Oliver Thiel, Joel Josephson, and Piedade Vaz Rebelo

Automata for STEM

Step by step
teacher guide

1 Introduction

The aim of the project **AutoSTEM** is to investigate how automata can enrich young children's play to promote a better understanding of Science, Technology, Engineering, and Mathematics (STEM).

It aims to provide Early Childhood Education and Care (ECEC) teachers and other stakeholders of young children's education of tools and materials to build a didactic path, which is simple, replicable and valuable in terms of

1) promotion of a motivation for STEM,

2) promotion of the development of creative thinking, problem-solving, and comprehension ability, and

3) cultural awareness and transversal values such as recycling.

In this document, firstly, we will explain what automata and STEM are (paragraph 2 on page 3). Then we explain our theoretical framework (paragraph 3 on page 6) and pedagogical concept (paragraph 4 on page 8). Finally, we present some key concepts for constructing automata (paragraph 5 on page 17).
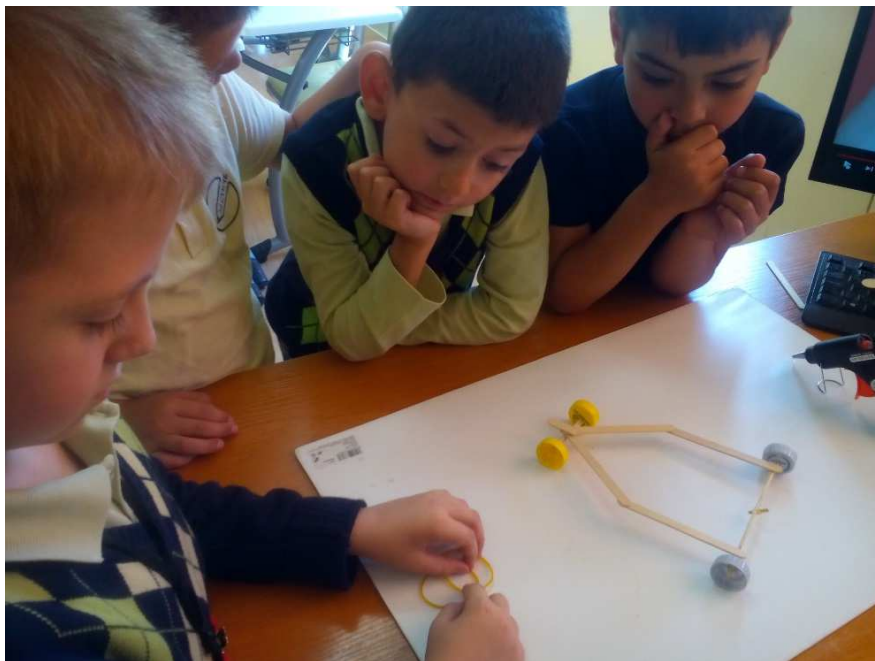

Figure 1: Automata promote creative thinking and problem-solving

2　Automata for STEM

2.1　Learning through Automata

Automata are fascinating mechanical toys, small Kinetic Art sculptures. Automata might be seen as an amalgamation between engineering, cultural awareness and artistic expression. As with other manual artefacts, automata are designed as child centred communication devices and can be defined as 'storytelling mechanical objects'. Automata have fascinated children over the ages and today there are museums just of automata.

Due to the combination of narrative and mechanical parts, automata have several possibilities for use within education. Besides being much enjoyed by children, they are easy to create in the classroom. Automata can be built to suit the children's age, with simple to complex designs and motions.

When planning and constructing an automaton, children can develop different competencies including problem-solving, group work, creativity as well as exploring STEM content.

2.2　STEM

The US National Science Foundation proposed the acronym STEM in the 1990s standing for the concepts of science, technology, engineering, and mathematics (Sanders, 2009).

