Farm in the city

unplugged QUEST

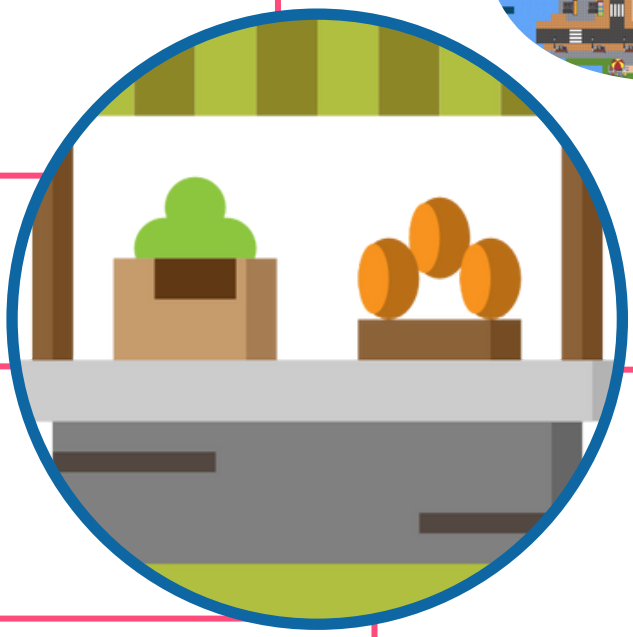
This activity sheet provides information on the construction of the unplugged challenge "Farm in the City" based on dominating sets. Dominant sets (belonging to the mathematical discipline of graph theory) allow us to approach the solution of problem optimisation at school on tangible and intuitively understandable issues. Thus, thanks to this activity, we can approach, from a young age and in a simple way, more or less complex concepts of algorithms (which can be applied to the field of computer science). The Farm in the City activity provides a simple and accessible version of the use of dominant sets to solve a combinatorial problem.

Printable resources attached: Map of the city, printable graph worksheet, badges to personify the role-playing part and make the activity more fun

Additional materials needed: coloured pencils, translucent paper

Territory 2 - The Strong Community

Total duration: 1 hour



Inspired by: CS Unplugged

CS UNPLUGGED
Computer Science without a computer

https://classic.csunplugged.org/activities/dominating-sets/

Linked SDGs

Learning objectives

- Understanding natural systems and technical systems
- Acquiring a sense of the rules of living together
- Understanding the relationship between object and space
- Sharing rules, taking on roles and responsibilities
- Understanding the representations of the world and human activity

Game modalities

- 6 - 12 years old
- Work in group
- In the classroom
- At home
- Support of an adult

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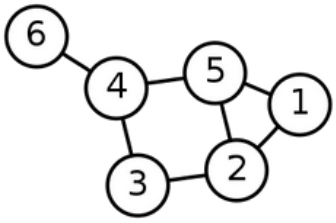
Pedagogical interest and topics targeted

Interest of the activity in understanding mathematical concepts - graph theory and dominating sets: Many real life situations can be abstracted into the form of a 'graph' or more commonly a drawing of networks connecting objects by edges. Graphs are of great interest for the development of algorithms because they allow to model relationships between a finite set of entities by considering both their properties and their interactions. The entities are the vertices or nodes of our networks represented in a simplified way. The image below is a very simple example of a graph drawing, where each number represents an entity, an object. The links between the nodes are the edges of the graph.

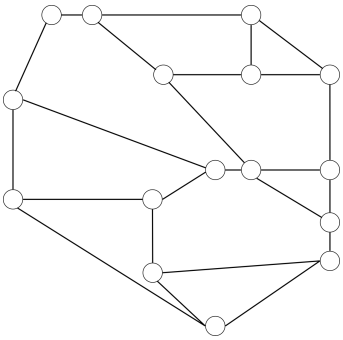
In order to illustrate the concept of graphs and dominating sets, we propose a simple activity that will allow us to understand the **interactions between entities but also their limits**. To do this, we consider a **city, with several streets (our edges) that cross each other, creating crossroads (which will be represented by nodes)**, and a challenge: to **create a network of urban farms that will allow each citizen to find fruit and vegetables in a short circuit close to their home**. We use the map presented here aside to represent the city. As we can see, the city is made up of edges (our streets, in grey) which connect vertices (our crossroads represented by white dots).



