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Playponics in India - Local Hydroponics Playground Gardens Utilising Kinaesthetic Learning to Promote Global Sustainable Practices

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Abstract. This research and development project set out to investigate possible means by which future populations might have or build closer links with environmental issues. The work has integrated the diverse fields of sustainability and STEM education, global products and local production. It aims to bring these aspects together in holistically considered learning environments where these elements can coexist in engaging ways.

This paper highlights the intended benefits to students of engagement in these systems such as cognitive development through practical or 'kinaesthetic' learning. The outcomes intent is that students who take part also learn how to implement basic mechanical knowledge that, according to school curriculums, are currently part of textbook education alone, "...most Indian classrooms remain dominated by rote-learning" (Learner-centred education reforms in India, Suzanna Brinkmann, 2015). Our intended forms of learning aim to impart a spirit of innovation and experimentation, whilst being surrounded by elements of nature. In this work we explore how we learn about and 'instil' senses of responsibility and empathy, community and co-operation in future populations towards greater environmental sustainability.

We report and discuss various strands of the research to date including methods to identify and develop the concept. We conclude that evidence to date strongly indicates high levels of acceptance of this approach and report on our progress, findings, and our anticipated next steps. This project is being funded through Global Challenge Research Fund (GCRF) and E the Research England, Expanding Excellence England (E3). The work is collaboration between Designers from Lab4Living at Sheffield Hallam University in the UK, businesses in Delhi, and has been delivered jointly by Playponics design research teams in the UK and India.

Keywords: Sustainability, STEM Education, Kinaesthetic Learning, Play, Hydroponics.

1 Introduction

This study involves apparently unconnected topics; physical play, environmental sustainability and early years STEM education delivery. The research has led the team to propose a new kind of sustainability education concept, a physical play park for schools that 'captures' children's play energy and uses it to help sustain edible crops. Although this applied research is at early to intermediate stages, this disclosure discusses and positions our thinking, rational, research themes and methods when designing in these 'spaces'. From practicing designers' perspectives, we consider what kinds of learning mechanisms can be capitalised upon when designing educational experiences, and how these diverse headline topics might be holistically considered and integrated into new learning experiences. We explore the role of physical play in learning about STEM and design education, with the aim of increasing awareness in future populations of environmental sustainability issues. We focus on and discuss four key aspects of the study, namely issues about Sustainability, Education and STEM education, the provision of globally relevant products that support sustainability and locally sourced production. Finally, we discuss the concept and conclude.

2 Sustainability

Our focus in this study is early year's education and relationships future generations will have with our world, how we consume, and the balance between consumption and living in more sustainable ways. With India's middle classes on the rise (data indicates the group is set to grow rapidly, from around 80 million today to 580 million people by 2025), is it sensible that these developing societies 'ape' the consumption patterns the so called 'developed' countries have? Excessive consumption, pollution, natural resource depletion and a disconnect from nature have been the warning cries of environmentalists for many years. This project specifically explores ways children might engage in learning about those issues, how we may instil knowledge about sustainable living, through education which in turn may help us to reconnect with and value natural systems. '...today's global imperatives - to eradicate poverty and improve wellbeing, while restoring the Earth's balance - form a single agenda, and that the most effective means of achieving it is education (Bokova, 2015).

A motivation for undertaking this work is, in a pragmatic sense, is 'how' we achieve this learning and potential behaviour change as 'Alongside any form of promotion of learning about issues such as climate change, ...there needs to be consideration of how children learn about (it)' (Bourn, 2016). Our research takes 'why do it' very much for granted, and focuses on 'how'.

This is perhaps most adequately captured in the World Economic Forums article 'Why education is the key to sustainable development' which includes that '...education can bring about a fundamental shift in how we think, act, and discharge our responsibilities

toward one another and the planet. After all, while financial incentives, targeted policies, and technological innovation are needed to catalyse new ways of producing and consuming, they cannot reshape people's value systems so that they willingly uphold and advance the principles of sustainable development. Schools, however, can nurture a new generation of environmentally savvy citizens to support the transition to a prosperous and sustainable future.' (Bokova, 2015) 'Reshaping people's value systems' is of particular interest and importance to our work.

