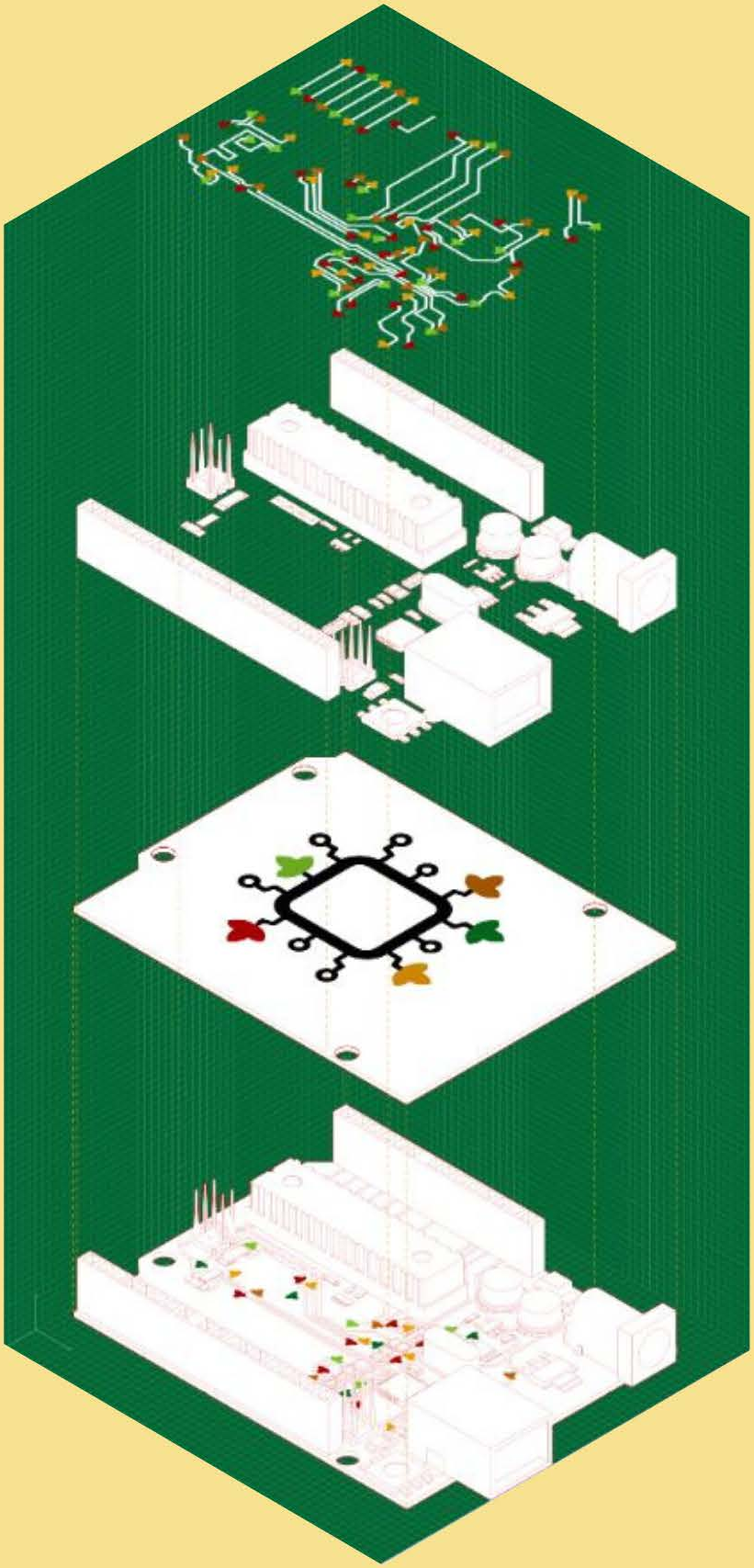
Green STEAM Incubator

Handbook on “Design Thinking Models”



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IO 4.4. HANDBOOK ON "DESIGN THINKING MODELS" AND THEIR UTILISATION IN STEAM - ORIENTED DISCIPLINES

Definition of Design Thinking

We live in a world of rapid changes and innovations where new problems and challenges are arising. Due to these changes, the way we think, teach, and solve problems needs to be redefined. This new reality suggests STEAM's view, which focuses more broadly on interdisciplinarity, creativity, authentic or real-world learning, and project-centered thinking. To apply STEAM in this way, we must give teachers support or structures for enacting messy creative practices within the already messy and challenging contexts of teaching.