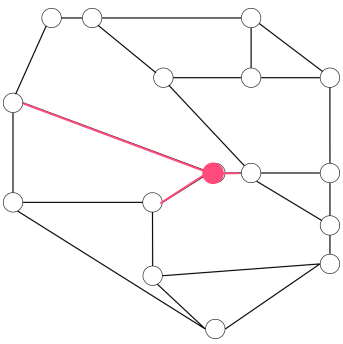
Example of a graph

Our city illustrated

Thanks to the mathematical concept of graphs, we can represent our city by a mathematical model which simplifies the initial concepts. If you superimpose our plan and our graph, you will see that the two representations coincide perfectly, one being complex because it includes a lot of information that is not necessary to solve the problem (i.e. finding the optimal location of urban farms to serve all the citizens of our city). The second one is simpler, proposing only the useful information (the areas where the farms can be located i.e. the vertices, and the adjacent streets that will be served by these farms i.e. the edges).


Our city as a graph

In order to solve the problem, we will **use the city graph to propose an optimal location of the farms**. To do this, we propose a simple activity: **using the crossroads (the vertices), locate the first farm**. Once located, **we can consider that the inhabitants living in the adjacent streets (i.e. those located on one of the edges touching the node)** will be served. To do this, you can use the proposed graph and colour the vertice (or crossroad) where your farm is located and the adjacent edges (the streets) to visualise your choice, as in the diagram opposite. After this first step, you can continue with the positioning of a second, third, fourth.


Position the first farm

Pedagogical interest and topics targeted

At this stage, the activity is simple, it would be enough to place a farm on each vertice to cover the whole city. Let's add an intuitive constraint to avoid redundancy of farms: **we want to have a minimum of farms that cover the whole city (all streets). Can we easily find a minimum set of locations that can cover the whole city? It comes down to asking, what is the minimum number of farms that need to be positioned to allow every citizen to have easy access to food?** Although easy to formulate, this is actually a **surprisingly difficult problem to solve mathematically**. Today, no one yet knows whether there is an algorithm for calculating this minimum set of locations that would be more efficient than a manual method of trial and error and/or iterations of strategies (called heuristics).

We suggest that you get the pupils to **work individually** to start with, by providing them with the graph of the city - printable 2 (on transparent paper if you want to overlay the results or on normal paper) and asking them to **cover their city with as few farms as possible without insisting on the method to be applied**. To motivate the students, you can make this a **class challenge**. When all the pupils have proposed the solution they think is best, you can compare the results. To make it clear that behind each solution, there was a **process (which we will later call an algorithm),** ask the pupils who had good solutions to **explain how they found them**. Emphasise the **choices**, the **repetitions** and the **strategies** used to make the students understand the key concepts of algorithmy. Based on this oral systematisation, ask the class to repeat the challenge to come up with the **"best algorithm"** possible.

Through this activity, students will therefore cover several topics, including mapping, relationships, puzzle solving and iterative goal finding, combinatorics and graph theory.

Simply approaching game theory: To make the activity more complex, you can also introduce the roles proposed below to approach **game theory**. Indeed, by repeating the game, each player can implement a **strategy that will not follow the same logic from one round to the next**. By introducing new role constraints into the game, each player will have **conflicting objectives**. We suggest that you introduce up to 4 roles and secretly propose the following objectives to the children:

- Citizens: To have access to a maximum of public and economic services in the city - **Hidden objective: to increase the number of urban farms offered in the city territory**
- Urban farmers: To offer a profitable service i.e. a good cost/benefit ratio in the installation of their harvesting and selling points - **Hidden objective: to have a minimum of farms for a maximum of customers**
- Real estate developers / Builders: Increase the value of their building through additional services - **Hidden objective: offer a maximum of urban farm services in order to attract residents to the buildings**
- Urban planner (add random bus stops to the graph): Find the best match between public and private services provided to citizens - **Hidden objective: Locate farms near a bus stop to enhance urban transport planning.**

