UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Visual Display Systems for the SUB Atrium

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APSC 261

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ABSTRACT

The UBC Student Union Building (SUB) is an ongoing project to replace the current SUB with a facility that aims to showcase the highest levels of sustainable building design. Through innovative Student-Driven Decision-Making Processes, the students of university courses such as APSC 261 is able to contribute to the development of the facility.

This paper summarizes the research and decision behind installing a display board in the Atrium of the SUB. The display is to bring attention and information to the building occupants about sustainability and features of the building as well as provide general information on events and schedules. This research analyzes the hardware, location, and content of the display board to propose an optimal solution for the stakeholders and end users. A triple bottom line assessment will consider social, ecological, and environmental impacts of the display board on the sustainability agenda.

The major criteria used to make decisions on this project was that the display had to have the cheapest purchase and operation cost throughout its lifetime. The display should also have lower negative impacts on the environment not only in manufacturing, but also in transportation and use compared to other technologies. For these reasons the LED backlit LCD display was recommended for use in the SUB Atrium. Displayed content was proposed based a survey on the public to gauge the forms of visual media that would be most attractive to the people in the SUB. It was determined that the most effective content would be facts about the new sustainable technology that is being used in the SUB and tips on how to reduce individuals environmental footprint. It was also decided that the most effective locations to place the displays to engage the public is in areas like food courts where they may be viewed while waiting in line or eating.

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GLOSSARY

CCFL -	Cold-Cathode Fluorescent Lamps
Eutrophication –	The over enrichment of nutrients in the water leading to sudden increase in biomass that negatively impacts the ecosystem.
LCD -	Liquid Crystal Display
LED -	Light Emitting Diode
Pixel -	A minute area of illumination on a display screen, one of many from which an image is composed.
Plasma -	A state of matter similar to gas in which a certain portion of the particles are ionized.
RGB -	Red Green Blue

1.0 INTRODUCTION

The new SUB is being built to be one of the most environmental student buildings in North America and will try to achieve the LEEDS Platinum+ award. However, the building is not being designed solely to be environmental it is being designed to promote a social shift towards sustainable thinking. As such it is required that the building has a means to engage students, staff and visitors to enact theses changes. It has been requested by stake holders that a triple bottom line analysis be conducted of potential display ideas. The main focus in our report is the new display board in the SUB. The question we will be trying to answer is what display board type will be need and what will be the content. For this reason we will be conducting a triple-bottom-line analysis, which focuses on economic, environmental and social impacts of this board. We will be looking at manufacture data sheets and survey students for their preference in the display content. From this information and an analysis using the three components of the triple bottom line analysis a recommendation will be made detailing the best option both for the physical display and its content to be used in the new SUB.

2.0 ECONOMIC IMPACT

Significant economical savings may be made if the optimal type of display board is chosen. There are five types of display boards that were initially considered in our research. These types are; electronic paper, projectors, LCD televisions, LED-LCD televisions and plasma televisions. The technologies will be evaluated though four different categories of assessment. The different categories of comparison are overall usability, cost, size available for displays and energy consumption. After comparing each of these technologies individually in each category, it possible to select the best economical choice for the display.

2.1 TYPES OF DISPLAY BOARD

2.1.1 Projector

First type of display considered is the projector. Projectors usually are LCD projectors, meaning inside the projector there are three LCD panels with a halogen bulb placed in the center. The panels are a standard RGB type of panels, which will produce the colors wanted on the display. As that bulb heats up it melts the crystals, allowing light to pass through them. Intensity levels of bulb will determine the tone of each color in the image. After the light image is made by the LCD component of the display it is then passed through the lens so it can be focused on any point where the screen may be. There is one major problem with projector and this problem is that it has to be dark in the area to see the image. Therefore with having a display in the atrium it would render this technology useless during the day time, due to the bright sun light.

2.1.2 Electronic Paper

Second type of display is using electronic paper which is a display that is implemented in many kindles. The electronic paper uses microcapsules in figure 1, containing both positively charged white particles and negatively charged black particles [1]. When a negative electric field is applied, the microcapsule it will bring the positively charged particles to the top, making it appear white. Also if a positive electric field is applied, the negative charges will come to the surface, appearing black. This technology does not need any backlight to create its display it just

reflects the natural light given off. The down fall to this is when it is not bright enough outside from sun light in the atrium, there will have to be enough light on the display for it to be seen.

