# Experiment design

The following assumptions are used to guide the design of the data structure representation of experiments and data:

* Each layer in a GrowCube has one set of sensors which take one set of measurements for the whole layer
* The sensor pack and probes will take up approximately 10cm2 in a layer (more precise measurements to follow)
* There will be up to six species of plant in each level
* The species mix may be different from one level to another
* Plants may be harvested several times during a project
* Plants are only harvested once at the end of an experiment
* The species mix may change over the course of the Dandelion project
* Species will be grown in patches
* Measurements may relate to individuals or to an entire patch
* Some experiments may compare plants grown in a GrowCube to others grown elsewhere
* Some experiments may be based solely on plants that are not in a GrowCube
* Manual measurements are only take in the context of an experiment
* A project is a way to group related experiments together
* Projects may be exclusive to one school or shared across multiple partner schools
* Every project has a lead school responsible for coordinating the other partners
* The lead school defines experiments that are templates for partners to follow
* Partner schools in a project can create experiments from the templates defined by the lead school
* Partner schools can run the template experiments as many times as they wish
* Partner schools cannot add further experiments of their own to a project where they are not the lead school

Constraints

1. Plants that are subjects in one experiment cannot simultaneously be subjects in another experiment. This would introduce confounding factors and invalidate the experimental design.
2. Variables can only be shared if the time periods for the associated experiments overlap. That is, variable observations must be contemporaneous with the experiment.
3. Variables can only be shared if they are measured in the same location (unit)

Business rules

One PROJECT may have one or more EXPERIMENTS

One EXPERIMENT belongs to one and only one PROJECT

One EXPERIMENT must have one or more CONDITIONS

One CONDITION must belong to

# Thigmomorphogenesis project

This is a project for all participating schools. Each school will run the centrally-defined experiments. It is important that the data can be easily combined across all schools.

<https://www.amazon.co.uk/Nutleys-Wooden-Seedling-Labels-Pack/dp/B00JB93PYE>

## Simple version

Experiment

|  |  |
| --- | --- |
| Field | Value |
| Code | TMG |
| Title | Thigmomorphogenesis |
| Description | How do plants react to being touched? |
| Text | When they are growing outside, the wind blows plants about. They may also be pushed or squashed by people or animals. But how do these interactions affect their growth? That is what we aim to find out!  Note that the plants must be at least 2cm tall before starting this experiment.  Set out the seedlings so that those in condition 1 are in the top tray of the GrowCube, those in condition 2 are in the middle tray and those in condition 3 are in the bottom tray.  Do plants grow faster or slower?  Do they weigh more at harvest?  Do they feel stronger?  Do they look different? |
| Measurement frequency | Weekly |
| Harvest frequency | Four-weekly |

Conditions

|  |  |
| --- | --- |
| Field | Value |
| Condition no | 1 |
| Description | No touching |
| Text | This is the simple case where we have removed all forms of touching. We can compare all other conditions to this one. The difficult part is making sure that the plants in this condition are not touched by accident. |
| Treatment frequency | None |

|  |  |
| --- | --- |
| Field | Value |
| Condition no | 2 |
| Description | Gentle tickling |
| Text | Carefully and gently pass a plastic ruler over each square of plants to flex (bend) the plants to at least 30 degrees from the vertical, taking great care not to break to the stems. Do at least one flex per second and do 10 flexes |
| Treatment frequency | Weekly |

|  |  |
| --- | --- |
| Field | Value |
| Condition no | 3 |
| Description | Moderate tickling |
| Text | Carefully and gently pass a plastic ruler over each square of plants to flex (bend) the plants to at least 30 degrees from the vertical, taking great care not to break to the stems. Do at least one flex per second and do 30 flexes |
| Treatment frequency | Weekly |