Pedagogical interest and topics targeted

With regard to the different roles proposed, potential alliances can already be identified, for example between the farmer and the urban planner, or between the citizen and the real-estate developer. By encouraging discussions between each of these representatives (group work for this stage), the children will be able to choose their strategy, which will no longer correspond to a single constraint but to a **plurality of sometimes antagonistic needs**. They can thus decide either to play collectively, i.e. to cooperate, or to play individually by trying to influence the other members of the group, and thus to enter into a competitive logic. As a teacher/facilitator, you will be responsible for encouraging the search for a **win-win strategy**. This second phase of the game will allow you to work on the approach to citizenship and living together. In this context, **game theory should enable us to learn that the game defines the players, but that in the end, it is we, the players, who define the game**.

Open discussion on food consumption and smart city practices: Finally, as with all the activities offered in the Unplugged Quest, we want to be able to enable teachers to **open up discussion on societal issues in the classroom**. In the "Farm in the City" game, the aim is to enable children to learn more about **urban agriculture, local food systems and the importance of learning cities in facilitating more sustainable practices by citizens** who support urban policies. In addition to the implementation of the game, it is also possible to **take a look at the other resources** provided in this document to initiate concrete agricultural projects with students and illustrate the need for these practices even through a mathematical activity.

Game rules

Welcome to our city.

After many years of public policies aimed at stimulating urbanisation, citizens are now asking local authorities to prioritise their well-being, through a better provision of quality public and private services (e.g. in the fields of transport and healthy and affordable food). Thanks to the last elections, a change in policy making in the city has promoted new practices and dedicated public funds to the development of the "city of tomorrow", with urban agriculture as the first priority. In response to this new initiative, a group of farmers is trying to find the best strategy within the city to locate their farms, considering both the minimisation of costs, while ensuring a maximum number of customers and thus that every citizen has easy access to their production.

Rules of the game :

The game "Farm in the city" is made up of a series of activities allowing the discovery of graph theory and dominant sets. To do this, we suggest that teachers carry out the following activities:

- The children will first be asked to work individually. They will represent urban farmers who are trying to answer the question: **how to minimise the number of farms while maximising the number of customers?** To do this, they will each work on **their own graph**. Students will compare their results by counting both: the number of farms installed and the number of streets covered. **The student(s) who find the best match between the number of farms and the number of streets will win this round.**
- The children can then **work in groups**, once the initial mathematical activity has been understood. They can choose to **represent the farmers' group, the urban planners, the citizens or the building owners**. The teacher will be responsible for distributing the roles and **secretly informing each group of students of their hidden objectives**. Mixed groups will be created, with each player taking on the role of a representative of the city. Having the children experiment with different positions will **help to compare strategies**. Remind them as often as possible of the different objectives they are pursuing: **minimising** (the farmers, the planners), **maximising** (the building owner, the citizens) or **optimising** (the win-win strategy). After this round, the students will have to **present their strategy and the difficulties encountered**. The team that manages to find the best win-win strategy will be crowned champion of this round.

Teacher's role in the development of the activity :

1. Explaining the rules during the different rounds and ensures that all players understand the game and their roles.
2. Facilitating the team collaboration process.
3. Mediating the sharing of strategies and the negotiation process in the third round.
4. Opening a discussion on sustainable cities, including transport, food production and supply, and principles of living together.

Game rounds

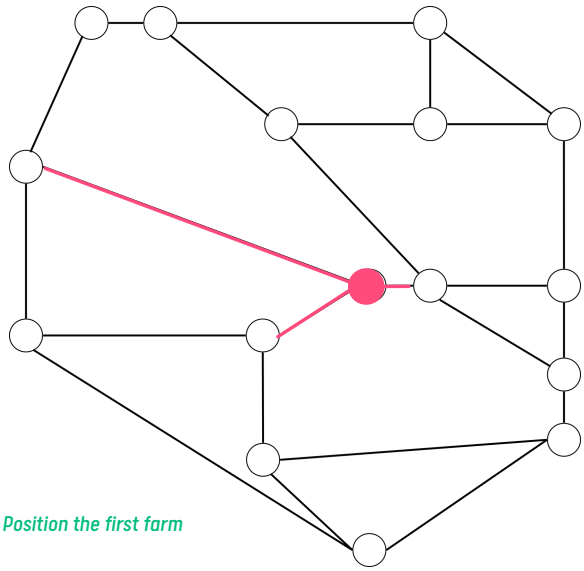
Phase 1 - Understanding the dominating sets