3 STEM Education

Reports from various media channels confirm that the condition of government schools in India is poor; 'The Union government may have made right to education a fundamental right by bringing into force the Right To Education (RTE) Act of 2009, but government schools are lagging far behind in providing quality education...' (Government schools imparting poor quality education, 2018). Further, a significant proportion of the population cannot afford private education. It is referred to as a commodity that is not affordable for all; 'Being a publically provided private good, Education needs a greater focus on Accessibility, Equity and Quality...' (ESAG-2018.pdf, 2018).

Many schools lack basic amenities; in short transformation of education in India, and around the world, is needed. Keeping in mind sustainability education problems faced by these students we have researched, designed and propose school playgrounds that harness 'play energy', to help power that change. In one embodiment, we proposed that playground equipment is used to facilitate hydroponic crop growth and is constructed and deployed using locally sourced materials like bamboo, readily available at economically viable rates in country.

'Too often, as architects, engineers and owners, we get caught up in sustainability codes and guidelines and neglect to consider what might be most logical--and effective- -for a specific building, client or locale.' (AP, 2009)

Working with educationalists and schools in the Delhi region, designers established broad frameworks of understanding and developed their knowledge of different types of education provision in India. This included lay understanding of government and privately funded school provision, the quite diverse nature of infrastructural situations and a sense of school staff opinion and willingness to engage in sustainability education curricula.

A finding of school visits and subsequent investigations was that there is opinion within teaching staff that traditional pedagogical methods need to change, or at least require augmentation, as the very nature of children's experiences, expectations, and their inherent capabilities have changed. These aspects were cited as being due to increasingly

consumerist behavior and a change towards faster paces of family life, but predominantly due to technological advances. This view was reinforced by literature in terms of changing pedagogy in the context of sustainable lifestyles, in that ‘...today's youngsters are born into an India that readily embraces consumerism with all its accompanying trappings. Besides being surfeited by a plethora of toys and gadgets, the average middle-class child is tethered to a global network that tends to homogenise childhood. As childhood has undergone tumultuous shifts, the dynamics of classroom life have been altered.’ (Sankaranarayanan, 2011), and that consequently, ‘Teachers cannot rely on plain chalk-and-talk anymore but have to keep pace with a generation raised on a multimedia diet.’ (Sankaranarayanan, 2011).

Alongside methods used to teach children, who are reported as 'having increasingly short attention spans', notions were expressed that the curricula itself can be ‘out of date’ and ‘bland’. ‘... syllabi for various subjects continue to remain dreary and uninspiring. Students continue to cram information to score marks without engaging actively and meaningfully with content.’ (Sankaranarayanan, 2011). It was also found that although embraced by some schools, and evidenced in some state/authority curricula, educational syllabuses seldom have a specific focus on sustainability issues delivered through experiential learning. ‘...even after Environmental Education was introduced as a compulsory subject, we have not managed to cultivate a green conscience in children.’ (Sankaranarayanan, 2011).

Reportedly, current ‘...awareness of environmental issues comes not from direct engagement with the environment itself but from a more passive and indirect understanding of these issues. Direct interaction with the natural environment appears to be increasingly absent in children's lives and this new phenomena gives rise to concern because such experiences are essential in developing children's knowledge and understanding of the world.’ (Bokova, 2015). Although somewhat anecdotal, discussions proved highly valuable in terms of building understanding in designers of current contexts, which served to reinforce designs premises.

The design team (not being educationalist) needed to build understanding of what kinds of learning mechanisms, or ‘modes’ exist, and which ones may engage learners to greater or lesser extents. Discussions with educationalists led the team to understand degrees to which current provision relies on ‘traditional’ repetitive, information transfer, or ‘rote-learning’. Investigation confirmed that “...most Indian classrooms remain dominated by rote-learning” (Brinkmann, 2015), or at least that was reported to be the case up to 2015. The team investigated a range of teaching modes. By way of summary, we adopt educational theorist Neil Fleming’s VARK model in explanation. ‘VARK is an acronym that refers to four types of learning styles: Visual, Auditory, Reading/Writing Preference, and Kinesthetic.’ (The VARK Modalities (2019) A Guide to learning Preferences).