Variables

|  |  |
| --- | --- |
| Field name | Value |
| Quantity | Length (mm) |
| Name | Plant height |
| Description | Vertical height of the plant measured from the substrate surface to the highest point without touching the plant. |
| Variable type | Repeated |
| Observation type | Numeric |

|  |  |
| --- | --- |
| Field name | Value |
| Quantity | Weight (g) |
| Name | Plant weight |
| Description | Harvested weight of an individual plant excluding those parts below the surface of the substrate. |
| Variable type | Final |
| Observation type | Numeric |

|  |  |
| --- | --- |
| Field name | Value |
| Quantity | Angle (degree) |
| Name | Plant strength |
| Description | After harvest, the angle at which the plant stem snaps when held between two points 4cm apart and bent double. |
| Variable type | Final |
| Observation type | Numeric |

|  |  |
| --- | --- |
| Field name | Value |
| Quantity | Opinion |
| Name | Appearance |
| Description | Note down anything interesting about the appearance of the plants compared to those in other conditions. |
| Variable type | Repeated |
| Observation type | Text |

## Complex version

Experiment

|  |  |
| --- | --- |
| Field | Value |
| Code | TMG |
| Title | Thigmomorphogenesis |
| Description | An investigation into the relationship between physical interactions with the environment and plant growth |
| Text | When they are growing outside, the wind blows plants about. They may also be pushed or squashed by people or animals. We hypothesise that increased physical interactions encourage plants to develop stronger stems and to increase the concentration of characteristic chemicals leading to greater weight at harvest, brighter colours and stronger flavour.  Note that the plants must be at least 2cm tall before starting this experiment.  Set out the seedlings so that those in condition 1 are in the top tray of the GrowCube, those in condition 2 are in the middle tray and those in condition 3 are in the bottom tray. |
| Measurement frequency | Weekly |

Hypotheses

|  |  |
| --- | --- |
| Field | Value |
| Hypothesis no | 0 |
| Name | Null hypothesis |
| Text | Physical interactions have no effect on plant growth |

|  |  |
| --- | --- |
| Field | Value |
| Hypothesis no | 1 |
| Name | Higher strength |
| Text | Increased physical interaction is positively correlated with stem strength |

|  |  |
| --- | --- |
| Field | Value |
| Hypothesis no | 2 |
| Description | Increased weight |
| Text | Increased physical interaction is positively correlated with plant weight at harvest |

|  |  |
| --- | --- |
| Field | Value |
| Hypothesis no | 3 |
| Description | Stronger colours |
| Text | Increased physical interaction is positively correlated with colour saturation of leaves |

|  |  |
| --- | --- |
| Field | Value |
| Hypothesis no | 4 |
| Description | Stronger flavour |
| Text | Increased physical interaction is positively correlated with the strength of flavour at harvest |

Conditions

|  |  |
| --- | --- |
| Field | Value |
| Condition no | 1 |
| Description | No touching |
| Text | This is the simple case where we have removed all forms of touching. We can compare all other conditions to this one. The difficult part is making sure that the plants in this condition are not touched by accident. |
| Treatment frequency | None |

|  |  |
| --- | --- |
| Field | Value |
| Condition no | 2 |
| Description | Gentle tickling |
| Text | Carefully and gently pass a plastic ruler over each square of plants to flex (bend) the plants to at least 30 degrees from the vertical, taking great care not to break to the stems. Do at least one flex per second and do 10 flexes |
| Treatment frequency | Weekly |

|  |  |
| --- | --- |
| Field | Value |
| Condition no | 3 |
| Description | Moderate tickling |
| Text | Carefully and gently pass a plastic ruler over each square of plants to flex (bend) the plants to at least 30 degrees from the vertical, taking great care not to break to the stems. Do at least one flex per second and do 30 flexes |
| Treatment frequency | Weekly |

Variables

|  |  |
| --- | --- |
| Field name | Value |
| Quantity | Length (mm) |
| Name | Plant height |
| Description | Vertical height of the plant measured from the substrate surface to the highest point without touching the plant. |
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| Observation type | Numeric |

|  |  |
| --- | --- |
| Field name | Value |
| Quantity | Weight (g) |
| Name | Plant weight |
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| Variable type | Final |
| Observation type | Numeric |

|  |  |
| --- | --- |
| Field name | Value |
| Quantity | Angle (degree) |
| Name | Plant strength |
| Description | After harvest, the angle at which the plant stem snaps when held between two points 4cm apart and bent double. |
| Variable type | Final |
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|  |  |
| --- | --- |
| Field name | Value |
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