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A Smart Hydroponics-Based System for Child Education

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Abstract: In this paper, a novel smart system based on hydroponics is proposed. It is aimed to help educate children by contributing to their improvement on cognitive domain, affective domain and psychomotor domain. This hydroponics-based smart education system is task oriented, does not interfere the child's daily needs such as studying and sleeping and includes instant child control. It is an interdisciplinary system which consists of Android application, Raspberry Pi, Web server, MySQL server and hydroponics system components. Improvement of children in terms of cognitive, affective and psychomotor could be contributed with this system's various features.

Keywords: Smart system, mobile application, embedded system, Web, MySQL, hydroponics system, child education, cognitive domain, affective domain, psychomotor domain
Categories: J.7, K.3.0, K.3.1, K.8.0, K.m

1 Introduction

With the rapid development of technology, technological products have been used in every part of human life in general. Education is one of them. There are various technology related works for education. Some recent ones are as follows: [Yang et al. 2014] developed a smartphone application which uses image recognition in order to improve children's mathematics. [Salman and Antonius 2017] developed a mobile application that teaches the alphabet to children with more fun. [Nouwen et al. 2016] developed a fun and educational mobile application that teaches children how to use musical instruments. [Kourakli et al. 2016] investigated Microsoft Kinect-based learning games' impact on the improvement of cognitive, motoric and academic skills of the children with special educational needs. [Carrozzo et al. 2018] developed a hydroponics system, Idropo, to educate children by gardening and playing. Idropo is like a toy. It has two LCD displays as eyes. One expresses whether the water is low and the other one expresses whether the brightness is low. In addition, it has four buttons. One is used to introduce Idropo and how to use the system by talking, other one gives some information about nature by talking, one other initialize the date and the last one says how many days passed.

Other than the Carrozzo et al.'s work, any hydroponics-based-smart-system related academic and/or industrial work that is for child education was not found.

In our work, we aimed to develop a smart system based-on-hydroponics for helping educate children in the way of contributing to their improvement on cognitive [Bloom et al. 1956; Anderson et al. 2001], affective [Krathwohl et al. 1964] and psychomotor [Simpson 1966] domains. We named our system as Hydroponics-based Smart Education System (HSES) (named it as “Happy Plants” also). HSES mainly consists of hydroponics system, embedded system and smartphone application.

Hydroponics is a method for growing plant in water that contains nutrient, not in soil [dos Santos et al. 2013]. Due to hydroponics system is a clean agriculture, the child would use our hydroponics-based system at home without any inconvenience. This would lead the child to use HSES more reachable and more comfortable. To be able to see the plant’s healthy growth during the process could cause positive effect on the child. Hydroponics gives us this opportunity since it lets plants to grow healthier [Umamaheswari et al. 2016]. [Schneller et al. 2015] did a case study with 10-11 years old students for indoor garden-based learning with hydroponics and aquaponics. In their study, there were two groups which were the treatment student group who were participated in the indoor garden-based learning and the control student group who were not participated. One of their statements is that the increment of the treatment group’s pro-environmental behaviors and knowledge of environmental issues. Their study shows that it is possible to use hydroponics and aquaponics in child education. Nowadays, embedded systems are popular. Embedded systems are cost effective and provides easier communication between the electronic parts. Furthermore, embedded systems, such as those that includes Raspberry Pi, are small in size and allow us to have more useful and more elegant designs. Smartphones have become a part of our lives. The world population was above 7.6 billion in the mid of 2018 [Worldometers 2019] and it is estimated that smartphones would be used by 2.53 billion people in 2018 [eMarketer 2016]. With the smartphone application in HSES, it is possible to form more interaction between the child and the plant. With all the aforementioned three main components, HSES could be more attractive, therefore more motivational, for the child. The other components which are Web server and MySQL server support the main components.

The rest of this paper is organized as follows: The next section describes system design of the proposed system; section 3 explains the implementations done for the proposed system; section 4 explains methodology used for the proposed system’s test; the next is results and discussion section; and the last section concludes our work and gives future work.

2 System Design of the Proposed System

2.1 System Architecture

System architecture of the proposed system HSES is given in Figure 1.

Raspberry Pi is the control unit which controls the hardware part of the system. Temperature & humidity sensor, ultrasonic distance sensor, touch screen and speaker are directly connected to Raspberry Pi. Water level sensor is also connected to Raspberry Pi but indirectly. Arduino Nano is used between since Raspberry Pi does not support Analog-to-Digital Converter (ADC). Raspberry Pi displays the following information on touch screen: The values comes from the sensors; the minimum and maximum temperature requirements of the plant taken from MySQL server via REST API; and the child's Task Score (TS) taken from Web server via REST API (Web server gets the values from MySQL server and makes score calculation). Furthermore, it processes these information and, if needed, it displays warning on touch screen and gives message to the child in speech by the speaker. It also sends some values coming from the sensors, i.e. temperature value and Nutrient Water (NW) level, to MySQL server via REST API for storing. Lastly, Raspberry Pi assigns changing-the-NW-in-the-tank task to the child when the time comes.

