which has been updated that needs less power, but the results are better than in older systems from other buildings. Methods of using otherwise wasted resources for various tasks always increases a systems level of efficiency, and a good example of this is the use of grey water harvesting, which provide water to the toilet cisterns. The Design School has acquired a BREEAM rating of 'excellent' with organisations giving credit. DETAIL (2012) state, "the building has impressive sustainability credentials, predicted to produce less than 20 kg/CO_2/m^2 per year (compared to the common good practice level of 70 kg/CO_2/ m^2 per year)" (Maier, 2012).

User interaction is a key to the success of an educational building. The Design School itself has been created by maximising space and available light to provide excellent working areas for students. Using sustainable materials and features throughout, students are exposed to a green working environment enabling them to open their mind for a better future in design. Sustainable design provides features such as automatic windows. These are sensored windows, which open and close automatically to regulate the temperature of the building. This ensures the student's comfort at all times. This eliminates the task of manual usage, which in turn, can cut down time that would be otherwise used for a more productive activity. Staff members working inside the building also have automatic windows to regulate temperature inside their offices. Remaining on the topic of electric sensors, the bathroom flush system is sensor activated, the taps and hand dryer also follow suit therefore eradicating the need to touch any material within the bathroom. This above all keeps hygiene levels high, but is also another excellent demonstration of low electrical usage that is powered from the energy that can be harvested from solar panels.

The Loughborough Design School, like many other educational buildings, will not be perfect in every area. There are always alterations and issues that need to be addressed, either during the building phase or during the use stage. A main example during the building phase was that the large solar panels that line the rooftop had to be repositioned, as the angle they were originally installed at was not collecting sunlight well enough. This added cost and time to the process, however still a minor problem that was quickly seen too. Where sustainable buildings are concerned, a negative outcome usually entails the building not reaching its target figures or goals. These include aspects, such as carbon dioxide output and monthly energy usage. Therefore, it is not that the building has serious default, it is simply that it did not quite achieve the expectations.

A relatively major issue with this Design School is that of the rooftop windows that open and close depending on the temperature inside the building. Building Talk (2012) phrase this system as an "entire system is controlled by a series of SE Controls' OS2 networked control units and an OS2 modular panel for the atrium vents, which are seamlessly linked into the buildings". Loughborough Design School rooftop windows are shown in Figure 2.

They worked well until the humidity levels were higher than expected which triggered the sensors to open them. This happened on an occasion when it was raining, therefore the rainwater dripped onto the main staircase in the centre of the building creating a hazard for everyone using it at that time. This was quickly fixed, but this was originally a negative effect. Regarding the Building Management System, some rooms took time to optimise temperatures through sensors, which is considered a

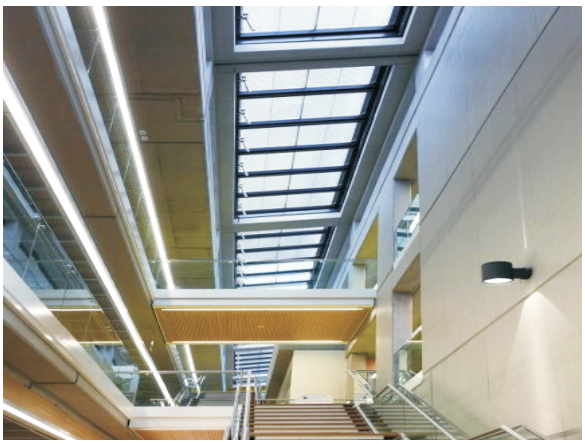

Figure 2. Rooftop Automatic Windows

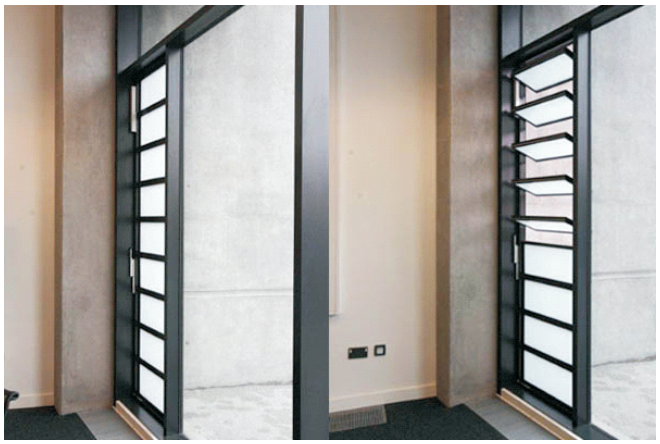

Figure 3. Louvre Windows

technological issue. This was also soon addressed. The complicated automatic lighting strategy, however, is still not working effectively as some lights stay on overnight in some areas of the building. This counters the energy saved by other, correct working areas of lighting, so this will have to be adjusted.