One method of implementing STEAM education is Design Thinking (Henriksen, 2017). Design thinking may provide a guiding framework to support an expanded view of STEAM teaching. It also offers a structure to help develop more creative and interdisciplinary practices, as a framework to guide their thinking and as a part of students' STEAM experiences. As shown in Table 1, Design Thinking (DT) is a user-centered and action-oriented approach to innovation that emphasises interdisciplinary collaboration and problem-solving modes. This kind of approach has become very popular in business schools, engineering, interdisciplinary studies, and design programs (Graham,2020). It combines creative and analytical approaches and dissolves boundaries to create new social, cultural, and hybrid ways of understanding and representing knowledge. (Costantino, 2018; Knochel, 2017; Liao, 2016; Marshall, 2014, 2019).

The designer's sensibility and problem-solving methods can remodel how different organisations develop their products, services, or strategies. Furthermore, DT brings together what is necessary and desirable from a human perspective, which is technologically feasible and, in the same way, economically viable. It also allows people who aren't designers to develop their creativeness and face the new challenges that the 4th Industrial revolution imposes.

In traditional schools, design activity has not been emphasised, except in art and vocation training. That's where DT comes in STEAM-oriented disciplines and asks students to become creative investigators to solve their math and science problems and issues they identify in their environment, focusing on innovation. Then it helps them bridge and overpass the gaps of knowledge independently, collaboratively, and resourcefully (Henriksen, 2017). Thus, we conclude that STEAM education and DT may enlarge the boundaries of disciplinary fields by creating hybrid ways of understanding and representing knowledge.

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Human-centeredness (developing empathy for the people for whom you are designing)
Bias toward action (spending more time doing and making)
Radical collaboration (bringing together innovators with diverse backgrounds and viewpoints)
Culture of prototyping (building to think and learn from multiple iterations)
Show, do not tell (communicating vision in an impactful way to your audience)
Mindfulness of process (knowing the goals and stages of the process)

Table 1 Habits of mind in design thinking (adapted from Stanford d.school)(Cook, 2018)

Design Thinking Models

Studies on Design Thinking Models count many years ago, especially in engineering (e.g., Schön, 1983; Simon 1973, 1996). In the literature, many different design thinking models are reported, with each having a different number of process steps. One of them is the famous five-step cyclic model, including problem definition, empathy, Ideation, prototyping, and testing. This model aims to improve critical thinking and creative problem-solving skills, in addition to the engineering skills needed to bring an idea from sketch to prototype. Purposefully Design Thinking integrates an empathy component through which designers need to consider the needs and values of those for whom they are designing (Cook, et al., 2018). DT combines empathy in the context of a given problem, the creativity devoted to generating perceptions and solutions, and the rationality and feedback to analyse and adjust solutions for a given context (Leitão, 2019). A combination of all this helps to find a solution to a specific need that also generates income.