Android application is available for the child and the parent. It consists of “Plant Detail”, “Game”, “General Knowledge” and “Task” sections for the child and “Plant Details”, “Task”, “Children” and “Settings” sections for the parent. The application gets all the required information (except the child's TS) for each section from MySQL server via REST APIs. For the child's TS, it gets from Web server via REST API.

Web application is available for administrator of the system. It consists of plant device, plant and general knowledge pages. The Web application gets/stores all required information for/on each page from/to MySQL Server without using REST APIs.

Bot is a software agent and runs continuously on Web server. Firstly, it gets the usernames of all children who have assigned-plant device from MySQL server. (Plant device assignment is explained below.) Then, for each child, it creates two tasks and assigns them to the child.

2.2 System Components

In HSES, there are various components as given below.

2.2.1 Hydroponics System Component

There are 3 main parts of this component which are plant, water tank and water pump engine. NW in the tank contains the nutrients that the growing plant needs. As long as energy is available, the water pump engine in the tank provides NW flow through the plant's roots.

Hydroponics system component is a part of plant device as shown Figure 1.

2.2.2 Android Application Component

Initialization of the system has two stages. The first one is being on Android application component and the second is being on Raspberry Pi component which is discussed in the next section. Firstly, the parent registers himself to the system. Then, the parent registers her/his child(ren) to the system. During the registration of the child, the parent enters some personal information of the child and free-time of the child. (Each task is being created for a specific time period. When a task is created, the child is needed to be available for the task during that specific time period. Therefore, the free-time is required to know the available time. Note that controlling of the task completion is also being done during this specific time period.) After the registration is completed, the parent assigns the system to the child by using the system’s unique ID. Once these processes are completed, the child can log in to the system with her/his smartphone. Note that the parent can register another her/his child with a new plant device; besides, s/he can assign another new plant device for her/his previously registered child.