There were various complaints from staff members and students relating the window actuators that operate automatically through CO_2 and heat sensors, as they were very noisy. They would continuously open and close when the temperature was at certain levels near the sensor limit, so repeatedly therefore they constantly adjusted to coincide with the minor changes in temperature. This would distract students mainly in the studio areas and the discussion rooms. These had to be replaced within a couple of months into the buildings use. FEIGER Louvre Windows (2012, cited from http://www.louvre window.com/en/en/news/) explain, "the vents were supplied complete with 24 volt DC actuators, to facilitate integration into the SE Controls' OS2 system and the Building Management System." Figure 3 is an image of the windows.

There was also an issue with the natural ventilation system that caused drafts and noises that affected the buildings' users. This issue effects the users considerably as it is compromising the main tasks performed on a daily basis so alterations have to be made. Wind is an obvious problem with the Design School, and being in an open, flat land area does not help, so more consideration should have been taken into account, but this was not a problem recognised initially by the contractors. Users initially used the bathrooms, with the electronic sensors, without complaining. But the walk-away sensors on toilet flush became an issue. They were very unpopular with users as they performed fake flushes and non-flushes, which were considered an immediate problem due to their regular use, within a building with a large population holding. This issue has currently been resolved by installing new systems that have not received any complaint thus far.

Sustainable design must be designed that will be appreciated and well received by the users on that particular building. The building must uphold certain sustainable qualities without compromising the needs of the user. In the user tenant section of *User Satisfaction in Sustainable Office Buildings: A Preliminary Study (2011)* covers similar topics and states, "A modern design, state of the art services and new technology are incorporated to ensure the building meets recognised sustainability criteria, however the most important factor as a benchmark of a building's success in meeting the design objectives is the level of user satisfaction". This is true with educational buildings, as effectively there is a workforce on a daily basis and user needs is of the upmost importance.

When educational buildings are designed to a high standard, students can find inspiration for their course. A good example is the Scott Building, University of Plymouth,

which was designed by Burwell Deakins Architectures. Tanya Griffiths, a regional juror and director of an architecture company, explained, (cited from http://www.acdandc.org.uk/22/architecture-news-and-events-2/latest-3/riba-sw-award-winners-358.html) "The space is a welcoming contrast in shape and material to the rest of the school, and one student has actually taken the project as an inspiration to study structural engineering." The working environment in which one is attending, will almost definitely adjust the users approach to certain aspect of their work life, and even personal life. Clean, green environments encourage green thinking, which if applied by the user will benefit a range of issues. If the creativity and finished features are appreciable enough within design related buildings, users will use large systems, or even small sections, of the design they see before them and incorporate it into their own designs. Students often get inspiration from what they see around them and designing innovative surroundings will no doubt boost creativity.

There has to be a sound balance between achieving sustainable targets and achieving the user needs. The common issue is the introduction of solar chimneys. They are a good idea as they are aiming to replace regular chimneys, which heavily pollute urban areas. Within solar chimneys, a change in temperature is created, even on cooler days, forcing air to rush upwards through the shaft and therefore regulating the temperature inside the building. As this technology has not been perfected as such, there are some issues. Noise pollution can replace air pollution, which when in a working environment causes major issues. Also, the solar technology only works when there is sunlight available, so there will need to be a secondary system to regulate temperature as well. These issues combined with the expensive initial setup costs, some would say that the technology is not as advanced at it should be for commercial buildings. This could result in the negative effects to outweigh the positive effects, in the future this maybe a more viable option. An example of a solar chimney installed on an educational building is the Tanga School, Sweden (Figure 4).

After a sustainable building has been in use for sometime

Figure 4. Tanga School, Sweden

and is undergoing a review, the building must achieve certain 'green' targets. Even so, more important are the comments and feedback from the users who work live and work within it. Sustainable buildings will often receive negative feedback as new techniques and technologies are being essentially trialed. This increases the chance of failure, but afterwards alterations can be made change this outcome.

There are frequent technological discoveries throughout the year increasing the amount of systems being used on buildings to achieve sustainable targets. Disregarding user needs, the technology and features themselves need to prove efficient, practical, and effective. Users might be content with a particular feature of the building regarding their own personal needs, but the feature itself maybe be underperforming when observed by professionals focusing on the impact to the environment. Certain features will therefore require routine checks throughout the year to confirm everything is in order. The advancements in technology, when put into practice, provide excellent examples for other companies and groups to find inspiration from, and this is leading the world forward within the sustainable sector providing a bright outlook on the future.