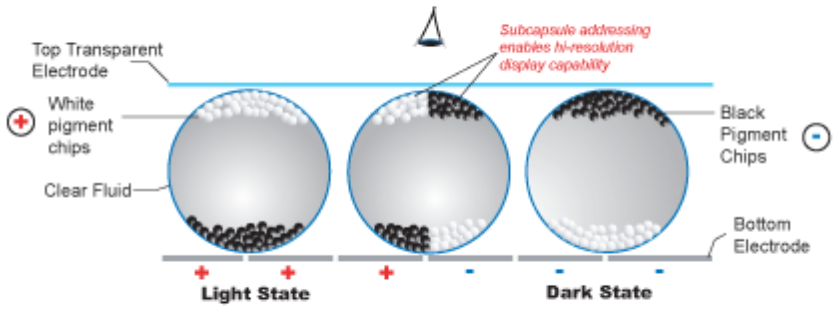

Figure 1: Electric Paper Microcapsules

http://www.eink.com/images/feature_technology_ink.gif

2.1.3 Plasma Televisions

Plasmas types of television work off the concept of RGB plasma tube pixels. The key concept of plasma televisions is the gas between the two thin panels of mounted glass that the screen in composed of. In between those panels are networks of pixels that are composed of tiny pockets of compressed phosphors gas. Each pixel has three sub pixels made up red, green and blue. The pixels are stimulated by electrical flow into each pixel, the red green and blue tubes act like colour fluorescent lamps. This leads to the brighter more vibrant colors to consume more electricity than the dark dull colors. One downfall to the development of plasma televisions is the glass front plate. Having such front plate will cause glair when light hits it from angle, thus obstructing the viewing.

2.1.4 LCD Televisions

LCD type of display work with much of the same technology as a projector, this technology is liquid crystal technology. An LCD Television is composed of two sheets of

polarized glass. The glass is polarized to only allow certain wavelength of light to pass though. Between these two sheets of glass is a liquid crystal solution. The molecules of the liquid crystal shift by varying the electrical current in the desired area. From this current the liquid crystal will become transparent in some parts and obstructed in others, allowing some wavelength through. Like the plasma, LCD also has many pixels and each pixel has a subset of RGB parts. To illuminate this whole procedure they use a backlight to pass light through these liquid crystals to create the image. The type of backlighting in a regular type of LCD televisions is CCFL backlights. With this type of backlighting LCD televisions are the thickest of all the televisions , at 80.4mm thick on average [2]. Unlike plasma LCD are not finished with glass they are finished with a plastic that is less reflective to light so it will reduce glair

2.1.5 LED-LCD Televisions

The LED-LCD televisions are almost identical to regular LCD televisions, with only one small variation, this difference is the back light. In regular LCD's a CCFL backlight is used, while LED-LCD televisions use LED's as there lighting source. LED televisions also don't have to have the lighting at the back, they can line the sides with LEDs. This can lead to having LED-LCD being much thinner televisions and on average are only 29.9mm thick [3].

2.2 COST COMPARISON

There is only one technology that will have one set price for the display and that is the projector. There will only be one projector for the display and it will have a set cost of 900$[4]. The hardest price to judge is the electronic paper, due to the fact that it is hard to find a producer with set prices. From knowing this, the only cost we have to go off of is smaller scale E readers that go for the cost of $100 for a 5 inch screen. This would result in the cost per square inch to be approximately $20 for this display, but as you get bigger the price like many other products would go down to around $15 dollar per square inch. Plasma televisions have the best cost per square inch in almost every size they are produced at a average of $17 per inch. However they only produce televisions between the range of 40in to 60in, making it only possible to have medium to large types of displays. LCD displays are produced in a variety of sizes from 20 inch

to 60 inch, costing on average $2.33 per square inch more then plasma. Lastly there is the most expensive of all the type of televisions displays and that is LED-LCD displays. Though they have the largest variety of display sizes, the displays cost on average nearly $5 more per square inch then regular LCD and almost $7.25 more than plasma. All this these prices can be seen in table 1.

