chatter plant

INTEGRATED HUMAN PRACTICES

ANALYSIS, ADOPTION AND IMPLEMENTATION OF CHATTERPLANT

Universidad Politécnica de Valencia
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After centuries and centuries of practicing agriculture, mankind appears to have all the knowledge it could ever need on crop production and cultivation. Despite the high level of understanding for farming, the possibilities for the further application of such information are astounding: *"Knowledge is power, but enthusiasm pulls the switch"*. Per usual, there tends to be controversy surrounding any attempt to let go of familiar practices for an unconventional methods.

It is important to respect the opinions of others for even the slightest possibility that they might see the matter from a different perspective and in time change their minds. Our story begins from that very desire to help and change our society

WHERE DID CHATTERPLANT BEGIN?

Since the beginning of **agriculture** , there has been a lack of respect for the environment: natural resources have been exploited and the use of pesticides have damaged the natural richness the soil. Only a few years ago, **sustainability** and environmental impact have have become a factor to be considered. However, it is perceived that the advancement of technology is not as fast as the advance of agriculture. Consequently, it is evident that agricultural industry is not taking full advantage of **new technologies**.

To counteract this situation, the integration of **synthetic biology** with agriculture would be a way to establish innovative technologies into agriculture, with the objective of making crops more sustainable.

To transform the beginning ideas into what is now **ChatterPlant**, a social and a legal framework analysis was performed. With the knowledge obtained, the construction of ChatterPlant was completed. Furthermore, a plan to encourage the adoption of such technology was put together through additional research. Through a **step-by-step**

workflow, known as a pilot project, the adoption of ChatterPlant was proposed.

WHAT HAVE WE DONE?

In order to squeeze the whole potencial of our project, we have ordered our Integrated Human Practices in the following actions:

- A global analysis of ChatterPlant skateholders necessities
- A suitable adaption of our project main objetives accordingly to obtained conclusion from previous analysis
- An in-depth step-by-step strategy to implement our project in current society

SOCIAL ANALYSIS

In order to transform the principal ideas of ChatterPlant into a practical, tangible SynBio solution, the necessities of stakeholders were taken into account thus modeling the project off of their requirements. As a result of such inquiries we were able to create a more convincing, more effective product tailored to the concerns of stakeholders.

Based on the initial ideas of ChatterPlant, the target user is projected to be the following groups:

- Greenhouses
- Restaurants
- General public

The legal framework revolving around ChatterPlant we also also studied and evaluated.

GREENHOUSES ANALYSIS

Fruit and vegetables are considered the basis of staple diets in almost every gastronomic culture. For this reason, greenhouse production is being advanced to become a better alternative to regular farming, ensuring current and future food security. Consequently, the analysis of greenhouse necessities was mandatory to transform ChatterPlant's main objectives to reality.

EVALUATION OF LOCAL GREENHOUSES

The first place of investigation was at La Unió de Perelló greenhouse near Valencia, Spain. Another place of investigation was at the Iberflora exhibition, an annual fair of plants and gardening in Valencia. Furthermore, we interviewed Ángeles Calatayud, a researcher at the "Instituto Valenciano de Investigaciones Agrarias" (IVIA) research center.

EVALUATION OF INTERNATIONAL GREENHOUSES

The Netherlands is one of the leading countries in greenhouse flower production with some of the best plant-production technology in Europe. An interview with **Marta Vázquez**, a post-doctoral researcher of Wageningen university, reinforced the notion that controlling the growing conditions of a plant increase the overall plant production (link). In Vázquez's professional opinion, there is should not be any problem in the application of high-tech tools given that the current devices used are being successfully implemented.

To learn more about greenhouses in the United States, we **collaborated** with the iGEM team at Purdue University in Lafayette, Indiana. Several American greenhouse owners responded to a questionnaire sent to them regarding their respective greenhouses and current problems they are facing.

EVALUATION SUMMARY

What follows are the conclusions reached based on the information gathered from interviews:

- There is general **acceptance** for any progress made to increase food accessibility, food production, nutritional values, and organoleptic properties of crops.
- The SynBio device developed should have the capacity to **detect stresses**prematurely in order to reduce losses and increase production.
- There is high interest for a device that **controls all climate variables** to optimize plant production. Moreover, the ability to manipulate the plant's environment would allow plant growth in places known to be naturally unfeasible.
- One of the major **differences** between American and European greenhouse owners are that American greenhouse owners are much more open-minded.

RESTAURANTS ANALYSIS

Food science arose as an applied science dedicated to the study and improvement of food from the engineering, biology and technology point of view. A more sustainable agriculture adapted to consumers necessities and desires is possible controlling plant control, both in a genetic and environmental approach.

Four Michelin star awarded restaurants, El Riff , Canalla Bistro , El Poblet and Sents, were interviewed in order to obtain their opinion about GMOs and automated growing systems.