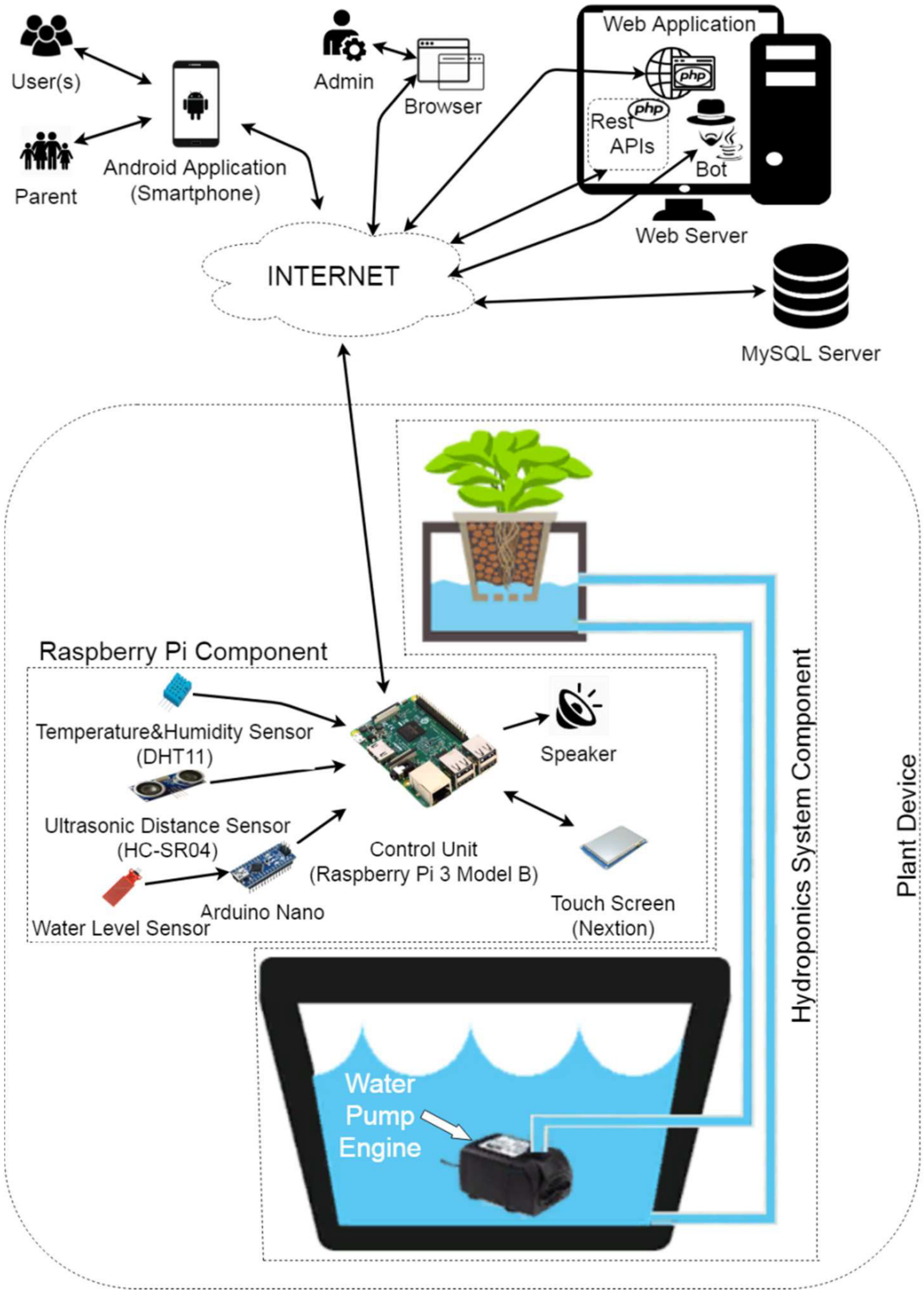

Figure 1: System architecture of HSES

In Android application component, there are various sections which are “Plant Detail”, “Task”, “Game” and “General Knowledge” for the child and “Plant Detail”, “Task”, “Children” and “Settings” for the parent. “Plant Detail” and “Task” sections are the same sections for the child as well as the parent; however, the parent sees these sections after choosing the child and the plant device and the child sees these sections after choosing the plant device.

The plant detail section shows environment temperature and humidity values, status of amount of NW in the tank, description of the plant, the child’s TS, plant's happiness mood (decided by the application based on the child's TS) and plant's picture (a standard picture that comes with the application). In addition, this section includes description of these information. Android application compares the last temperature value stored in MySQL server with the temperature range required for the plant to find out if the current temperature is higher or lower. If the temperature is higher or lower, a warning is displayed in the plant detail section. Android application compares the current NW level stored in MySQL server with the pre-defined ranges. If the level is lower than the required range, a warning is displayed in the plant detail section.

The task section shows tasks that need to be done by the child. For each task, description, creation date, the type (such as NW-related and game types) and whether the task is completed or not are listed in this section.

The game section shows all the games the child can play. Tic-Tac-Toe is developed (with four different difficulty levels) as sample game and made available in this section.

The general knowledge section shows various information such as “meaning and significance of the day” and “today in history”. These information will be entered into MySQL server by the administrator.

The children section shows all registered children of the parent. Here, parent can add new plant devices to any one of the registered child, add new child or update any of the registered child's information.

The settings section shows personal information of the parent. Here, parent can update her/his information.

The use case diagram of Android application component (Figure 2) is given additionally for better understanding.

The child can access the game and general knowledge sections during the free-time only while s/he can access the plant detail and task sections at any time. Note that Android application controls game and general knowledge tasks’ completion within the free-time. The parent has no the game and general knowledge sections but, like her/his child, s/he can access the plant detail and task sections at any time. The parent access the plant detail and task sections for controlling her/his child’s status. Being able to control the child’s status at any time is called instant child control.

2.2.3 Raspberry Pi Component

Raspberry Pi component is a part of plant device as shown in Figure 1.

As it is mentioned earlier, the second stage of initialization of the system includes filling-the-tank-first-time with the NW, placing the plant on to plant device and setting Raspberry Pi. After filling the tank and place the plant, the parent enters Wi-Fi login information via touch screen in order to connect Raspberry Pi to the Internet.

Then, over touch screen, the parent selects the plant to be grown and restarts Raspberry Pi. With the aforementioned processes: if it is re-initialization and there is stored data regarding the child and her/his plant device on the database, these data will be erased; and, then, the system will be initialized and activated.