The Stanford d. school Model

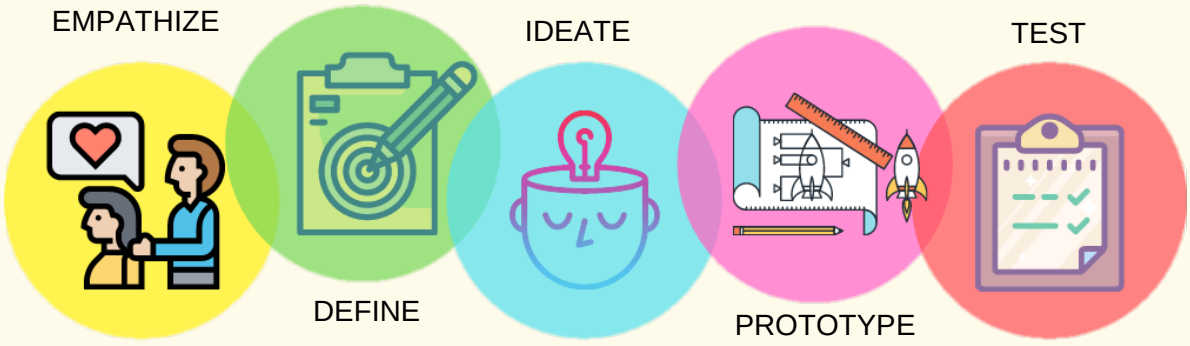

Figure 1 The Stanford d.school Model

Stages	Short description of each stage
Empathize	• Observation of user behavior in life contexts • Engaging, interacting, and interviewing users • Being able to immerse oneself in the user's experiences • Understand user's needs and wants • Stepping into the shoes of the end-users
Define	• Analyze and synthesize empathy findings into compelling needs and insights.
Ideate	• Explore a vast solution space and identify the best solution from a range of possibilities. Generate ideas through brainstorming, mind mapping, storyboarding, and other techniques.
Prototype	• Plan the approach, think about the needed materials. Make some initial sketches. Prototypes are low-resolution and can be storyboards, role-plays, physical objects, or services.
Test	• Testing is the chance to put the prototype into the user's hands. Iterate and refine solutions to better meet the user's needs.

The IGNITE Model

Ignite is a novel approach to STEM that uses design thinking. It began at Duke University with four undergraduate students who participated in a design-thinking biomedical engineering course. This approach wants the students to learn some engineering skills, work in teams to use the user-centered design process, and develop solutions to sustainable development goals using the skills previously learned. Ignite relies on collaborative learning, and it aims to improve the sustainability and scalability of STEM coursework. Moreover, this approach focuses on understanding a need directly related to a sustainable development goal using STEM concepts.

The 5 stages of the Human-Centered Design (HCD) are: (1) empathize, (2) define a problem, (3) ideate and brainstorm solutions, (4) prototype, and (5) field test with feedback (IDEO) (Figure 1).

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The IDEO Model

Figure 2 The circular feedback loop of the ignite model (Dotson et al., 2020)