A crucial benefit of using sustainable technologies and features in educational buildings is the impact that they have on the environment. Air pollution, noise pollution, and energy usage are at the forefront of this issue so these factors have to be tackled well and achieve certain benchmarks that have been set. Independent organisations will monitor, help and award buildings

regarding the sustainable qualities. One of the leading organisations is BREEAM (Building Research Establishment Environmental Assessment Method). They review and grade various sustainable systems to judge buildings' 'green' credibility. Like many organisations, they have their own rating system to show how much environment-friendly a particular building has become. Building contractors will therefore aim to produce a building of a high quality to receive the more prestigious awards, which will eventually result in their own reputation being exposed positively. In the introduction of sustainable technologies and features within the educational sector brings sustainability to light. Buildings are constructed following green programs and in some cases, provided with sufficient government funding, which encourage the rest of the country to take the same approach when they consider their own building design and use. Initial costs maybe higher than a similar building built in the traditional sense, not focusing on sustainability, but overtime technologies will become cheaper and more efficient and buildings will easily save more money and energy, providing the owners with a more stable future.

Technological systems and features have made vast improvements over recent years, but there are still many issues that have not become a commercially viable option for contractors to use in building design. The main factor is the cost of green building. The largest sustainable rating system in America is carried out by a company named LEED (Leadership in Energy and Environmental Design). They have recently been under scrutiny recently as the cost of providing buildings to meet their demands is extremely high. Gehry, F., a prize-winning architect, explains in an article written by Singh (2010), "A lot of LEED is given for bogus stuff." The costs of making a green building are "enormous," and "they don't pay back in your lifetime." There is a large wave of similar arguments aimed at organisation similar to LEED all around the world as sustainable design, in some cases, does not appear to be cost efficient at all. On a smaller scale, features of educational buildings often need far more regulation than traditional systems. This is partially due to the use of unpredictable weather conditions, and also because electrical technologies often function well for small amounts of time. In the Loughborough Design School case study, many systems had to be altered and replaced due to minor errors. There are many systems that have not failed, generally across the world, but these systems are often accompanied by huge initial set-up costs. In some cases, the running cost is also very large with no financial benefits at all, with only environmental benefits. In educational buildings, this can damage the overall institutions' financial status and result in less opportunities for students, as facilities will have to save money by cutting corners.

There are many different approaches to sustainable building design and various educational buildings from around the world have undertaken contrasting methods on construction and user testing. The final outcome is dependent on many different criteria so no two buildings are the same. The resources and landscape play an important part for architectures presenting difficult tasks, and sometimes end up in failure. Comparing and analysing case studies will enable decisions to be made on what good sustainable design actually consists of. Many organisations compare case studies and create a structured method of evaluating the buildings. They are then graded or awarded, and other constructors can then learn a lot for future projects.

A very relatively well-received educational building is the Lillis Business Complex, University of Oregon. This was completed in October 2003 at a cost of forty-one million US dollars. It received Silver LEED award gaining nearly full marks for innovation. There was a very large focus on lighting, which were controlled and supplied by Lutron Electronics. There was a mix of ventilation systems ranging, including; natural, hybrid natural, and mechanical ventilation throughout the building, which successfully managed the temperatures and was extremely well received by the users. Malin (2008, cited in Emerald Architecture, p. 47) explained "the design provided for a combination of fans and passive airflow to circulate air from classrooms and offices to the atrium, where the natural stack effect is supposed to drive the air out through the vents in the roofs" (Figure 5).

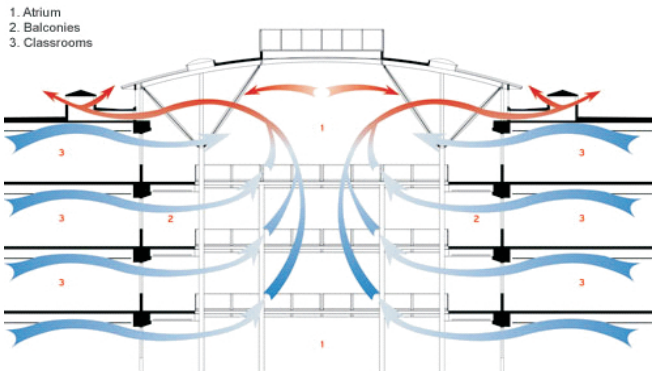

Figure 5. Atrium Ventilation Diagram

Another successful case is the Thomas L. Wells Public School, Toronto. This was completed in August 2005 costing sixteen million US dollars. This building also achieved a silver award from LEED gaining nearly full marks for the design accomplishments indoors. Boehland (2008, cited in Emerald Architecture, p. 59) explains, "The request for proposals stressed a desire for an integrated design process and an energy-efficient building with good indoor air quality." The projects' ventilation system is most the innovative feature. It allows heat to be expelled in the summer, and to be captured in the winter. This was made possible however the board in charge allowed a ten-percent budget increase. (ibid: p. 60) "This allowed the team to consider green alternatives that would pay for themselves after about ten years". The success of this project was aided a comprehensive post-occupancy review, which included staff and faculty members. The building was to be rated out of five, and the average from all these results was over four. This type of attention to user needs is what can bring huge amounts of success to an educational building. There was a good plan for the future, and example of this is, (ibid: p. 62) "since the school board plans to operate Wells for at least seventy-five years, the team selected durable materials that would require little maintenance." As this building was so successful, further projects are going to be undertaken following suit, (ibid: p. 63) "In response, the school board is planning another K-8 school a mile north of Wells. It too will be green".

