Development of ControLearn SDBT: A Low-Cost Bubble Tube for Sensory Skill Development in Individuals with Learning Difficulties

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Abstract

This paper presents ControLearn SDBT, an affordable version of a sensory development bubble tube that provides visual, tactile and auditory stimulation to children with learning difficulties (LDs). The literature review on the use of bubble tubes for development of multi-sensory skills in children with LDs demonstrates that it is an effective tool. The materials used are described with their cost.

ControLearn SDBT uses affordable parts and an open source software Arduino to make it extremely affordable and offers an array of features in addition to the choice of the level of complexity as per users' requirements. It offers a 92 percent cost saving over the bubble tubes currently available in the market. Testing the prototype with twelve children with LDs at a pyschologist's clinic showed that ControLearn SDBT leads to marked improvement in challenging behaviour, communication and prosocial behaviour, concentration and engagement, enjoyment and relaxation of the users.

Keywords: bubble tube, learning difficulties, multi-sensory environment, India, affordable

Introduction

Sensory stimulation for individuals with cognitive disorders (LDs) is not a novel concept. In 1866, Sequin (1971) employed it as one of the educational methods for youngsters with learning disabilities. Kwok, To, and Sung (2003) found that the utilisation of these kind of activities to satisfy the complex requirements of individuals with LDs has increased significantly in the last 15 years. Applied behavioural analysis was utilised in the majority of investigations, but physiological measures were employed in a minority (Hogg et al, 2001). Bunsen (1994) documented the favourable results of using Snoezelen at Limington House School and Whittington Hall Snoezelen Project. The majority of participants found the Snoezelen programme to be fun and calming, and their problematic behaviours decreased as a result. Lindsay et al. (1997) did a study to determine the efficacy of four restorative therapies for people with severe LDs. They found that Snoezelen helped with concentration and seemed to be more enjoyable than hand massage and active therapy.

The original goal of Snoezelen was to create a place where people with LDs could be stimulated, relax, and have fun without having to do anything.. The underlying principle was that individuals with significant disabilities can engage in delightful leisure activities for their personal reasons, instead of compulsion. The carers were expected to share and engage, and to allow the participant to derive full pleasure while retaining control. It allowed persons with severe disabilities who were unable to engage in art to engage in delightful leisure activities and develop relationships with their caregivers (Stephenson, 2002).

Kwok (2003) stated that a Snoezelen room can help with nine things: 1) relaxation; 2) building self-confidence; 3) gaining a sense of self-control; 4) encouraging discovery and artistic activities; 5) building relationships with caretakers; 6) providing leisure and enjoyment; 7) encouraging choice; 8) improving attention span; and 9) reducing difficult behaviours.

In the US, UK, and Australia, schools for students with severe disabilities are getting more and more Snoezelen rooms and other multisensory environments (MSEs) (Stephenson and Carter, 2011; Botts et al., 2008). Upwards of 50 per cent of the schools in Australia's New South Wales (NSW) that take in students with severe disabilities and responded to a recent survey said they had an MSE (Stephenson and Carter, 2011).

Intelisense (2000) discusses about how MSEs are set up and how they can help motivate people and be used as a place to directly teach therapy goals, especially motor skills. Based

on this characterization, an MSE uses music, sound, and light to respond right away to a person's preferred motor pattern and to encourage and incentivize movement that the person chooses to make. Several cases demonstrate that students who touch and press a strategically placed switch are rewarded with sensory effects (Stephenson, 2002). Friends of the Willows (1998, p. 79) says that an MSE has "switches like pressure pads and sound-activated switches that can turn even the smallest action into a meaningful reward. This means that we can actively encourage effort by giving each person a reward that is relevant and enjoyable to them."

Teachers agree, according to research, that MSE helps kids with LDs focus on certain tasks with very little distraction (Stephenson, 2011). Holt (2000) and Porter (2000) also discuss how switches and multisensory rooms can be used to help teach control. They maintain that MSEs can be used as a way to motivate children with LDs to learn how to use switches, that a session in an MSE can help them pay more attention to the task at hand, and that using MSEs fosters positive relationships and trust. A study by Stephenson and Carter (2011) found that teachers specifically gave importance to the skill of visual tracking and choice making that is developed by MSEs. Hotz, Kuluz, and Castelblanco (2006) discovered that Snoezelen therapy is also beneficial for children healing from severe brain injuries.

In addition to research on the benefits of MSEs, some studies focus on the advantages of using a bubble tube for children with LDs. Typically two metres in height, a bubble tube is a cylindrical tube filled with water. When engaged, bubbles flow continuously upwards, and the water's colour can be altered using coloured lights. The bubble tube primarily provides visual stimulation. However, the motor of the bubble tube causes it to vibrate, so providing tactile stimulation, and makes a buzzing sound, thereby providing auditory stimulation. (Unwin, 2019).