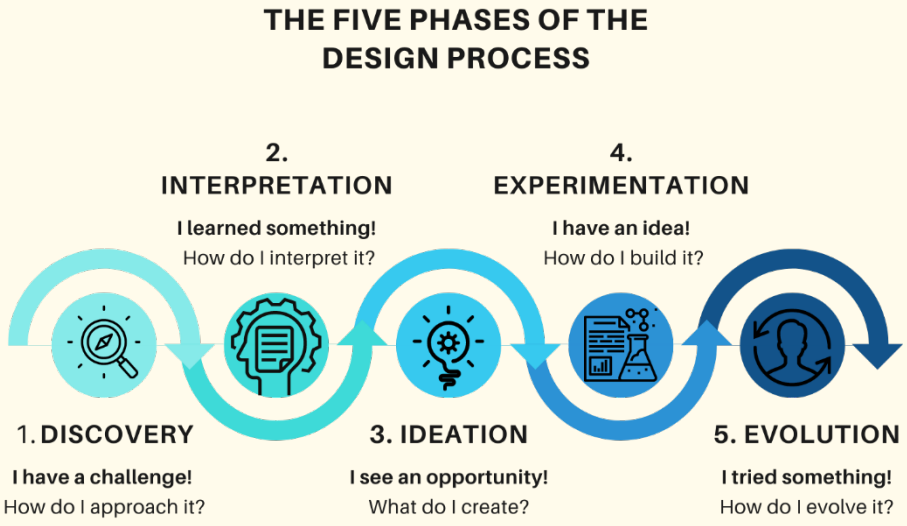

Figure 3 The five phases of the design process

The Google Design Sprints (II) Model

Google Ventures created the Google Design Sprints Model, and it is based on the understanding of Design Thinking. Google Design Sprint (II) Models is a five-step process for answering critical business questions and solving design problems through design, prototyping, and real-life testing with end-users. The first phase of the Sprint is understanding. It requires finding the right people to share business goals, technology capability, and user needs. The purpose of this stage is to expand the knowledge of the product/project. The next step is called Diverge/Sketch. Here we need to explore all possible solutions to the end-user's problems. After that, it is time to vote. During the third phase need to decide which of the previous stage's ideas are the best to be prototyped. Prototyping is when the best idea will be quickly built using cheap products, like Lego or just paper, and then tested insight the organisation. The goal is to give the prototype to real end-users during the validation phase and gather feedback. This final step helps to learn what works and what needs to be designed differently. This model can be used anytime during the product design process as it solves design problems quickly, and it allows you to fail early without losing money and time.

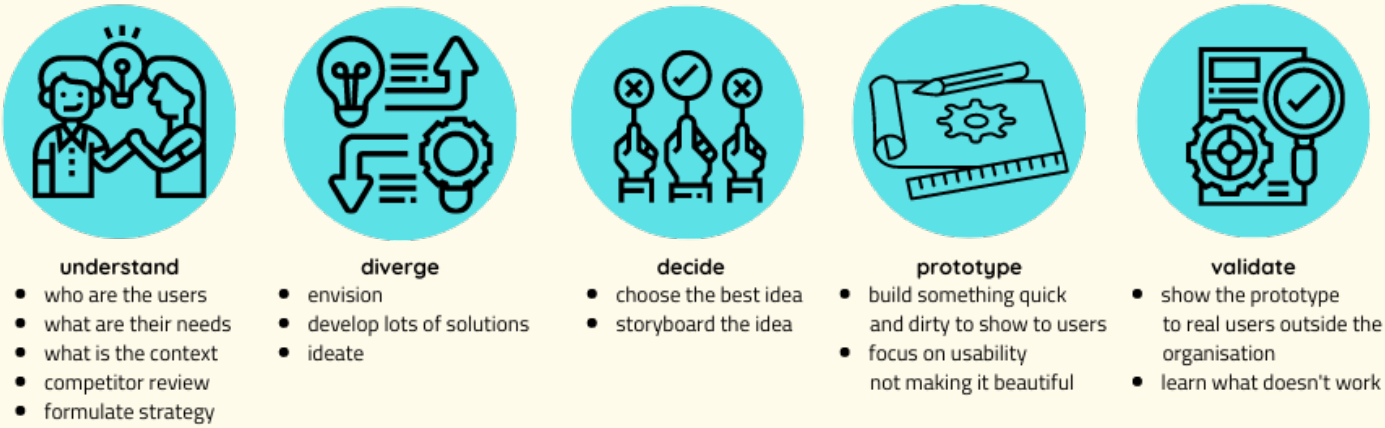

Figure 4 The Google Design Sprints (II) Model

The HPI D-School Model

The HPI School of Design Thinking (HPI D-School) was founded by Hasso Plattner based on the Stanford d.school model. In this model, the design thinking process consists of six steps, which should be performed in iterative loops, if necessary, to go back to a previous step, as shown in Figure 5. The HPI D-School models do not show the multi-disciplinary approach, nor does it describe what is happening in each step of the process. Understand is the first step of this process. Existing information about the topic is gathered through secondary research. The second step, Observe, aims to collect insights about problems and the users' needs, of which they are usually unaware but must be identified by the design thinker. The observation results are then shared among the group through storytelling and then synthesised into a visual framework called Point of View. The next phase is Ideation. The team uses brainstorming to come up with ideas based on the Point of View. In the end, the best ideas are selected to be built in the Prototyping phase, using legos, paper, and other objects. Finally, during the test phase, the prototypes are tested by the users to gather feedback. According to feedbacks, the prototype is revised, or sometimes we need to go back to the first phase and start the procedure from the beginning to understand the user's needs better.