2.3 SIZE OF COMPONETS OF THE DISPLAY

One important consideration is the size of the board. The projector will make it easy to have either a large scale or small scale display. The one requirement of the projector is that it must be the right distance away from a screen. Also, the image from one projector may be divided it into many smaller displays within itself. The electronic paper display would have to be made up of many smaller displays. The reason this would have to take place is there is no major retailer that you can buy large scale displays for electronic paper. After comparing all the televisions displays size costs in table 1, the most economical way would be to make one large display made up of four medium to small size displays. Also if one television were to break down and not work, you would only have to replace that one component of the display, rather than the whole display itself.

Size	Projector	Electronic paper	Plasma	LCD	LED-LCD
20 in	44.9995 $/in	13.45 $/in	NA	10.47368 $/in	12.653846 $/in
30 in	29.9996667 $/in	NA	NA	12.46875 $/in	14.060938 $/in
40 in	22.49975 $/in	NA	12.79047 $/in	13.975 $/in	18.74975 $/in
50 in	17.9998 $/in	NA	17.64706 $/in	18.39604 $/in	27.272545 $/in
60 in	14.9998333 $/in	NA	21.65 $/in	26.65 $/in	31.6665 $/in
70 in	12.857 $/in	NA	NA	NA	64.271429 $/in
80 in	11.249875 $/in	NA	NA	NA	NA

Table 1: Price per Square Inch

2.4 ENERGY CONSUMPTION

The most energy efficient device would be the electrical paper display, after the initial arrangement of the display the still image will consume no energy at all. If the board is only still images and updated a couple times a day, it will consume negligible power. Also with this type of display there could be an integrated solar cell to power it, causing the net power consumption on the building system to be zero. Projectors have the highest power consumption of all the displays at a 270W per hour [4]. This would cost $207.65 every year ending up being very costly. Plasma is the second highest consumer at 112W per hour [5], costing $86.15 yearly, more than half of the cost of the projector. LCD has some savings on plasma with the usage of 101.1W per hour [2], costing $77.76 yearly. Lastly there is LED-LCD which cuts the power consumption almost in half again at 58.3W per hour [3], costing $44.84 yearly, as seen in table 2.

	Projector	Electronic Paper	Plasma	LCD	LED-LCD
kW per year	2365.2	NA	981.12	885.636	510.708
$ per year	207.66456	NA	86.14234	77.75884	44.840162

Table 2: Power Consumption per Year

3.0 ENVIRONMENTAL/ECOLOGICAL IMPACT

The environmental analysis of the display technology factors in effects of the environment on performance of the technology, the efficiency of the product, and the environmental impact of the product's manufacturing process.

3.1 LOCATION AND PLACEMENT

Based on renderings and layouts provided, a display screen will have a hard time capturing peoples' attention simply due to the features of the building itself. The wall to wall window and unrestricted glass ceilings will provide ample natural light into the building, but at certain parts of the day would result in glare to parts of the Atrium making the visual display hard to see.

Ideal locations for the Display board would be against the walls near the centre of the building; examples being on the wall under the stairwell to the right in Figure 2. The idea of having the display in darker areas mean higher contrast visibility and less chance of glare from sunlight.

Figure 2: Rendering of SUB Atrium

UBC_SUB_Render_INTERIOR low res [9]

3.2 OPERATING COST

Energy costs of operating these various display technologies have been discussed previously. It is also important to consider maintenance costs during the lifetime of the display. Based on Consumer Reports (via sampling forums and online user accounts), users that paid for non-warranty repairs spent on average of $264 on LCD and $395 on plasma displays [6]. This means that on average, plasma screens require more expensive parts and may need replacement more often. This makes LCD screens less wasteful in that it requires less upkeep.

At the same time, the display is going to be powered close to 24 hours a day and will need to be as bright as possible during the day for better visibility. This makes projectors an unsuitable candidate, as high heat of the projector bulbs make replacements common and costly.