Different conclusions were extracted from the interviews:

- An interest of **self-designed** food from the beginning of the plant growth.
- **High-quality** off-season products
- **Proximity** and **accessible** fruits and vegetables.

GENERAL PUBLIC ANALYSIS

Social acceptance must be considered in order to develop a suitable project. A survey was developed with the objective of gaining a societal perspective on agriculture and Genetically Modified Organisms (GMOs). The survey also served as an evaluation as to how the project can make an impact on society.

This survey was reviewed and studied by 'Data UPV', a student run group at the Polytechnic University of Valencia which specializes in data analysis. The following points can be extracted from the survey results:

- **Seasonal and local** fruits and vegetables are preferred (55,5%) over imported and off-season products. (44,5%)
- **Household horticulture** is an enticing idea (96,5%) but time (64,3%) and space (44,6%) constraints are both two obstacles for its development.
- **GMOs techniques** are not fully accepted (58,2%) due to the lack of general and demonstrated information about this issue.

The first and second conclusions made from the survey have led to a change in focus for the overall task. The results of the survey also appears to contradict itself. The solution in this project was approached through the development of transgenic plants. However, the survey indicates a societal prejudice towards GMOs and transgenic plants. It is important to address the controversy surrounding GMOs by first looking at legal framework.

LEGAL FRAMEWORK ANALYSIS

EUROPEAN AND SPANISH REGULATION

In order to identify the legal matters to be considered in the application of ChatterPlant, the European and Spanish legal framework relevant to the device were carefully studied. To ensure the **legal regulations** were accurately interpreted, Javier Company, a lawyer at UPV assisted us in legislative explanations

INTERNATIONAL REGULATION

To gain a general idea as to how the legal regulations of other countries affect ChatterPlant, it was useful to seek help from other iGem teams. Paris IONIS, Dusseldorf and Rice iGEM teams answered three questions providing insight into transgenic regulation in their respective countries.

LEGAL FRAMEWORK EVALUATION SUMMARY

Following items recap the main points of our legal framework analysis:

- A **strong legal framework** is established in Europe to ensure the development of GMOs in safe conditions.

- Each European nation has the authority to evaluate and decide the environmental risk of a particular genetically modified organism.
- There is a legal black hole in the GMO's application because there is no regulation on cultivating GMOs in private, non-governmental properties in Europe
- Thanks to the input collected from iGEM groups worldwide, it can been seen that the regulations on transgenic plants in European countries are much stricter those of the United States.

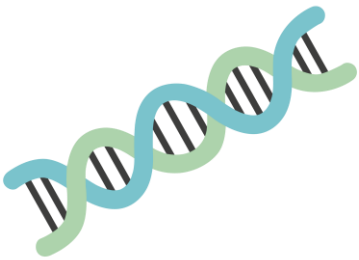
The information gathered from meetings, interviews and surveys ultimately identifies themain concepts for creating a viable SynBio solution to sustainable agriculture based on plant communication.

CHATTERPLANT EVOLUTION

Our social analysis conclusions strengthens ChatterPlant's ideas in terms of its objectives, delineating characteristics an open access agriculture must offer. Interviews with stakeholders provided background to redefine the working lines in different aspects, as will be explained subsequently in more detail.

CHATTERPLANT SYNBIO EVOLUTION

Greenhouse interviews brought to light the need to implement a non-invasive abiotic and biotic stress detection system, capable of detecting stress before the development of visual phenotypic damages. Interviewees emphasized that the apparatus developed should be simple and direct.



To meet the requirements of the stakeholders, a predetermined Color Code system was instilled in order to associate color reporter proteins with particular stresses. This particular genetic construction enables ChatterPlant to indicate the presence of any problems related to plant

growth activity in an easy and practical way. A **deeper** analysis of their current growing problems enabled us to establish the following stress inducible promoters to be used for indications of stress:

- A **pathogen** infection inducible promoter
- A **water stress** inducible promoter
- **Macro and micronutrients** absence inducible promoter

Controlling internal processes within a plant is one of the mainstays of the current agricultural and agronomic area. Interviews with greenhouse supervisors reflected real agronomical requirements that were figured out with a modular optogenetic circuit. This ON/OFF circuit allows the control of a specific phenotype within a plant at a particular moment. What follows is a delineation of plant growth topics to be considered in our final project design:

- **Flowering** time control
- **Climate conditions** protection, against frost and high temperatures
- **Ornamental** plants features, such leaves color

Restaurants interviews revealed the importance of **season-less, high-value** fruits and vegetables. In general, GMOs are not a barrier for them, provided food quality is fitted to consumers wishes. Also, high-quality restaurant supervisors did not perceive GMOs as a dangerous alternative, despite their legal framework.

ChatterPlant optogenetic circuit offers multiple possibilities to improve and biofortificate crops due to its modularity. Following topics were checked to be interesting to take into account to define ChatterPlant possibilities:

- Improved **organoleptic** characteristics of edible plants, as more colorful fruits.
- Higher macro and micronutrients **levels** food, as iron or calcium.
- **Biofortificated** fruits and vegetables, increasing their nutritional values.