Another successful case study is The Mathematics and Statistics and Computer Science (MSCS) Building, Canterbury University, New Zealand. Baird (2010, cited in Sustainable Buildings in Practice, p. 150) explains, "the average perception scores for satisfaction factors were well above their respective benchmarks and scale mid-points." The lighting was overall rated highly, as glare from the sun were the only negative issues. Baird has constructed a scoring system for sustainable buildings focusing on user feedback, producing a conclusion from a nonbiased perspective. The whole of the thermal environmental control plant and motorised window openers are under the control of the Universities computer-based building management system. This is much like other buildings so it would appear to be the most efficient method at this point in time.

The Sustainable Technologies Building of Black Hawk College, finished in 2012, another case study, have focused a lot on the environmental issues involved with building design. The project consisted of; an eleven kilo-watt wind turbine, closed loop geothermal field, two twenty panel solar arrays, vegetation roof, solar thermal heating, and a daylight harvesting system. The main focus is energy saving, as on the Black Hawk College website (cited: http://www.bhc.edu/sustainable-technologies-building/) states that "the college and the design team joined with MidAmerican Energy and the Weidt Group to explore and evaluate a number of alternative lighting and mechanical systems with the goal of selecting design strategies that demonstrate the highest value of energy savings." (see Figure 6).

An unsuccessful case study is the ZICER Building of the

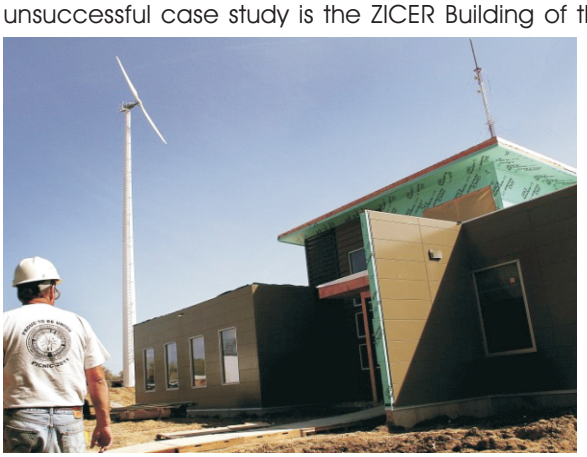

Figure 6. Black Hawk College Sustainable Technologies Building

University of East Anglia. This was opened in 2003 and has won various awards. Baird (2010, cited in Sustainable Buildings in Practice, p. 103) explains, "the building have won several awards, including the 2004 European Association for Renewable Energy Award for solar architecture, a high commendation for sustainability in the 2005 Royal Institute of Chartered Surveyors regional awards, and the 2005 Building Magazine Low Energy Building of the Year Award. "Although many awards have been won, there were problems with building and user feedback was very negative. In this case, user feedback was considered more important and therefore the building is not considered a successful design. Firstly, there were numerous complaints about noise levels from other colleagues and people. This was a product of the design layout of the building, which failed to cater for noise travel. The layout of the building was mostly open plan, which many users felt was not conducive to research, and noting the difficulty of holding conversations. Tables constructed by Baird (ibid: p. 110) indicate "around twenty-one per cent were positive, fourteen per cent were balanced, and sixty-six per cent negative – from the building as a whole." Light was also a prominent issue as (ibid: p. 111), "the main comment related to the lack of daylight and the need for artificial lighting to be on most of the time". From this case study we can see that lighting and noise are very important factors for users. These are two issues that must adhere to certain levels of expectation otherwise the living organism, of which is the work force, will break down.

Another unsuccessful case study is The Red Centre Building in the University of New South Wales, Australia. It was the largest project undertaken by the university for a number of years and the building incorporated many classrooms, theatres, and studios for a range of academic courses. The systems controlling temperature were very modern at the time and Francis-Jones (1997) explains, "the cooling, heating, and ventilation process has been achieved through an integrated design of thermal mass, air shafts, thermal flumes, sun shading, vents, and 'breathing' facades." However, users were asked for feedback and over seventy percent of six hundred and twenty-five responses were negative. Baird (2010, cited in Sustainable Buildings in Practice, p. 240) explained that, "The building's computing facilities and lighting featured highly among the aspects that worked well, while hindrances common to all three groups included acoustic, temperature, and glare issues." Noise pollution, like previous case studies, proved to be a major problem that constructs seem to frequently disregard as a main factor.