3.3 MANUFACTURING IMPACT

The environmental impact of the product starts from the manufacturing process, throughout its lifetime, and after disposal. It is important to place preference on products with low ecological footprints and minimal environmental impact. Taking plasma/LCD/and LED monitors as having roughly the same manufacturing process, studies have been conducted that show that in these flat panel displays water eutrophication and aquatic ecotoxicity were more pronounced compared to other forms of displays [7]. When comparing the manufacturing stages of each monitor type in the baseline scenario, the LCD has greater relative burdens on the environment in eight categories. Energy, global warming, and human health toxicity impacts are also presented in greater detail, showing contributions from each life-cycle stage [7]. It is also important to consider a recently discovered "green house gas" nitrogen triflouride (NF3) used as a plasma echtant for thin-film liquid crystal displays. If all the NF3 produced this year were to be released into the atmosphere, it would be on par to adding 67 million tonnes of carbon dioxide to the air. But since only 1-2% escapes into the atmosphere, it is considered non-distressing [8].

Comparatively, CRT and projectors have lower manufacturing waste and disposal impacts. With regards to shipping, projectors require the least amount of packaging and shipping cost. In this category, projectors have the advantage of reduced ecological footprint in manufacturing, transporting and disposal.

4.0 SOCIAL IMPACT

The form of the physical display does not significantly influence the social impact of the display providing it is sufficiently visible throughout the day in various lighting. There are two main factors for the display that influence the individual's social awareness. They are how engaging the display content is and how visible are the location or locations are in which the displays are placed. As there is little relevant literature or previous studies on the specific topic of engaging individuals in sustainable thinking through visual displays, a survey was conducted to answer these questions.

It was important to create a survey that accurately represented the full spectrum of individuals that may utilize the new SUB. To achieve this, students were surveyed both at the SUB and on the other side of the campus. As well several fundamentals for creating a survey outlined in the webpage "How to Write a Good Survey" [10]. The specific points that were found helpful were ensuring that the wording of questions could not result in them be interpreted in different ways and keeping the questionnaire short. The survey that was used may be found in Appendix A.

Several trends were observed in the results of the survey. The first question determined the frequency that individuals used the current SUB. It revealed, though intuitive, that the individuals surveyed in the SUB use the building far more frequently than those not surveyed in the SUB as seen in table 3.

	3+	2	1	<1	<1/month	Total
SUB	30	2	2		2	36
Non Sub	3	3	5	2	1	14
Total	33	5	7	2	3	50

Table 3: Frequency of Visits to the SUB

The second question focused on the reasons that the individuals use the SUB most frequently and the results may be found in table 4. The primary reason that individuals responding to the survey listed for using the SUB was to buy food. This however may be biased due to the individuals that were willing to take the survey. It was observed by the surveyors that individuals who were studying were less likely to respond to the survey stating that they were busy while those waiting in line and eating were more likely to respond. In order to take a survey that truly representative, it would have to be conducted in a manner that was not impacted by which individuals are willing to respond at the time. A possible solution to this problem is to conduct a survey online or through email.

	Food	Beverage	Studying	Social	Other	Total
SUB	30	2	2	2		36
Non SUB	6	3	1	2	2	14
Total	36	5	3	4	2	50

Table 4: Most Common Reason for Visiting the SUB

The third question focused on which content students would find most interesting. The options included facts about "Green Technology" used in the SUB, real time updates of the power the building is using, trivia about green technology and sustainability, tips on how to reduce an individuals impact on the environment, maps of the building and campus, and a twitter feed where questions may be posted. The results for those interviewed in the SUB, not in the SUB, and the combined totals may be found in table 5, 6, and 7 respectively. The choices that scored the highest were facts about the new SUB and tips on reducing ones environmental impact. Therefore it is suggested that these two options are used as the core content for the display. The other options that were real time updates, trivia, and maps were also felt to be interesting and may be used to supplement the other display content. The one option for display

content that scored the lowest and is not recommended is a twitter feed where individuals may post questions. It was felt that the main reason for this option scoring so low was that only a small segment of student have or use a twitter account and therefore it engages a smaller percentage of students.