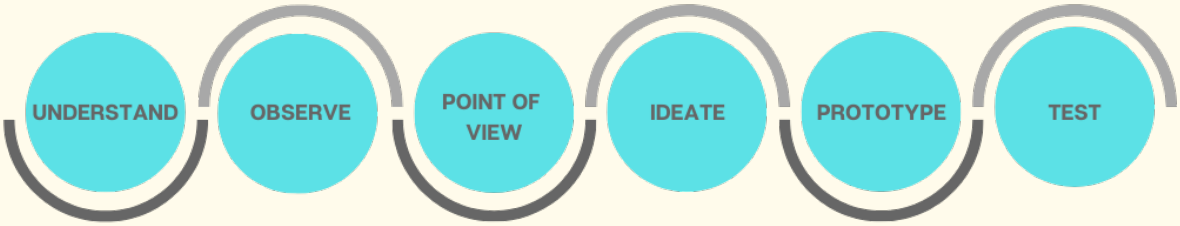

Figure 5 The design thinking process at HPI D-School (Source: Thoring, K. et al. (2011))

HOW TO UNDERSTAND THE PROBLEM

To understand the problem, we need to profoundly investigate the problem we are trying to solve and build empathy for the people most impacted by the issue. It is crucial to understand who has and who has not the problem, where this problem occurs, what this problem is, and how extensive it is.

HOW TO OBSERVE

During the observation phase, the focus goes on the end-user. In this phase, the observer tries to empathise with the user's role and better understand it. The observation could be carried out by different persons with different knowledge and backgrounds, as each observer pays attention to every other aspect according to their expertise.

HOW TO DEFINE THE PROBLEM

The define stage helps you use the information gathered in the previous steps to identify a more narrow focus for the solution. An excellent way to define the problem is by synthesising all the observations that were previously carried out. Synthesis involves creatively piecing the puzzle together, organising, interpreting, and making sense of the gathered data to make a good problem statement.

HOW TO SELECT IDEAS

Before selecting the best ideas, we need to concentrate on idea generation. Ideation is an exciting and creative process through which a large number of ideas is generated in order to develop solutions. Some Ideation Methods that help to come out with innovative ideas are:

- Brainstorm
- Gamestorm
- Crowdstorm
- Workshops

HOW TO PROTOTYPE

Prototyping is an essential part of design thinking as it allows to test and explore ideas properly. Prototypes need to be tangible forms of ideas to make it easier to understand the idea's pros and cons and improve it.

HOW TO TEST THE IDEA

Testing is when our product goes to the target group that we set from the beginning and test it in real-time. During this phase, observation is essential, as we need to spot the weaknesses of the product and see if the problem was framed correctly. Comments and negative feedback are critical during this phase as it helps uncovers issues that might not previously have identified. There are different methods to test the idea developed. The most appropriate method depends on the design thinking stage you are in and what you want to try (usability, concept, etc.). Some of the testing methods are the following:

- Usability testing: This testing evaluates the degree to which a specified target group can use the system with effectiveness, efficiency, and satisfaction in a specified context of use—this method the usability of the product to be improved.
- Concept testing: This testing evaluates the consumers' acceptance of a new idea.
- Focus group: This testing focuses on 6-9 participant users, and the goal is to discuss what they want from the product.
- Surveys: Survey is an easy way of collecting quantitative data from many users within less time. Surveys consist of a set of questions (closed or open-ended) to gather comprehensive information on a wide range of topics. Surveys can be sent

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with the google forms tool as it allows you to contact hundreds of people in a few minutes.

- A/B Testing: A/B Testing helps choose between two competing elements of a design (color, shape, etc.). This method can be done online.
- Beta Testing: In Beta testing, an almost completed product that includes all the final product's basic functionalities is tested with end-users. The beta version of the product is given to users and asked to use it for a few days and come back with feedback.