In this case study, where the building was situated caused many problems. The Eco-Design Laboratory in Livermore Califencountered problems during the construction phase and in the use phase. Due to sustainable materials being used and specific sustainable features, minor earthquakes and uneven ground proved to compromise the buildings structural integrity. As a result of the surrounding environment, shrinkage of the clay and silt during the drying phase, the walls ended up curling in small sections near the top. King (2008) says, "It didn't occur to me that the wall might shrink enough to curl the wall back, if I were doing those walls again, I would add rebar on the outside." The building still was considered a success overall, but it is example of how important the environment in which the building is situated can be. Especially when the sustainable design is used as new features may prove to fail due to a lack of testing over many years, compared to traditional unsustainable methods that have been trialed and tested over a long period of time.

The sustainable design of buildings is a very broad topic, as no one appears to have the same conclusions on what 'sustainable design' actually is. McLennan (2004) states, "Almost every architectural and engineering firm today claims, to some extent, that it practices sustainable design or at least has done a few green buildings, while in reality, most have little true understanding of the subject. The word "sustainable" has been applied to many buildings that do not deserve the designation, thus shrouding the few that do." This is also partly true for the design of educational buildings. Sustainable does include many key factors such as; materials and afterlife, but the buildings has to remain excellent at its main

objective, in this studies case, to harbor students and staff members comfortable encouraging creative thinking and suitable working environment for specialised or a range of academic paths. From analysing case studies it is clear to see that users take a completely different approach when analysing a building, than the designers or constructors. The key for a good designer or architect would be to envision the users' expectations and cater appropriately for their needs.

Cost also is a deciding factor, as in the Loughborough Design School, many systems needed to be changed, or replaced which increases the cost above the intended budget. This coupled with the large initial costs of sustainable building anyway present companies with unrealistic goals. To move sustainable building towards a state where it is easily accessible by almost everyone, will take time. Appleby (2010) states, "To achieve exemplar performance has required considerable investment in most cases, whereas achieving this performance on a large scale demand both the mass production of high performance building elements and services, sustainable energy, and water infrastructure for entire developments. Therefore, a balanced need is to be met between sustainable creditability and realistic costs. This balance will continue to weigh in sustainability's favour as time progresses.

Throughout the literature review, in some cases, educational buildings were not focused upon the aesthetical features of the interior and exterior. This study focuses on the technological features and user interactions, however aesthetical beauty is a part of these, especially when the user in concerned. Architectures focus very heavily on creating a structure is sustainably excellent, but also looks sustainably sound as well and everyone may not appreciate this, so this could be considered a missing gap in the design world. DeKay (2011) stated, "As an example, there are no LEED credits for creating experiences of beauty, none for creating or fitting ecological order and none for placing people into rich symbolic relationships with nature." LEED is the biggest organisation in America performing sustainable reviews on buildings and therefore a gap does exist.

2. Methodology

After completing the literature review, sufficient evidence has been gathered to highlight the main positives and problems where sustainable building design is concerned. This has set up strong foundations in which the research will be carried out within the next sections. Further research must be now carried out for contrasting opinions and figures. Although not all the research carried out will agree entirely with the literature review, it should help prove whether they were viable. For the research, quantitative methods can be used, using the traditions of science, and qualitative research methods can be used for an exploratory approach (Davies, 2007; p. 25).

Qualitative research offers an interactive approach, which could include observations and interviews with a range of different people, which can then be recorded in a descriptive manor, including feelings and exemptions. These methods can be considered much more dynamic that quantitative research methods. Quantitative research is a much more strict approach, where questionnaires and surveys will be carried out and precise data will be collected, and produced as a numerical analysis. Qualitative and quantitative researchers are forever disagreeing on which is the best methods so the divergence is increased between them (Hammersley, 2012).

Approaches to research must be carefully planned out to gain maximum evidence for a more reliable study. A variety of research methods must be considered, as certain methods will be suitable for particular investigations. The majority of research took place at Loughborough University focusing on the main case study, the Loughborough Design School. This was easily accessible and student communication is on hand to maximise question responses. A range of participants was sampled for varied research methods to gain a broader perspective of how sustainability when used in building design affects the users. All the questions must be realistically answerable and provide a sound contribution to the data (Davies, 2007; p. 18).

No names are mentioned to hide the identity of the

interviewees, which is covered in the next section. When researching, research methods such as voluntary participation and informed consent must be applied at the appropriate times. This ensures the protection of both parties and therefore a participating information sheets and consent form will need to be completed. These forms explain that they are within their rights to withdraw from the research method being undertaken, at anytime (Robson, 2002).

"Questionnaires are intended to facilitate communication, usually brief, but are always driven by the researcher's own agenda" (Davies, 2007; p. 82). Questionnaires are quantitative methods for conducting research enabling a broad range of users. Questionnaires were conducted on the Internet through a survey distributor website for fast and efficient researching. Users directly involved with the main case study could be easily reached to provide supporting evidence to coincide with the literature review. After sufficient data had been collected, demographics were produced to summarise key findings and statistics.