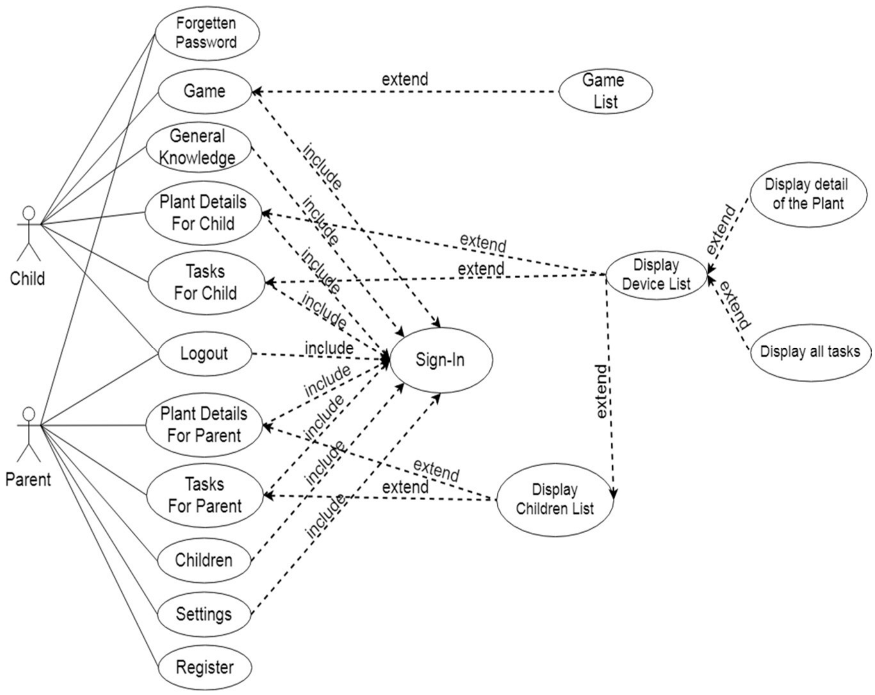

Figure 2: The use case diagram of Android application component

Raspberry Pi displays the minimum and maximum temperature requirements for the plant (taken from MySQL server) and the child's TS on touch screen (taken from REST API). In addition, Raspberry Pi displays current temperature, current humidity and current NW level status on touch screen by refreshing in every 20 seconds. It reads displays current temperature, current humidity and current NW level from the corresponding sensors. Furthermore, it sends the last values of current temperature and current NW level to MySQL server in every 10 minutes in order to be stored for further usages. Note that it is thought that 10 minutes is reasonable since radical changes on these metrics' values could not be possible in less than this duration.

Raspberry Pi compares the environment's current temperature value taken from the sensor with the temperature range required for the plant to find out if the temperature is higher or lower. It does this in every 10 minutes. If the temperature is higher or lower, a warning is displayed on touch screen and a corresponding message is spoken via speaker. Raspberry Pi compares the current NW level taken from the sensor with the pre-defined ranges. It does this in every 10 minutes. If the level is lower than the required range, a warning is displayed on touch screen and a corresponding message is spoken via speaker. The warnings are done always; however, messages in speech are done only during the free-time.

The changing-the-NW-in-the-tank task is needed to be done when particular NW change time (that the administrator decides) comes. Hence, Raspberry Pi assigns changing-the-NW-in-the-tank task to the child when the time comes. The child should do this during the free-time.

Raspberry Pi controls movement in front of ultrasonic distance sensor. If there is a movement in the range of 30 centimeters, it gives a related message in speech via speaker for drawing attention. This is called draw attention function. It is always active; however, there is 10 minutes restriction between the messages. Frequently spoken messages could see less value by the child and the restriction would prevent this.

Raspberry Pi calculates how many days passed since the plant was planted by taking the difference of the finish time of the second stage of initialization and the present time and, then, displays it on touch screen.

Raspberry Pi decides plant's happiness mood based on the child's TS and displays it on touch screen.

Raspberry Pi displays the date of the day on touch screen.

Note that, over touch screen, the Wi-Fi network change can be done by the parent/child and re-starting of the second stage of initialization can be done by the parent.

2.2.4 Web Server Component

Web server has three parts which are Web application, Bot and REST APIs.

With Web application, the administrator can make add, update, delete and list operations for plant device, plant and general knowledge. The administrator adds unique ID of every produced plant device, the minimum and maximum temperature requirements, after how many days NW is needed to be changed, description of the plant and the information for general knowledge task (e.g. "meaning and significance of the day"). The administrator can update, delete and list these. Note that the previously stored information for general knowledge task can be used every year by the system.

Bot creates as well as assigns two tasks for each child, after it gets the usernames of all children who have assigned-plant device. One task is for the game section and the other one is for the general knowledge section. Bot do this in every 24 hours.

REST APIs in our system provide communication between components via HTTP protocols. Android application and Raspberry Pi components make request to the corresponding REST API. The API interacts with MySQL server component and returns the result to the component which made the request. In our system, all requests except Web application's requests are provided with REST APIs.

One of the requests is for the child's TS. When the request comes, the Rest API calculates the child's TS for the time starting from beginning of the current week to until then. The formula of the child's TS is as follows:

$$TS = (TPET*1000)/TPE \quad (1)$$

where TPET is Total Points Earned from the Tasks done and TPE is Total Points can be Earned. Game and general knowledge related tasks are 1 point each. Temperature and NW related tasks are 3 points each. If there is no assigned task for the considered time range, the child's TS is being 1000 points directly.

2.2.5 MySQL Server Component

There are two triggers in MySQL server. These are triggered, when Raspberry Pi sends current temperature and current NW level and the server stores them. This happens in every 10 minutes. The temperature-task-trigger finds out if the temperature is higher or lower. It compares the last temperature stored in MySQL server with the temperature range required for the plant. If the comparison shows that the temperature is higher or lower, then the trigger assigns a corresponding task. The water-adding-task-trigger finds out if the NW level in the tank is lower. It compares the last NW level stored in MySQL server with the pre-defined ranges. If the comparison shows that the NW level is lower than the required range, then the trigger assigns a corresponding task which guides the user to add the required amount. (In order to keep the nutrient balanced in the NW in the tank, different water type (i.e. regular or nutrient) is needed for different time ranges. The user will be asked to add the corresponding water type based on the time range.) Task created by a trigger is checked by the same trigger to see if the task is completed. A trigger creates and checks task within the free-time. Note that the water-adding-task-trigger checks the changing-the-NW-in-the-tank task (created by Raspberry Pi) as well.

In addition, there are procedures in this component. They are responsible to register, retrieve, update and delete data to/on MySQL server.