Teacher/Mediator: "Welcome to this first working meeting of the "Farm in the City" project. Let me introduce myself, I am your newly elected mayor. After several years of public policies aimed at stimulating excessive urbanisation, I have made the well-being of my fellow citizens a priority in my election campaign and I intend to keep my promises. My first major project will be to offer cheaper, more local access to healthy food to a maximum number of inhabitants of our territory. I have therefore brought you together in your capacity as committed farmers, to propose the creation of a network of urban farms, using the unoptimised space available on the roofs of all those buildings that the previous municipality had built in partnership with real-estate developers. I know you are concerned about the cost of these new facilities, we cannot honestly promise to create a harvesting and selling point on every street corner. But I ask you to think individually about a proposal that could allow us to cover as many streets in our city as possible, minimising the number of installations to be done in the coming year. I look forward to your proposals!"

The game starts with an introduction to the objectives and the story. At this stage, all the students have the same objective: **to create a network of urban farms with the constraint of minimising the number of installations while maximising the number of streets that will be served by these harvesting and selling points**. They all represent farmers, brought together by the municipality to make a first proposal for a network.

To do this, each student will be given a **graph worksheet (printable 2),** representing the simplified version of the fictitious city in which we live (you can show them the complex version of the city - printable 1 - and the simplified version - printable 2 - to introduce them to the basics of graph theory). On the graph, the instruction will be simple: **position farms at the crossroads (vertices of the graph) in order to serve the adjacent streets**. To do this, your students must **first place the first farm on a vertice**, then **colour in all the streets concerned by their choices** (as shown in the diagram below). Then, they will repeat the same process with a second farm and a third, etc. As they make their choices, **remind them that farms are expensive and that the idea is to have as few as possible**. It is obvious that without constraints we could place one at each intersection - the interesting question is how many farms do we need as a minimum. In order to facilitate iterations, you can provide several graph sheets per student, or have them work with pencils that are easily erased, as the strategies will evolve as the student gets to grips with the activity and builds their intuition of the process of creating a good solution (the algorithm).

When the time for the activity is over (about 10-15 minutes), each student should count the number of farms he/she has placed and the number of streets served. By pooling these results, you can vote for the student(s) who found the most optimal solutions.



Position the first farm

Game rounds

Phase 2 - Introduction of hidden objectives

The teacher/mediator: "Welcome to this second meeting which follows a consultation with local farmers in order to propose to our citizens an optimal network of urban farms to promote access to healthier and more local food in our city. As a newly elected mayor, I wanted to involve all stakeholders in this project as early as possible, which is why I have brought you together today. With our group of advisory farmers, we have already defined a first strategy for the location of farms in order to cover as much of our territory as possible. As representatives of the different actors involved in this project - citizens, developers, planners, farmers - we would like to have your opinion and your strategic view on this project. We therefore propose a collective working session in order to find, we hope, a common strategy at the end of this day! We hope to see respectful discussions throughout the debate. Thank you in advance for your valuable contribution".

The second phase of the game starts with a presentation of the context and history. After receiving the farmers' proposals, the local authorities are ready to open the debate to the representatives of society, especially in order to secure the support of as many actors as possible to launch this project. **As a mediator, you therefore divide the class into 4 groups of students to distribute the roles. Each group is given a role, and a hidden objective which you only reveal to the pupils in that group**. The roles are as follows (you can distribute badges available in the printable section to make this phase more playful):

- Citizens: To have access to a maximum of public and economic services in the city - **Hidden objective: to increase the number of urban farms offered in the city territory**
- Urban farmers: To offer a profitable service i.e. a good cost/benefit ratio in the installation of their harvesting and selling points - **Hidden objective: to have a minimum of farms for a maximum of citizens (clients) covered**
- Real estate developers / Builders: Increase the value of their building through additional services - **Hidden objective: offer a maximum of urban farm services to attract residents to the buildings**
- Urban planner (add random bus stops to the graph): Find the best match between public and private services provided to citizens - **Hidden objective: Locate farms near a bus stop to enhance urban transport planning.**

Once the roles have been distributed and the hidden objectives have been defined, you can divide your class into working groups, each of which has **at least one representative from each category of stakeholder**. Phase 2 can begin. Once the groups are together, **give the students new worksheets in the form of a graph**. Ask them to come up with a **common strategy** to take into account **all the demands of each representative** and let them open the **debate**. Don't hesitate to intervene if you see blockages or tensions in the groups in order to raise new issues or refocus the discussion.