The questionnaire was carefully thought out to receive maximum benefits from user opinions. "Such impatience is a sign of professional incompetence" (Davies, 2007; p. 84). The questionnaire was tested with a small group of individuals to make sure it was user friendly and that the questions appeared comfortable and understandable to the user.

Interviews are carried out with a simple, sounds structure as a lot of insight can be gained from conversation focusing on a single user sharing a large amount of knowledge. As in most forms of qualitative research, there will be a need to achieve trust between the interviewer and the interviewee. The information provider will then accept the interviewee and will be prepared to talk openly and sensitively (Davies, 2007; pp. 153). The interviews were conducted at the interviewee's convenience and all situations had a relaxed and comfortable atmosphere. A brief overview of the project was explained at the start of the interview to make sure that the questions were completely understandable and obvious to the person being interviewed.

Interviews were conducted with three different users varying in age and profession. This enabled a wider understanding for the researcher to analyse and compare to the literature review. The interviewees consisted of; a studying designer who attends The Loughborough Design School, a facilitates manager of a newly built sustainable college and a physical education teacher who is working in a modern sustainable building. The interviewees vary in ages from twenty up to fifty-five years old.

The interviews provided a source of knowledge that indicated what needed to be researched next, and also how well their personal interactions with educational buildings related to the literature review. The interviews were separated in two halves, one focusing on positives of the technological features and one half the negatives. This was important to discuss as this topic forms a vital part of the study. As Davies (2007; p. 158) explains that you cannot let your interviewees discuss the topic in "the angle they put it on."

A mixture of qualitative and quantitative data was collected throughout a range of people to ensure a large diversity of opinions was analysed. An online survey allowed a large amount of data to be quickly summarised to discover trends within the topic. A large portion of the data was collected from user of the main case study, the Loughborough Design School.

3. Data Analysis

The literature review was reviewed prior and after the data collection stage to highlight similarities and remain on topic. The online survey was successfully filled out fifty users allowing good diversity. The online survey clearly stated in the beginning that they should only fill in the questionnaire if they had a good source of knowledge or was often working inside an educational building that had been sustainably built. The samples for this questionnaire were also reviewed by a small group of samplers to notify the researcher of any problems that needed to be addressed. This research was analysed alongside three separate interviews for a more in depth outlook, where alternative views could be noticed and summarised.

Out of the fifty people that successfully completed the online questionnaire, sixty-two per cent were students who are studying at the Loughborough Design School. Ten percent were other students studying at Loughborough University. Ten per cent were studying at other universities or colleges, and eighteen per cent were not students (see Figure 7).

This question, above, was asked in the first section of the online questionnaire to find out how much contact time the users are getting with the topic of the study. With the vast majority either spending the whole day, or most of the day, nearly everyday each week was a very good result. This means they have had time to use the educational building extensively and will therefore be in a better position to provide more reliable insights. The six per cent, who answered only one day or less per week, is a very low figure, that being three persons. This is better than expected so as a whole, the entire groups feedback will be reliable.

Below are three charts displaying the results from three separate questions from the online questionnaire. These questions, such as based on the literature review, lighting, temperature and noise were the main factors when users decided whether or not a sustainable building is successful.

From Figure 8, only fifty per cent are satisfied so it is clear that lighting still needs to be tackled better. Some areas are too bright, so glare needs to be addressed too.

Analysing Figure 9, there are no buildings that a very poor at temperature regulation. Extreme weather conditions are still an issue however.

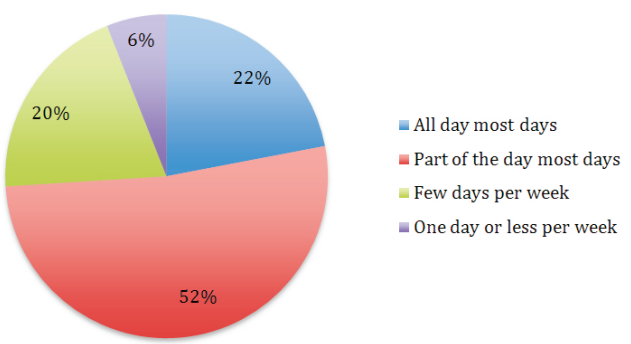

Figure 7. How often are you Involved with, in anyway, Sustainably Built Educational Buildings?

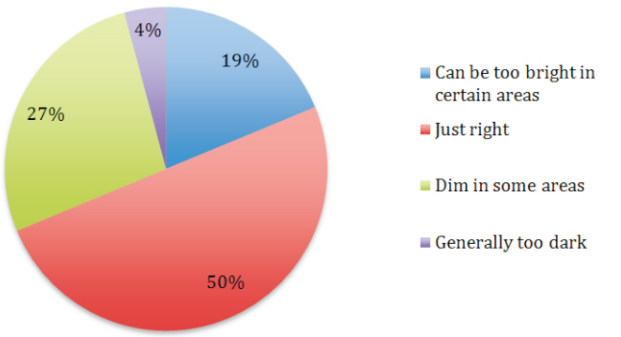

Figure 8. How do you find the Natural Light Levels inside the Building(s)?