Design researchers came to understand this model and that it upholds that there are favoured ways learners absorb and hold onto knowledge. The designers came to appreciate that the Playponics proposal may be more in line with the Kinaesthetic learning modality because, by definition, it refers to “perceptual preference related to the use of experience and practice (simulated or real). Although such an experience may invoke other modalities, the key is that people who prefer this mode are connected to reality, either through concrete personal experiences, examples, practice or simulation.” (Fleming, 1992).

Therefore, the principles and practices of kinesthetic learning are of particular interest to the design team, as it is ‘a learning style in which learning takes place by the students carrying out physical activities...’, and that, ‘The key is the reality or concrete nature of the example. If it can be grasped, held, tasted, or felt it will probably be included. People with this as a strong preference learn from the experience of doing something and they value their own background of experiences and less so, the experiences of others.’ (The VARK Modalities, 2019). It is not suggested that other cited modalities will be void in this example, as ‘...such an experience may invoke other modalities’.

The team have invested in research to build knowledge about educational mechanisms that ultimately are the purpose of this work. However, a wide range of other technical, maintenance and facilitation research was required. This includes investigation of physical formats of play equipment and appropriate energy capture systems integration, building knowledge about what is preferred, safe and practical. A pilot workshop with Indian children aged 11 years was undertaken where the kids were asked what kinds of play format they thought was ‘fun’.

Based on feedback from local schools the design intent now includes the development of materials intended for the education of staff and students in regard to maintenance of play systems, the hydroponic (and/or horticultural), and back-up systems. Back-up systems were agreed to be essential to ensure crop survival out of school hours. We further established that it would be feasible, in principle, to integrate these backup and maintenance regime into the taught programmes.

Through these engagements the team further recognised that, in the spirit of sustainability, proposed systems needed to be designed with respect to local materials fabrication, manufacture, installation and maintenance. Being trained and experienced product designers (and capable makers), a phase of research activity focused on local resource provision and experimental fabrication. This was undertaken to ensure proposals could be locally made, both in terms of materials, available skills and tools.

Our focus is to make each setup effective and efficient using sustainable materials in different parts of the country. This will help the children in identifying sustainable materials and practices. The crops produced by the setup can be used in the school kitchen, sold in the market to generate funds for the school / community or to maintain hydroponics playgrounds themselves. Following successful test runs, educational content

will be developed and distributed to students and faculty members of the schools to inform curricula.

Another focus of this study is to make the setup as simple as possible so it is easy to maintain for the students, and become part of their early stage STEM education. The project aims to reach out to as many under privileged schools as possible following our first prototype installation.

4 The Concept

At the emerging concept's heart is learning through physical play enabled by bespoke designed playground equipment. This equipment is augmented with systems that in turn enable crop production. In this scheme, physical play energy expended by children is made tangible, harnessed, stored and used to help facilitate crop growth. In this way, from an educational perspective, we aim to help address shortfalls in current 'information transfer only' (or 'chalk-and-talk') type teaching such that 'Rather than just being informed about the environment and the wider world, children will be supported in both understanding and experiencing (it)' (Rickinson, 2006).

Amongst the many business infrastructure, economy, materials and fabrication facilitation challenges around how such systems will be implemented in India, the teams focus was very much on how Playponics system would manifest. This diverse research set led the team to further refine and develop the Playponics system (see figure 1.). In this most recent concept we bring together and integrate diverse subject matter. For example, in technical facilitation we can demonstrate that children riding a seesaw [A below] fitted with pumps (engineering) [B], can effectively transfer water around the play learn system. As water is pumped it is retained by a 'header tank' (energy storage) [C] that in turn gravity feeds (physics) [D] nutrient rich water through a hydroponic crop growing frame (horticulture) [E].



Figure 1. The resulting 'Playponics' set up on display at the Griha Summit, Delhi, December, 2019.