2.3 Additional Software Details

For Raspberry Pi 3 Model B, Raspbian Stretch (June 2018 version) is used as operating system. For sensors, touch screen and speaker control, Python (version 2) programming language was used. Arduino IDE was used for programming of Arduino Nano. Smartphone application was developed with Android Studio 3.0.1 by targeting the Android 8.0 (API Level 26); but the application was compiled with the last Android 9.0 (API Level 28). Note that the application can run on the smartphones that have at least Android 4.0.3 (API Level 15). MySQL version 10.1.31-MariaDB is used as database management system. phpMyAdmin 4.7.9 was used for MySQL. Web application and REST APIs were programmed with PHP 7.1.15 scripting language. Bot was coded in NetBeans IDE 8.2 with Java programming language. Apache 2.4.29 is used as Web server.

3 Implementation of the Proposed System

HSES has three different type of implementations. These are Web application, Android application and plant device.

Administrator type user can use Web application for doing the corresponding operations as described above.

Parent type and child type users can use Android application. Activities for the main duties of Android application are given in Figure 3 and 4. Figure 3(a) is an activity where the parent can add new child as well as edit existing children. Figure

3(b) is an activity where the parent can assign a plant device to the selected child. To do this the parent enters unique id of the plant device. So the child can log in to the system. Figure 3(c) is an activity that the child can see after log in. The child can see the current plant details, assigned tasks, game list for playing in Figures 4(a), 4(b) and 4(c), respectively.

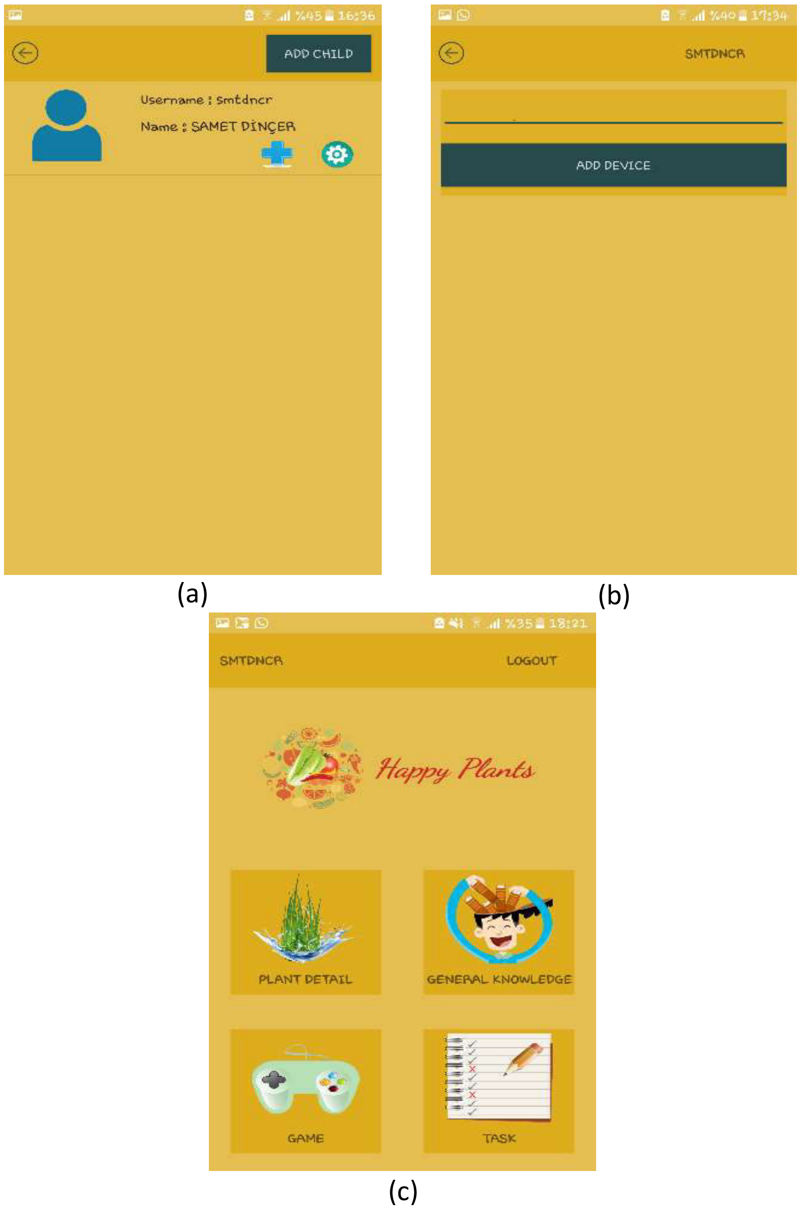

Figure 3: Activities for the main duties of Android application (1 of 2)