CHATTERBOX EVOLUTION

Public surveys affirm the existence of social interest about **self-controlled** home cultivation. Nevertheless, the availability of **space** within certain properties remains one of the leading problems house farming has to face. As an attempt to resolve the issue, a redimensional design was carried out in our hardware tool to afford a **small-scale** device more appropriate for private use. Moreover, our Hardware design was improved according to restaurants necessities. A dimensional readjustment was performed in ChatterBox to offer a compact device more suitable for restaurants use.

The concept of self-controlled plant growth would further make the ChatterPlant device sound appealing. Hence, a **remote-control** mobile application with these this very quality was developed, thus making ChatterPlant less dependant on direct human action. ChatterApp lends a user-friendly and accessible way to be notified about current status of our cultivated plants and to control environmental and genetic growth conditions.

EVALUATING CHATTERPLANT EVOLUTION

Finally, ChatterPlant was comprehensively developed and built around all the information obtained on meetings, surveys and interviews from our previous analysis. SynBio, Hardware and Software tools were **defined** according to this information. That's time to see how our project could be implemented in society and urban environment.

CHATTERPLANT PILOT PROJECT

AN INTEGRATED APPROACH FOR SOCIAL IMPLEMENTATION

When taking on a task as complex as bringing about societal change, its is more effective to take a **step-by-step**approach as opposed to an all at once radical change. Often times, distant social agents are the ones who drive the **normalization** of the idea, acting as spearheads of the concepts and allowing the idea to develop.

Bearing that in mind, an exhaustive adoption study was performed following an experimental pilot project. A **pilot study** is a small scale study conducted before the main study to integrate and normalize cutting-edge ideas into society following a step-by-step strategy.

In the midst of researching paradigms of well-established societies that were open to change, architect **Eva Kail** became of particular interest. Kail was able to make Vienna, Austria a city where gender mainstreaming, the consideration of gender perspective in the in the creation of policy, was taken seriously and applied to every **urban space** in the city. Eva Kail, Chief Executive Officer of the city of Vienna and one of the most specialized architects in urbanism.

After interviewing her, a complete pilot project was designed in order to **standardized** the consumption of **GMOs** in regular diet through ChatterPlant technology.

PILOT PROJECT DESIGN

After reaching out, Kail explained her successful strategy for addressing the issue and gave advice as to how her approach to the concern can be applied on the topic of transgenic plant acceptance. Based on this

notion, the pilot project created to gain society's acceptance toward transgenic plants follows the step-by-step technique.

Following bullets outline main actions in our step-by-step pilot project workflow:

- **Talks and divulgation** of Syn-Bio and ChatterPlant. PlantLabCo Magazine publication
- **University** pilot experiment as a small-scale prototype.
- ChatterPlant in a first **private** community for a primary social test.
- **Participative process** to perceive public awareness.
- ChatterPlant in urban orchards, restaurants and **public spaces**.
- **Popular legislative initiative** to present a draft bill to change current GMOs legal framework.

This step-by-step solution is projected to last about 20 years; it is a long process. It is difficult to change society and all those kinds of movements require time to go deep into society. In spite of the difficulties that will be faced on the journey to change society and improve plant understandings, there is a firm belief that society can indeed be changed.But we strongly believe in it, not only because the change in the social criterion we are proposing, but because in the project evolution that urban environment will cause in our device.

HUMAN PRACTICES CONCLUSIONS

Throughout this process, several ideas were developed and transformed into a SynBio solution thanks to the social, legal, and incorporation methods analyzed. ChatterPlant **was built** based on the knowledge and concepts obtained from the different **investigations** as well as our own ideas. Once ChatterPlant was developed, its implementation and acceptance in society was considered. To correctly proceed with the endeavor to **integrate Chatterplant into society**, a step-by-step product integration workflow was designed through a **pilot project**.

Following actions have been done in order to establish a **bi-directional workflow** between current society and our project:

- **In-depth analysis** of social stakeholders necessities, taking into account greenhouse supervisors, high-quality restaurant chefs and the opinion of GMO lawyers through several interviews.
- **Public survey** in order to know the public opinion on GMOs and self-regulation plant growth systems.
- **Improvement** and enhancement of **ChatterPlant objectives** in order to fit the project feature requirements of stakeholders requirements.
- Design of **ChatterPlant's pilot project** to normalize and establish the consumption of GMOs and effectively implement ChatterBox in current society through a step-by-step strategy.

There is a great deal of controversy around the sciences ChatterPlant has been bassed off of. This project is an **innovative idea** for **sustainable agriculture**, capable of being integrated into society through plant communication. We hope that through our efforts to educate the public on transgenesis the bias surrounding this issue will decrease.

Thank you for reading.