HOW TO IMPLEMENT DESIGN THINKING

The first step of implementing Design Thinking is to get to know a Design Thinking Framework. At least a dozen different frameworks exist that describe how to do this in slightly different ways. One thing that they all have in common is that they represent a process. The most important thing to know is that design thinking is a problem-solving framework with a human-centered core - meaning that whatever method you will choose, the first and most essential step in the process is empathising with the end-user.

The next step is to identify the problem and start empathising with the user. If we take agriculture as an example, we could identify problems faced by farmers on a daily basis. Unexpected weather conditions that can destroy their crop is one of them. Once the users' problem is truly understood, it is time to ideate a solution to the issues. A good solution could be a weather station application that could warn the farmer in lousy weather. A prototype must be then designed to test this idea in real conditions and ensure that it solves our problem. Results from the prototype tests can show whether the solution addresses the needs of the end-user or not. If you spot an issue in the prototype, you need to go back to the previous steps and approach the next iteration with an educated eye. Eventually, you will arrive at the final stage on which your solutions are thoroughly tested, validated, and ready to be given to the user.

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EXAMPLES OF DESIGN THINKING MODELS IN 3D-OBJECTS

For many years, engineers and product developers have been developing products through the traditional manufacturing process. In the past, they used to create designs, talking to people, or describing something they produced. That is why particular skills were needed to draw something so that people would understand what the idea was about. As Professor David Weightman said, you can wave you arms around and use words or gestures to explain an idea, but you have to make it more tangible and physical beyond a certain point.

Now that technologies are becoming cheaper, more widely available, and significantly easier for people to engage with, product development uses 3D design and 3D printing for prototyping. Thus the designing and manufacturing rules have changed. Rapid prototyping, different platforms, and not just 3D printers have impacted the design thinking process and have made thinking tangible much quicker and easier. By implementing the design thinking approach, manufacturers can take advantage of the capabilities of 3D printing in the prototyping step to create products that revolve around the customer's needs. 3D printing is a technology that can rapidly iterate, as 3D models can be quickly manufactured using a 3D printer. A group of end-users can then test the prototype for any functional or design errors.

An important aspect of teaching 3D printing, or any technology, to youth, is to make engaging with the technology meaningful by giving them a problem and challenge them to solve it using the given technology.

Design a charging station for your mobile phone.

Here every participant can use their own phones for this challenge. The participant will need to take measurements of the device and the charging port to create their station.

Ideate/Brainstorm: Participants will have to write down or doodle different ideas for the charging station.

Sketch: Participants should complete an illustration of their design before attempting it in Onshape. Depending on the participants' level, we can require a scale drawing as an intermediate step between the rough sketch and the 3D model.

Model: Participants should translate their sketch into a 3D model in Onshape.

Reiterate: Participants will need to pair up and give each other feedback on their charging station designs. Encourage them to ask each other questions about the aesthetics, functionality, and printability of their design. The participant and the facilitator should verify the design together for any gaps or misalignment. In the end, the participants have to prepare the print.

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Test: Set up the printed charging stations and see how the phones fit. Participants need to write down two or three ideas for adjustments and modifications they would make in a future iteration of the design.

Design and print a watering can.

To draw a simple object like a watering can, we need to take many things into consideration. For this project, we will use a DT methodological approach used by F. Martins et al., 2020, that comprises four phases: Immersion, Analysis/Synthesis, Ideation, Prototyping.

Immersion: The participants should review the scientific literature on existing watering cans used in agriculture and learn about the specifications that should meet to be used by professional farmers. In this stage, the participants could organise meetings with farmers to specify their needs and problems concerning the watering cans that they use.

Analysis/Synthesis: During this phase, the participants will classify and analyse the previous step's information using diagrams and concept maps.

Ideation: This phase's main purpose is to create an alternative watering design, which meets the needs and specifications given in the two previous steps. The objective here is to find the ideal solution to the problem. In this phase, participants can use the General Morphological Analysis (GMA). GMA is an analytical-combinatorial technique based on the decomposition of a problem. Engineers are often using this method, especially for complex problems, by breaking down the problem into fundamental variables.