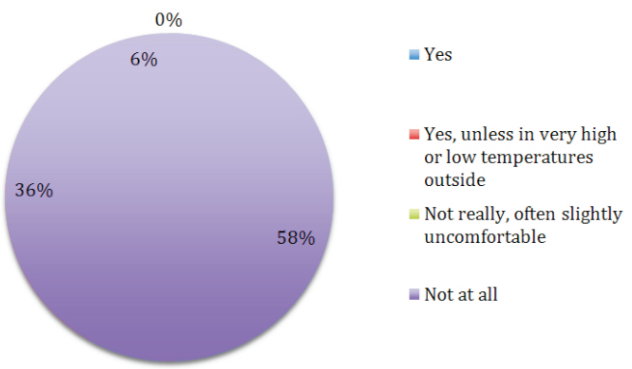

Figure 9. Is the Temperature of the Building(s) Sufficiently Regulated Throughout the Year?

Analysing Figure 10, only twenty-two percent of the participants are not distracted by noise pollution. This shows that sustainable buildings, with large open plans and open ventilation systems can boost noise pollution. Solutions will need to put into practice. Three interviews were conducted with three separate people of who have completely different professions and are of a range of ages. All three interviewees work and live in different parts

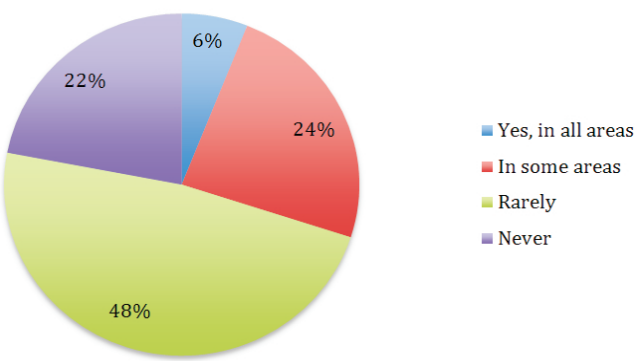

Figure 10. Are you Distracted by Noise Pollution within the Building(s)?

of the country to maximise the diversity further. The interviewees were very compliant with all the questions they were asked providing good information throughout. There were no unpredictable moments, such as confusion or frustration. Most questions were fairly similar for each interview, so different opinions could be analysed concerning similar topics. The questions all related to the literature review or order for all the sections to be compared, and queried by one another for a stronger final conclusion. Key findings mainly include interviewees completely agreeing with what was written in the literature review. Most of each interview was key for finding reliable information, so therefore key findings will be analysed in next sections, headed; positive effects, negative effects, and suggestions for improvement. The first key finding was when the design student was asked to comment on the temperature regulation inside the building. He gave a positive response commenting:

> *"It's usually comfortable. Only in crowded lecture rooms it can sometimes be to hot but I nearly always work comfortably."*

This shows that the Loughborough Design School has a good ventilation system most of the time, matching the literature review. The second positive key finding was when a question was asked if there had been a need to fix or replace any part of the buildings' electrical system to the college facilities manager. He stated:

> *"Not really, a couple of lights have blown their bulbs over the past few months but nothing major. Everything is working great."*

This shows that minor problems are not really considered a problem at all. There will always be a fault, but in this case, sustainable factors are not involved. The third positive key finding from an interviewee when the physical education teacher was asked if the sustainable architecture allowed for suitable spaces and natural light. He replied:

> *"Yes, the open plan design and large windows give a great sense of space."*

This is what you would expect from a new sustainable building. It reinforces the findings from the literature review well. The first negative effect was explained by the physical education teacher, who when asked if there was any noise pollution in the building, explained:

> *"When the automatic windows open, due to heat sensors, during break time shouting children can be heard from the staff lounge quite clearly."*

The heat sensors are obviously a technological feature, but where the building is actually situated does not fall under the topic of this study. Automatic windows do seem to produce problems in other case studies as well however, so this is a helpful comment. Secondly, the facilities manager of a college was asked to comment on the temperature regulation, he mentioned:

> *"During the summer, as we are situated in a heavily populated area in London, it can become very warm inside the building, even though there are large ventilation systems and open windows throughout the building."*

Again this has a got something to do with the situation of the building, but there should be a ventilation system that has been designed to cope with the temperatures. Many constructors will install systems expected them to work fine, but quite often unanticipated problems will occur due to a lack of foresight. The student studying at the Loughborough Design School, had suggestion of improvement that he explained:

> *"Apparently the toilets 'self-flushing' sensors were replaced for better ones. But I haven't noticed a major difference, as it always seems to take a while to activate one. It's annoying when you need to get to lecture!"*