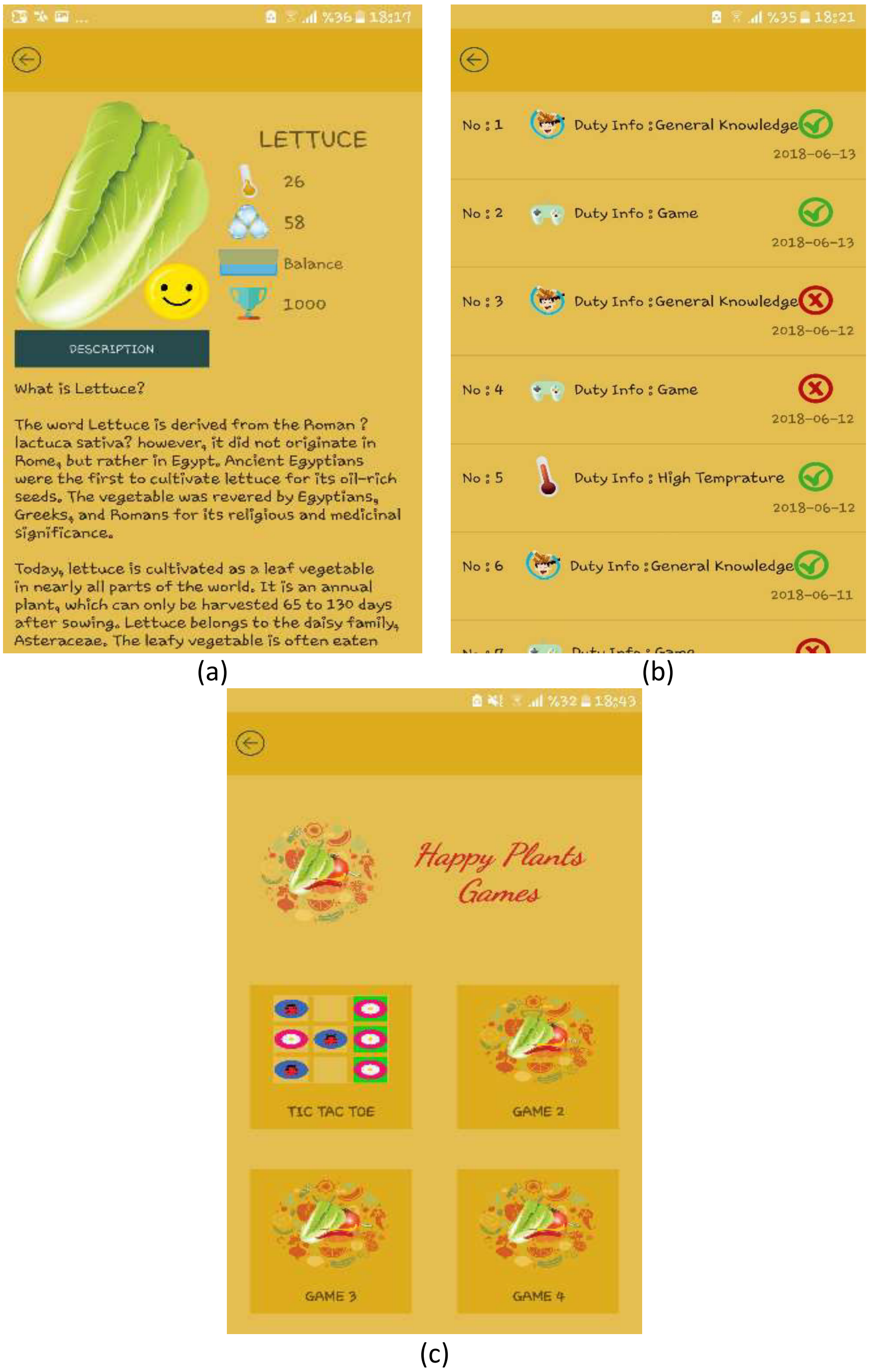

Figure 4: Activities for the main duties of Android application (2 of 2)

Figure 5: General view of plant device

Figure 5 shows general view of plant device. Figure 6(a) shows how to put the plant into the system. Figure 6(b) shows the water tank and, moreover, its RW/NW add and NW pour points. When the system is activated as first time, Wi-Fi configuration should be done (see Figure 6(c)). Then, after the plant chosen, the system restarts and Figure 6(d) shows. The child can see the current plant details, date of the day, plant's happiness mood and how many days have passed since the plant was planted on this screen. Settings screen can be opened from this screen for changing Wi-Fi login information and re-doing the second stage of initialization of the system.

When the plant grows enough or dies somehow, this means that a life cycle is completed. Afterwards, re-start of the second stage can be done in order to start over.

4 Methodology for the Proposed System's Test

The proposed system's test consists of four parts which are pre-survey, post-survey, trial and observation. One trial that would take about one month was done with a 10 years old child. (One trial was done because of the cost and limited time.) Two pre-surveys (one for child and one for parent) and two post-surveys (one for child and one for parent) were prepared as shown in Appendix A. The purpose of these surveys are to learn effects on child and thoughts of her/his parent. Pre-surveys were filled out before the trial and post-surveys were filled out after the trial. Before filling out the pre-surveys, details about the system were given to the parent and the child. Observations were done during the trial.

Note that, for this test, the necessary permissions were taken from both the child and his parent.