According to Kwok, To and Sung (2003), bubble tubes provide an additional appeal for students who enjoy feeling the vibration in addition to viewing the visual effects. Its portability also makes it easier to transport to other locations throughout the school. Children with LDs and even hearing impairments love touching and feeling the bubble tube and staring in the linked mirror, according to studies (Kwok, To and Sung, 2003). A bubble tube is an indispensable component of any sensory room or multisensory environment. It offers numerous advantages, including visual stimulation, the development of cause-and-effect skills, the comprehension of colour sequencing and colour matching, and the promotion of

touch through vibration. A bubble tube is an excellent approach to promote visual development and effective communication for those with a wide range of sensory issues (TTS Group, 2022).

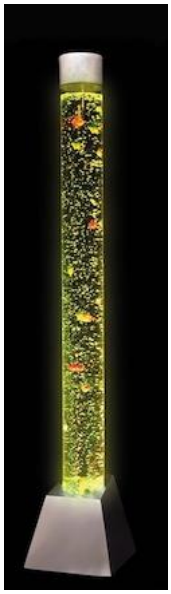
Thus, MSEs and more specifically bubble tubes are important in the learning process and treatment of people with LDs as they contribute to trust and relationship development, as well as fun and enjoyment for users (Stephenson, 2002).

Concept Overview

Currently several types of bubble tubes are available in the market. Some of the most commonly used ones are the Quiet Interactive Sensory Bubble Tube by Playlearn and Active Bubble Tube by Rhinouk. The average cost of a standard bubble tube is around INR 65,000 (C. Desai, personal communication, September 25, 2022).

A bubble tube consists of a pipe that is filled with water and contains air stones through which air is pumped out as bubbles. These air stones are connected to an airpump via a one way valve. A microcontroller controls the pump, as well as the LEDs, where the software inside creates cycles of changing colours. Most standard bubble tubes comprise of a long acrylic tube, RGB LEDs and a remote controller to control the lights and bubbles (Apollo Creative, 2021).

Figure 1: Standard Bubble Tube



Source: https://www.tts-group.co.uk/primary/sen-special-direct/sensory/sensory-room/bubble-tubes/

ControLearn SDBT is a Sensory Development Bubble Tube that uses affordable parts and an open source software to make it extremely affordable. It also offers consumers the choice to choose the level of complexity of the bubble tube as per their requirements. The use of Arduino open-source electronics platform enables offering an array of features that are unprecedented for bubble tubes.

The use of Arduino enables programming of WS18282B RGB LEDs and creation of different light environments that help capture the subjects' attention and improve their attention span as well as information retention. Additionally, it enables them to learn to identify as well as distinguish between different colours that further promotes development of their visual senses. Arduino Uno also allows for the control of bubble speed through the dimmer circuit module that is connected to the air pump. This allows programming of the air pump to five different levels of air output, corresponding to six different speeds at which the bubbles are released, which can be switched between speeds with a button.

The open source Arduino as the main controller of the entire circuit makes it easy to update the code in the future, use open source libraries, and add new sensors to the system. This is where modularity and complexity come into play. By attaching sensors and modules to the Arduino, ControLearn SDBT can exploit the already optimised Arduino libraries to add further applications.

Arduino is an open-source electronics platform that was made at the Ivrea Interaction Design Institute. It consists of user-friendly hardware and software. Arduino boards may convert inputs such as a finger on a button, light on a sensor, or a tweet into outputs such as activating a motor, activating an LED, or posting online. Using the Wiring-based Arduino programming language and the Processing-based Arduino Software (IDE), the user can can send a sequence of instructions to the microcontroller on the board (Arduino, 2022).

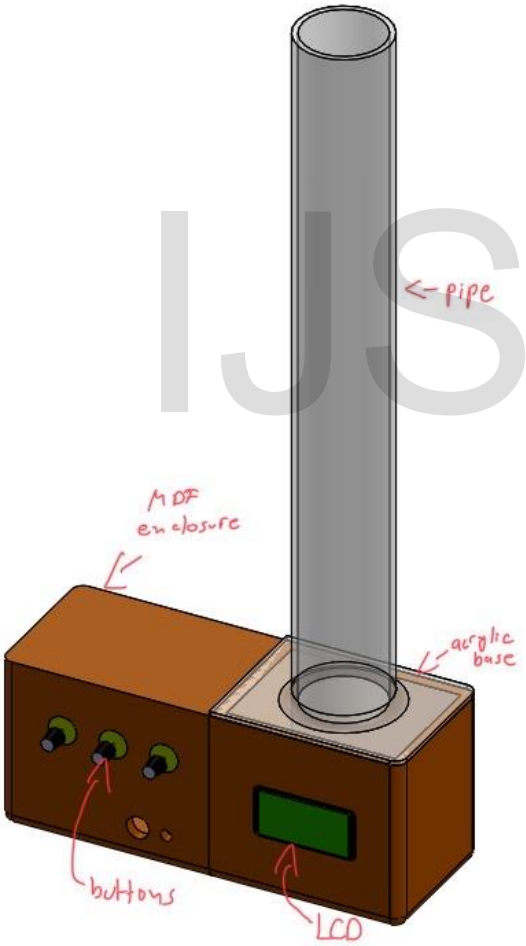
The base model of ControLearn SDBT include the RGB LED and various buttons, to which various other parts can be added as per the user's needs.