This is an issue that was altered some months ago, but there still seems to be a problem. This could indicate that the electronic bathroom systems might be a waste of time and money. Further research would need to be done to achieve the best solution for this problem. Possibly include new, suitable, technological features everywhere is not the greatest solution. The interviews conducted provided strong, reliable opinions on a range of topics covered in the literature review. Key points were highlighted and they strongly agree with key factors from the literature review as well. This further reinforces the fact

that lighting, temperature, and noise are of the upmost importance, in any type of building. All three interviewees were happy to conduct the interview and were fully aware of the chosen topic, and how their words would be recorded and analysed. These interviews, along with the questionnaire results will provide a stronger basis on which conclusions can be drawn for this study. When collecting the qualitative data, there may have been slightly biased answers. This could be due to the fact that a member of staff may not want to reveal a bad impression of their institution. Interviewees therefore have to be trusted on their words. Also there will be participants from both research methods, qualitative and quantitative, who will not be well informed of most of the sustainable factors when considering building design. Their insights are helpful as it offers a variety of opinions from different perspectives, but not all figures analysed can be taken as completely reliable.

4. Discussion

In this discussion section, the literature review will be compared with the quantitative and qualitative data gathered in the latter stages of the study. Case studies will be revisited and compared against the result of primary research methods. There are similar trends throughout the study, as sustainable design does not have a certain path to follow. People's perceptions are varied, but a variety of research methods collected and analysed in this study will finalise some aspects.

The literature review shows a large variety of case studies and attention to user needs. New technologies also play a big part in the emotions and the users feel when using the buildings. The participants of the interviews and questionnaires stated that they need further improvement, with nearly every building. When the answers were analysed, it was mainly a few main issues. Lighting, temperature, and noise seemed to be important to everyone. There was not case, where all of these criteria were thought to be adequate. The initial discoveries in the literature review are well joined with the research that comes later in this study.

The Loughborough Design School was used as the main case study. Contact with facility managers, technicians, and students who attend the school gave great insights that were useful to analyse. It featured small electrical problems like many case studies and encountered automatic window problems. This problem occurred elsewhere in the study including the interview with the physical education teacher. It shows a school, as greatly awarded as this, can still have inside problems that can only be discovered from well-planned research techniques.

A large section of the literature review was based on case studies from around the world. No two buildings are the same so a variety has to be analysed to gain a better understanding of the overall issue. Many case studies completely resembled the responses given by the interviewees and questionnaire participants. The case study research also showed that many buildings were deemed great upon opening, but later on starts to fail and decrease in popularity, and we can see these similarities with the main case study. The case studies display the same positive and negative issues that can be seen throughout the whole of the rest of the study.

Conclusion

Educational building success relies extremely heavily on user interaction and feedback. This became apparent during the case study research as buildings were being graded nearly completely on their reviews from the users, which is fair that the users have to use it everyday and achieve their work related goals. It is a good way of reviewing, but later on in the study, it was apparent that a reasonable amount of users are not clear on exactly how most of the technological features work. If the features were explained obviously, but in an interesting way, users will make a stronger connection with their buildings.

There was a small trend amongst case studies. That being all the buildings may claim to be sustainable, but there are different reasons behind this. Some buildings would look into the future and think about saving energy costs in the long run. There are buildings that just seem to want to demonstrate their own capabilities by installing the most impressive features that commit to the principles of

sustainability (Baird, 2010, p. 20).

The technologies are a large deciding factor on whether a building is successful. This was shown throughout the main case of the Loughborough Design School. Many great, sustainable features worked very well and this has inspired other parts of Loughborough University to start new, similar projects. Projects all over the world will either be in the process of construction or at early design stages, but they will all encounter the same main issues and any other obstacles they overcome or fail on, provides everyone else with hindsight. The increased use of sustainable design in educational buildings is therefore a positive way forward, but it will be a long way into the future before it becomes publically apparent.

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ABOUT THE AUTHOR

Tom's background is in Avionics, and has worked as a Development Engineer for Ferranti Defence Systems Ltd. in Edinburgh. In 1990, he took up a two-year fixed-term research assistantship at the Engineering Design Research Centre in Glasgow. Upon completion of this role, he taught Computer-Aided Engineering at the University of Hertfordshire in Hatfield. Since moving to Loughborough University in 2003, Tom has taught Electronic Product Design, Interaction Design, Design and Manufacturing Technology, and Physical Computing. He is the organiser and co-ordinator of all design and prototyping activities required for the Engineering Education Scheme (EES) workshop and is the outreach and widening participation coordinator within the Design School. Tom's work has been widely published in the form of Journal papers, Book contributions, refereed Proceedings, refereed Conference papers, and Technical papers. He has supervised research students, acted as external examiner on undergraduate and postgraduate programmes, examined Ph.Ds and M.Phils and has acted on the reviewing panel of a number of key Journals and Conferences. His research interests are in Engineering Design, Design Education, Technology Education, and Electronic Design Automation.