Figure 6: Plant device usage

5 Results & Discussion

HSES is an interdisciplinary system that consists of various components, i.e. Android application, Raspberry Pi, Web server, MySQL server and hydroponics system. Not for the whole of it, but it gets benefit from Internet of Things also. The main purpose of HSES is to contribute to improvement of children. HSES assigns tasks, which are temperature, NW, game and general knowledge tasks and draws attention in order to achieve this.

Every plant has certain minimum and maximum temperature requirements for healthy growth. In case where the requirements are not provided, the system assigns the temperature task to the child by declaring that the required temperature range in the environment should be balanced. Thus, the child would consider finding a solution to compensate the environment temperature. The child would apply the method(s) s/he has found such as opening/closing the window and moving the plant device to inside/balcony. As a result, this task could contribute to the child's improvement on cognitive, affective and psychomotor domains.

Plants need RW and certain nutrients. Because of our proposed system also includes a hydroponics system, certain amount of RW and certain amount of the nutrients are required. The system follows NW level in the water tank and if this level is lower than the required, it assigns the water task to the child for adding RW/NW. After the task assignment, the child adds the necessary amount of RW/NW through "RW/NW add point" into the water tank. Furthermore, there is one more water task type that changing the NW in the tank is asked. Hence, these tasks could contribute to the child's improvement on all the three domains.

The game task that the child would play with fun and improve himself on the domains is added to HSES. Currently, Tic-Tac-Toe game is included in our system as a sample game. It could contribute to the child's improvement on cognitive, affective and psychomotor domains. Other new games could be added in HSES; if so, those games that let the children to improve themselves on the domains with fun would be preferred.

The general knowledge task is included in the system with the logic of every-day-new-information. While giving this task to the child, it is aimed to contribute to the child's improvement on cognitive and affective domains.

Draw attention function is added to the system in order to attract the child's attention and, hence, motivate him to use HSES. This function tries to attract the attention of the child by speech, when s/he passes from front of the system or approaches to the system. The child's improvement on affective domain could be contributed with this direct motivation. The system does not recognize who is close; so, it also tries to draw attention of anybody else passing from front or approaching. That person might be motivated to motivate the child to use the system actively by poking him with questions about the system such as "Did you do today's tasks?" and "Do you care with your plant?"; therefore, the child would be indirectly motivated.

Table 1 summarizes individual possible contribution(s) of all tasks and draw attention function based on cognitive, affective and psychomotor domains.

Warning messages given via speakers about temperature and NW level, and some other features of the system, e.g. current date shown on touch screen, would cause the same effect with draw attention function. The warning messages would also provide support in the way of doing the corresponding tasks. Moreover, if filling-the-tank-first-time and placing the plant on to plant device operations in the second stage of initialization are done by the child (not by the parent), the same effect with NW task would be provided.

Domain / Task / Function	Cognitive	Affective	Psychomotor
Temperature Task	√	√	√
NW Task	√	√	√
Game Task (Tic-Tac-Toe)	√	√	√
General Knowledge Task	√	√	
Draw Attention Function		√	

Table 1: Summary of individual possible contribution(s)

The system provides opportunity to the parent to control and interfere the child as well as the plant, if necessary, during the process.

HSES considers the free-time entered by the parent to notify the child in voice and/or written formats. The parent identifies the free-time in order to be sure that the child's daily needs such as studying and sleeping are not interfered by the system. The free-time is a two hours interval per day that means the child can spend at most two hours. This interval is especially limited to two hours based on the following statement of [American Academy of Pediatrics 2013]: Children's entertainment-based-interaction with media should be two hours or less per day. It is possible to say that our system is appropriate for the entertainment-based-daily-media-usage duration of children. Note that: The child can check the information about the plant status (e.g. temperature) other than the free-time also; this takes no time; however, sometimes action(s) (e.g. temperature related action) need can be seen; in that case, the parent is expected to interfere for preventing the child to do the action(s) other than the free-time.

To the best of our knowledge, HSES is more advanced, has more features, has wider scope and uses more various state-of-the-art methods. Only Idropo, which is developed by [Carrozzo et al. 2018], was encountered as related work. A brief comparison of our system and Idropo is shown in Table 2.

Profile of the child who performed the trial is as follows: He was a 10 years old boy born in 2008; he has a personal smartphone, uses it between 3 and 5 hours a day and likes to play game on it (1-3 hours per day); he likes to grow plants. Before the child started to trial: Both the child and the parent liked the general view of the system; the child was willing to play with “Happy Plants” and was thinking that it can be fun and educational; the parent was willing the child to play with “Happy Plants” and improve himself; and the parent thought that it could be beneficial for the child. The aforementioned information are obtained from pre-survey and had showed us that the correct subjects were selected. Use of plant device by the child during the trial is shown in Figure 7.

After the system trial, the child said that he was interested with "Happy Plants" between half an hour and one hour in a day. He stated that he learned and enjoyed with "Happy Plants". He thinks to recommend this system to his friends. Furthermore, he suggested an additional feature that the system talks to the child user with her/his name. The parent stated that "Happy Plants" was beneficial for the child and is a nice work. In addition, he thinks to recommend the system to others. The child and the parent rated the system as 8 and 7 points out of 10, respectively.