Some of these optional additions are:

- The dimmer module that can control the speed of the motor
- The speaker which can be used to give audio cues to the button presses, which is extremely useful to the user

- The ultrasonic sensor which saves energy by turning the tube on only when someone is near it. The distance can be programmed according to user preference.
- The LCD which is useful to show the different modes
- The water sensor module to provide alerts for water leakage. The alerts can be received through message in LCD display or sound from speaker.
- The HC05 module which allows the user to control the bubble tube using a mobile phone

Figure 2: ControLearn SDBT prototype



Two models are proposed:

i) ControLearn SDBT – a less expensive model with less features,
This model will not have a dimmer module or any other modules(speaker, ultrasonic sensor, the LCD , HCO5 bluetooth module, and water sensor module). It

will have the cheaper Arduino Uno, along with the WS18282B (Programmable RGB LED). This will allow the user to change the colour using the single button provided, he/she would not be able to change the speed of the bubbles produced, or hear a corresponding sound to the change in colour.

ii) ControLearn SDBT Plus - a more expensive and accessible model with more features

ControLearn SDBT Plus will have all the features of ControLearn SDBT, but will incorporate a Arduino Mega, dimmer module and a speaker, which will allow the user to change the bubble speed, and hear a sound corresponding to the change in colour.

No matter which model a user buys, the option to include any specific part to the system is available. These parts include the dimmer module, the speaker, the ultrasonic sensor, the LCD , HCO5 Bluetooth module, and water sensor module. The user also has the option of increasing the size of the acrylic pipe, which can help incorporate more features.

Materials

Table 1 below shows the components used for the standard model ControLearn SDBT.

Table 1: Materials for ControLearn SDBT

Sr. No.	Component	Dimensions	Cost (in INR)
1	Pipe	82mm (outer diameter) by 600mm (height) by 0.5 mm (thickness)	1000
2	MDF Sheet 12mm		100
3	MDF Sheet 8mm	436mm (length) by 224 mm (width)	100
4	Longer side wall X 2	412mm by 60mm	50
5	Shorter side wall X 2	224mm by 60mm	50
6	Partition between bubble tube side and circuit side	200mm by 60mm	50
7	Bubble tube supports X 2	200mm by 40mm	50
8	Laser printed acrylic base	180mm by 180mm	35
9	air stones X 4		80
10	T-connectors and 4mm plastic pipes X 2		50
11	Air pump		245
12	One Way Valve (Non-Returnable Valve)		116
13	Dimmer AC module		850

14	Arduino	69mm by 54mm	1000
15	WS18282B (Programmable RGB LED)		390
16	Push buttons X 3		54
17	Breadboard	46mm by 36mm	75
18	40 Jumper wires each (male to male, male to female, female to female)		230
19	Arduino power cable		500
20	LCD		150
	TOTAL COST		**5175**

Thus, the ControLearn SDBT prototype represents a savings of 92 percent over a standard bubble tube sold by leading brands. This cost saving is a huge advantage and will help increase accessibility of the bubble tube to children with LDs in a developing country like India.

Application

ControLearn SDBT is a revolutionary sensory development aid to be used for relaxation and sensory development of children with developmental disorders such as Autism, ADHD, etc. Additionally, by adding buttons and giving them control over colors and speed of bubbles, ControLearn SDBT can help teach control through switch use.

Children's visual skills develop when they view bubbles being released at varying speeds under different light conditions in a controlled multisensory environment. By tracking bubbles as they rise up, they are able to improve their visual skills (Experia, 2022). Additionally, by learning simple body movements such as pressing a button, students with major physical impairments who find such movements extremely difficult at first can eventually perform more complex body movements and improve their daily lifestyle.

Testing and Feedback

The ControLearn SDBT prototype was tested on 12 children with learning disabilities by giving them four one-hour sessions with the bubble tube over a two-week period in August 2022, with the support of Dr. Chinmay Desai in Ahmedabad.

The testing revealed positive feedback about ControLearn SDBT and showed that it led to improvements in terms of challenging behaviour, communication and prosocial behaviour, concentration and engagement, enjoyment and relaxation (Chan et al, 2010).

Ten out of twelve children demonstrated marked decrease in aggression and self-injurious behaviour after the four sessions. Aggressive behaviour includes tantrums, crying bouts and biting (Kaplan et al, 2006). All the children demonstrated increase in overall positive behaviour including soft touch, non-threatening gaze and laughter and a decrease in negative behaviour such as screaming and pulling away. There was a marked increase observed in terms of concentration, engagement, enjoyment and relaxation too.

These findings of the testing of the prototype are in line with earlier studies such as Kwok et al. (2003), Kaplan et al (2006) and Lindsay et al. (2001).

Conclusion

The tests and experience of using the ControLearn SDBT prototype shows great promise for the future. The bubble tube performs well in terms of improvements in challenging behaviour, communication and prosocial behaviour, concentration and engagement, enjoyment and relaxation. The researcher will continue to test the prototype with more children and adults with LDs, and make changes to the materials, if needed.

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