The evolved installation design requires levels of maintenance that include mechanical, electromechanical and hydroponic systems management. The original concept ethos was that these processes include the child and school community. In discussions with educators on the ground this 'maintenance' was not deemed overly complex. It was felt that integrating specific topics into taught curricula may be problematic, but that in time these could be overcome.

5 Next steps

Our applied research has been planned in two distinct phases. Firstly, we identify known elements impacting upon the design of proposed educational play systems that include technical, teaching community, horticultural, and at a natural environmental level. This first level research informs physical design of systems we implement and test. A mixed methods approach is used in this first phase including desk based, interview and experiential research. Secondly, we plan to install and monitor systems arising from first stage research and attempt to measure their education benefits and impact. At the time of writing (December 2019) we have not commenced second stage research. The following outlines some key aspects of our enquiry to date.

To date we have developed these designs and the rationales for their implementation to proof of concept levels. Our current challenge is to refine these designs, install working systems and gather the pedagogical evidence to a stage that enables 'buy in' from schools. One school in India has stated that the proposal fits well with their ethos and ambitions for their pedagogy.

6 Discussion

We explore the position that engagement in this play 'ecosystem' by children (aged 6 to 12 years) will show benefits in developing primary stage understanding of STEM and Design subjects alongside broader lessons about cause, effect and cooperation. The term 'ecosystem', most usually used to define 'a biological community of interacting organisms and their physical environment' (Oxford Dictionaries definition) is used literally here as we explore integration of child learning through play, with building and embedding of early stage knowledge associated with horticulture.

In respect to learning about sustainability issues, education is key to our population's health, wealth and security. Although a simple idea, the benefits of this approach to play and sustainability technology education could be multifaceted. As a result of our research, we now consider the benefits in three primary ways.

- i. Benefits derived as a result of taking part in physical play, both cognitive and in terms of a child's healthy, physical development.
- ii. In the child's developing mind, the building of understanding about the relationships between physical effort made and a crop's subsistence (knowledge building around biological systems, cause and effect, ecology and symbiosis).
- iii. Design and STEM educational benefits derived from very real and tangible, physical interactions with the mechanisms and systems that enable energy capture, storage, transmission and utilisation, through the kinesthetic learning modality.

Added to these primary benefits for the child are potential wider social lessons, about community (teacher, parent, student, school) engagement, co-operation, nutrition and the bigger topics of future sustainable living. We further plan to test if the dependency of the crops on the use of the playground equipment actually encourages the children to play more.

The key anticipated benefits of the original concept were those associated with regular physical activity (PA) in promoting children's health. These, the team found, are well

known and understood. Further though, PA is associated with improvements in children's intellectual development, 'PA has a positive influence on cognition as well as brain structure and function' (Donnelly, 2016). However, for many schools, it can be hard to put programs into practice that bring about such holistic advantages. On presentation to teaching staff it was agreed the concept may be an appropriate 'platform' to enable multiple benefits.

The concepts were based on multiple lay understandings across a range of specialisms (education, hydroponics, physical activity, etc.) and as such initially, arguably, held a simplistic premise. Nonetheless, the concept acted as a catalyst to help identify, probe and validate aspects of the proposal across a range of more complex topics, from local cultural contexts to enabling technologies. Their subsequent development and manifestation, in the form of sketches and working prototypes sparked the imagination of the designers and collaborators. The concepts iterative development has resulted in what we now term a 'play grow ecosystem', and these approaches continue to gather momentum.

7 Conclusions

This phase of research concludes that multi-modal research is essential when we seeking to design learning systems that aim to have holistic benefits. The study has demonstrated degrees of 'validity' to the original proposition and strongly indicates high levels of in principle acceptance of the developing concept. Where our aim is to instill these understandings in children so that they may carry sustainability knowledge with them into adulthood, and where we propose integrating learning modes, mechanisms and topics as a means of achieving that, the breadth of our research needs to be as equally all-inclusive. Designers of learning systems must undertake research into each, often (on the face of it) diverse topic areas as holistically as possible, and it is this breadth of research that informs designs appropriateness for progression.

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