Once the time is up (15-20 minutes), each group should present its strategy and describe the potential tensions, alliances and concessions encountered and implemented during this phase. Facilitate discussion on this particular aspect of holding a debate. How is the democratic process complex, but still allowing taking into account multiple perspectives? Once the debriefing is over, you will be responsible for choosing the team that you think has come up with the best win/win strategy to be crowned the champion of the round! Show that often the best collective solution is not necessarily the mathematically optimal one. And that the more conflicting objectives there are, the less interesting pure optimisation is. After this phase, do not hesitate to open additional discussions on the themes of the city of tomorrow, urban agriculture, propose creative activities such as making seed bombs to make the surroundings of your school bloom... Feel free to use "Farm in the City" for new purposes!

Topic 1 - Game theory, communication & trust

More interesting materials about game theory for children you may find here: https://kids.kiddle.co/Game_theory & https://kids.frontiersin.org/articles/10.3389/frym.2017.00066

To practice further team strategy planning and communication you may wish to see other Unplugged activities, e.g. ***The Perfect City, Pop-up City of the Future, Reroute better world, Good Ways, Brain Twister***

Topic 2 - Urban farming

Take the opportunity of this game to discuss with the classroom regarding urban farming practices. More information on urban farming can be found over the web such as https://en.wikipedia.org/wiki/Urban_agriculture, https://www.unesco.org/en/articles/unesco-promotes-biodiversity-and-urban-gardening-its-own-premises, https://en.wikipedia.org/wiki/Urban_beekeeping. More interesting materials about urban farming adapted for children can also be found here: https://www.petitjourney.com.au/petit-childrens-garden-activities/, https://www.littledayout.com/urban-farming-for-kids/. You can also discuss with children regarding guerilla gardening actions: https://en.wikipedia.org/wiki/Guerrilla_gardening, and even create seeds bomb with your pupils: https://littlebinsforlittlehands.com/make-seed-bombs-earth-day-activity/

Eventually, to introduce the topic of sustainable and/or urban farming; you can also see other Unplugged activities, e.g. ***Cookies and Peace, PotLuck March, Ecosystem in a Jar, etc.***

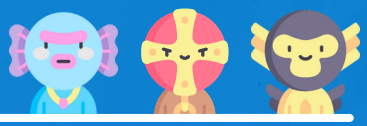
Topic 3 - Smart city

Discover with your students what is a smart city: https://mocomi.com/what-is-a-smart-city/, http://howtofunda.com/smart-city-model-school-project-for-science-exhibition/ and think and design your own smart environment, starting with a smart school: https://circularcomputing.com/news/10-ways-make-school-sustainable/. Create STEAM activities thanks to other EU-funded projects such as: https://smartkidsproject.eu/. To practice further smart city planning you may wish to see other Unplugged activities, e.g. ***The Perfect City, Pop-up City of the Future, etc.***