Based on the corresponding responses in surveys and the observations, it can be said that HSES ("Happy Plants") could be a successful system.

System / Feature	HSES	Idropo
Water level status control	√	√
Water level status display	√	√
Environment temperature control	√	×
Environment temperature display	√	×
Environment brightness control	×	√
Environment brightness display	×	√
Screen	√ (One 4.3" Touch screen)	√ (Two smaller LCD screens)
Game	√	×
General knowledge	√ (Everyday new information shown)	√ (The same information repeats)
Draw attention function	√	×
Notification	√ (Audio and written)	×
The days passed information	√ (Current date also shown)	√
Multiple plant	√ (No limit (With additional plant device(s)))	√ (Maximum four plants)
Multiple child	√ (No limit)	√ (Maximum four children)
Specialized on a plant	√ (Works for lettuce and pepper)	Not known
Mobile application	√	×
Web application	√	×
Internet connection	√ (For communication of components)	×
Instant child control	√	×

Multiple Plant: One child can have one or more plant devices at the same time in HSES, while Idropo has only four plant slots to be used at the same time. Multiple Child: HSES allows more than one child per parent (with at least one plant device per child) at the same time, while Idropo allows maximum four children under one or more supervisor(s) at the same time.
Note that it is assumed that only one child would grow the plant on a slot/plant device.

Table 2: Comparison table for HSES and Idropo features

Figure 7: Use of plant device by the child

6 Conclusion & Future Work

Our system is composed of Android application, Raspberry Pi, Web server, MySQL server and hydroponics system components. Its aim is to contribute to improvement of children on cognitive, affective and psychomotor domains. With its diverse features, this contribution could be done, as it is also perceived from the observations and the corresponding results of surveys in the test.

New games, brightness control, multi-way voice communication and talking to the child with her/his name will be included into our system. Separate plant device designs will be created for girls and boys. It is thought that our system is for 9+ years old children; however, a formal action is needed and will be done for finding out the definite minimum age limit. In order to declare the system's contributions more validated, the test will be repeated with more trials, more detailed versions of surveys and more observations.

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A Surveys for Testing

A.1 "Happy Plants" – Child Pre-Survey

1. Date of birth

2. Gender

   ◯ Boy

   ◯ Girl

3. Do you have a smartphone?

   ◯ Yes

   ◯ No

   If your answer is No, you can pass to question 5.

4. How many hours do you use it in a day?

0	1-3	3-5	5+
◯	◯	◯	◯

5. Do you like to play games on phone?

   ◯ Yes

   ◯ No

   If your answer is No, you can pass to question 7.

6. How many hours do you spend for playing games on phone?

0	1-3	3-5	5+
◯	◯	◯	◯

7. Do you like to grow plants? (including vegetables and fruits)

   ○ Yes

   ○ No

8. Did you like the general view of "Happy Plants"?

   ○ Yes

   ○ No

9. Would you like to play with "Happy Plants"?

   ○ Yes

   ○ No

10. Would you like to say something additional about "Happy Plants"?

A.2 "Happy Plants" – Child Post-Survey

1. How many hours did you spare for “Happy Plants”?

0	0 – 0.5	0.5 - 1	1 - 2
○	○	○	○

2. Did you enjoy with “Happy Plants”?

   ○ Yes

   ○ No

3. Did you learn with “Happy Plants”?

◯ Yes
◯ No

4. How many points do you give to “Happy Plants”?

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

5. Do you think to recommend “Happy Plants” to your friends?

◯ Yes
◯ No

If your answer is No, can you explain it in a few sentences?

6. Would you like to say something additional about “Happy Plants”? (Are there any different features you want to see in “Happy Plants”?)

A.3 "Happy Plants" – Parent Pre-Survey

Please read the description before starting our survey.

HSES (“Happy Plants”) is a novel smart system based on hydroponics. With this system, it is aimed to help educate children by contributing to their improvement on cognitive domain, affective domain and psychomotor domain. This hydroponics-based smart education system is giving different tasks to the child, does not interfere the child's daily needs such as studying and sleeping, and includes instant child control that you can control your child.

1. Did you like the general view of "Happy Plants"?

   ◯ Yes

   ◯ No

2. Do you want your child to play with "Happy Plants"?

   ◯ Yes

   ◯ No

3. Do you want your child to improve himself with "Happy Plants"?

   ◯ Yes

   ◯ No

4. Do you think "Happy Plants" could be beneficial for your child?

Yes	No	Undecided
◯	◯	◯

5. Would you like to say something additional about "Happy Plants"

A.4 "Happy Plants" – Parent Post-Survey

1. Do you think "Happy Plants" was beneficial for your child?

   ○ Yes
   ○ No

2. How many points do you give to "Happy Plants"?

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

3. Do you think to recommend "Happy Plants" to others??

   ○ Yes
   ○ No

   If your answer is No, can you explain it in a few sentences?

4. Would you like to say something additional about "Happy Plants"? (Are there any different features you want to see in "Happy Plants"?)