Choice	Facts	Real Time	Trivia	Tips	Maps	Twitter
1	8	5	2	7	9	5
2	6	6	7	13	3	1
3	10	7	10	2	6	1
4	7	10	4	7	4	4
5	1	6	10	5	10	4
6	4	2	3	2	4	21
Mean	2.97	3.33	3.61	2.89	3.42	4.78

Table 5: Response to Display Content SUB

Choice	Facts	Real Time	Trivia	Tips	Maps	Twitter
1	3		4	3	4	
2	6	1	3	2	2	
3	3	6	1	3		1
4	2	6	2	3	1	
5		1	4	2	4	3
6				1	3	10
Mean	2.29	3.5	2.93	3.14	3.57	5.57

Table 6: Response to Display Content Non-SUB

Choice	Facts	Real Time	Trivia	Tips	Maps	Twitter
1	11	5	6	10	13	5
2	12	7	10	15	5	1
3	13	13	11	5	6	2
4	9	16	6	10	5	4
5	1	7	14	7	14	7
6	4	2	3	3	7	31
Mean	2.78	3.38	3.42	2.96	3.46	5.00

Table 7: Total Response to Display Content

The final question posed to students was when they felt it was most likely that they would watch a display. The results are found in table 6 and it was seen that the majority of students believe that they are most likely to view displays if they are waiting in line or eating. As can be seen the results are similar to the observations made by the individuals conducting the survey that individuals studying are less likely to engage in another activity, while those in a line or eating are less opposed to participating or viewing something. From these results it was determined the best location for these displays, in terms of social impact, are highly visible locations where students may be able to observe them from the food courts or eating areas.

	Lines	Eating	Studying	Socializing	Other	Total
SUB	20	12	1	3		36
Non SUB	10	3		1		14
Total	30	15	1	4	0	50

Table 8: Location Most Likely to View the Display

5.0 CONCLUSTIONS/RECOMMENDATIONS

The lowest initial cost of all displays would be the plasma television, but due to its power consumption, after a couple years of use it would become more expensive. Plasma televisions also only come in larger size displays, therefore it you cannot make a large display from several smaller displays. If the plasma television breaks you will have to buy an entire new display, rather than one component. Projectors had lower manufacturing and transportation impacts, but highest waste during use due to the need to replace the projector lamps. There is also the issue that in the well-lit atrium it would be extremely difficult to view the projectors image. Although electronic paper requires very little power, there are no commercial retailers of large-scale versions.

It was concluded that LED-LCD televisions would be the best choice after conducting the triple bottom line analysis. Even though they have the highest initial cost over time with the power savings, of half of other flat screen televisions, it would be more economical than regular LCD's or plasmas. Also due to these power savings, LED-LCD televisions fair reasonably environmentally in comparison to projectors and better than plasmas and LCD's. This is in spite that both LCD's and LED-LCD's panels had higher environmental impact during disposal due to the materials used having potential to contribute to greenhouse gasses. Based on the researched results, LED-LCD displays were recommended based on the triple bottom line analysis.

It was determined through a survey conducted of 50 students that the most effective content for the display screens be facts about sustainable technology used in the new SUB and tips for individuals on how to reduce their environmental impact. Real time updates of SUB power consumption, trivia, and maps are all also suggested as supplemental content as they received an average score. Finally it was determined that the most beneficial locations to place the displays are in high traffic area where individuals waiting in line or eating may observe them, but do not obstruct the windows that provide natural light.

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APPENDIX A – SURVEY QUESTIONS

1. How many times do you visit the SUB per week?

3+ 2 1 < 1 < 1/month

2. What is the most common reason you visit the SUB?

Food Beverages Studying Meeting Spot Others

3. Rank in the order of what would be most interesting and engaging to you:
   _____ - Facts about "Green Technology" used in the SUB
   _____ - Real time updates of the power the building is using
   _____ - Trivia about green technology and sustainability
   _____ - Tips on how to reduce your impact on the environment
   _____ - Maps of the building and campus
   _____ - Twitter feed where questions may be posted

4. When do you think you are most likely to view the display?

Waiting in line Eating Studying Socializing Other