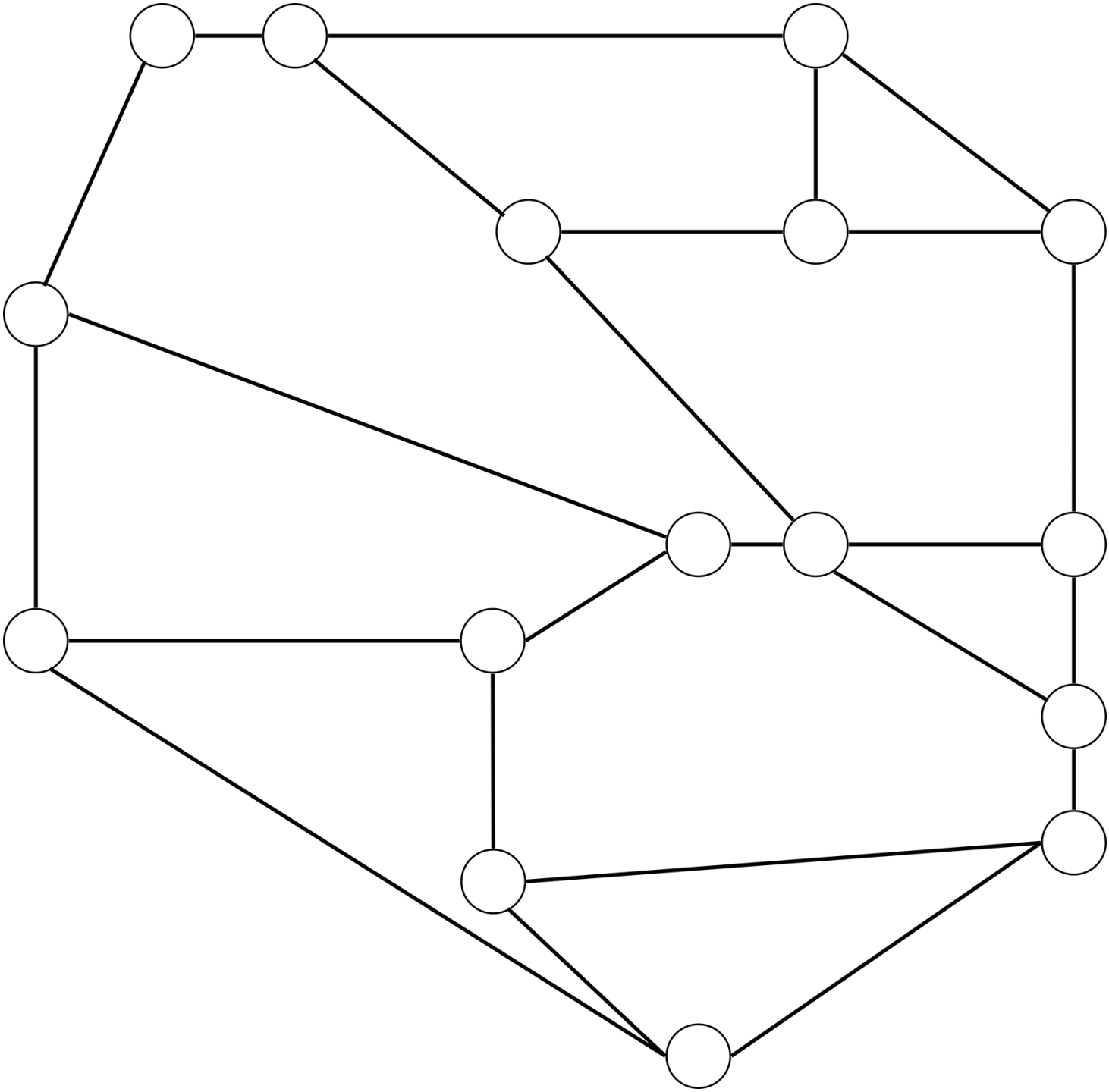
Printable 1

City map - 1 for the class - Use it as a background to illustrate the activity. It only helps to understand how we move from representing a city to a simplified graph. The students will not be asked to work on it.

Printable 2



Worksheet - Graph - To be used to complete the activity. To be printed on translucent paper (if you want to be able to delete the results) or normal paper. At least 1 per student / 1 per group or more to test different strategies by doing several rounds of the game.



Printable 3

Badges for children in the group round. For illustration their position. Can be used to discuss smart city roles. Children can draw them in the white boxes.

LOCAL ADMINISTRATOR

Role in the city: Plan the local policies according to the orientation of the mayor office, with constraint on budget and delay

CITIZEN

Role in the city: Orientate the choices of policies made by the municipality through voting, to enable living in a peaceful and consistent community

BUILDING OPERATOR

Role in the city: Orientate the choices of the municipality in terms of urbanisation, collect the rents from the appartments and offices and other services

URBAN FARMERS

Role in the city: Farmers who provide services in the city and want to be profitable i.e. find the right match between costs and benefits