Prototyping: In this phase, participants will use a 3D modelling software to create a prototype of their final and ideal watering can. The 3D model will also be printed using a 3D printer to be tested in real-life situations and make sure that the final product meets the end-users' needs and specifications.

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RESOURCES

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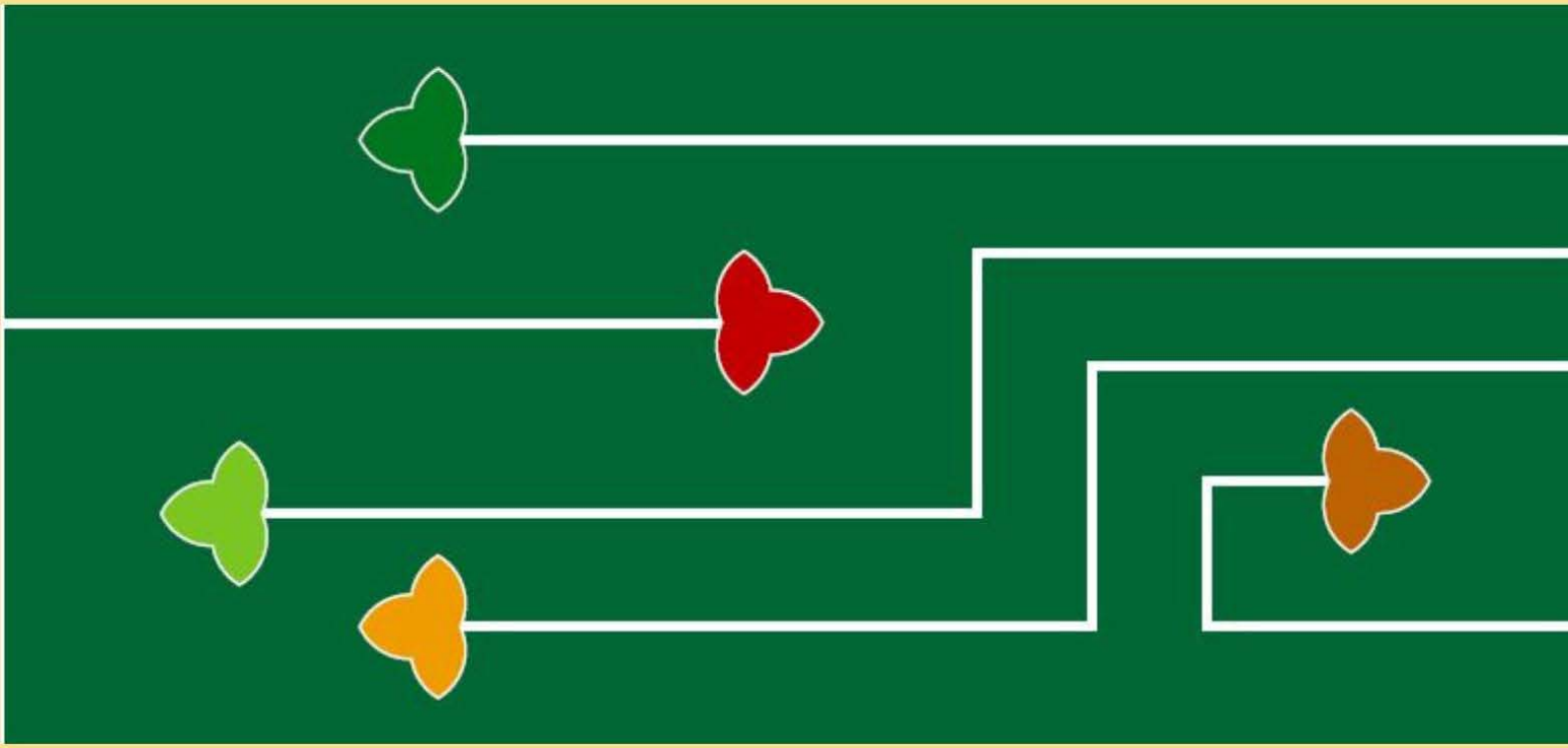

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