There are different definitions of STEM (see Figure 2). In most national and international reports, STEM is usually interchangeable with 'science'. In this context, science refers to 'all of physical sciences, life sciences, computer science and technology, and [...] includes mathematics – subjects that are commonly taught at primary and secondary schools in most European countries' (European Commission, 2007, p. 5). That means STEM can refer to the various domains of knowledge covered by the acronym (❶ in Figure 2). On the other hand, we can use STEM to describe interdisciplinary approaches that make connections between some of the four disciplines (❷ in Figure 2). Sometimes it covers even a fully integrated view of STEM education (❸ in Figure 2, cf. Rosicka, 2016, p. 4). This continues to be a source of ambiguity among practitioners, particularly in the area of education.
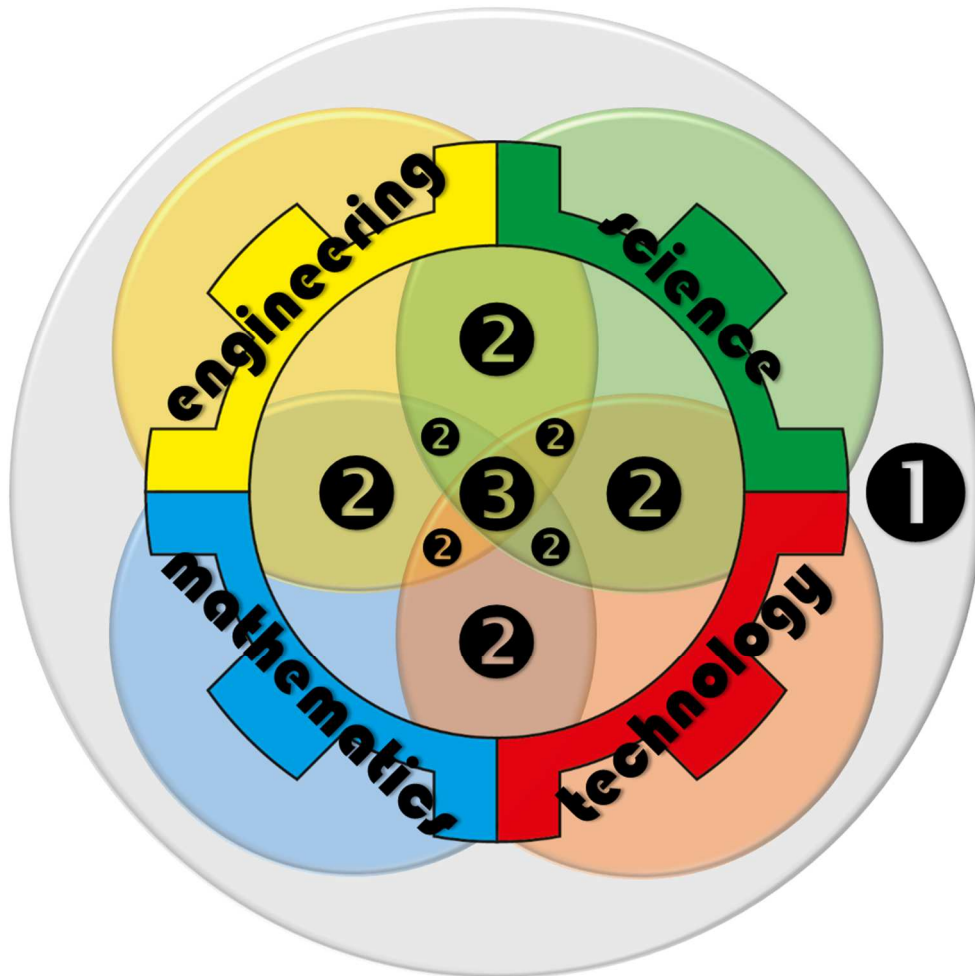
Figure 2: Different definitions of STEM

In the project **AutoSTEM**, we prefer an interdisciplinary approach. That means that each automaton allows the children not only to experience one or more areas of STEM but also to discover relationships and connections between the different disciplines.

Thus, **AutoSTEM** is placed at the 'intersection' of science, technology, engineering, and mathematics.

'When STEM education is placed at the "intersection" of science, technology, engineering, and mathematics, its meaning is usually expanded to refer to a rupture with "traditional" teaching. An integrative STEM education usually implies multidisciplinary teaching and is directed at developing students' problem-framing and problem-solving skills, as well as their ability to contextualise

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scientific concepts to real-life situations. In this understanding, STEM education is not defined in terms of a break with traditional subjects, but rather with a break from traditional instruction, in which lessons are strictly focused on the delivery of subject-specific content by the teacher and the acquisition of content knowledge by the students' (European Schoolnet, 2018, p. 6).

Finland uses an even more holistic approach to STEM. Students use inquiry and research in their learning. This enables them to apply what they have learned in an integrative manner (Geller, Neumann, Boone, & Fischer, 2014). This approach requires that teachers are explicitly trained how to work with problem-solving groups in STEM education (Schleicher, ed., 2012).

Young children's learning experiences have an effect on later academic success (e.g. Campbell, Pungello, Miller-Johnson, Burchinal & Ramey, 2001; Hadzigeorgiou, 2002). There are a lot of studies that show that mathematical experiences in early childhood are a strong predictor of success not only in future school mathematics, but other school subjects and life itself (Carmichael, MacDonald, & McFarland-Piazza, 2014; Duncan et al., 2007; Geary et al., 2013). Though there are fewer studies about other STEM disciplines, this might also be true for STEM in general. Thus, appropriate STEM experiences in early childhood can be starting points for supporting children's continued successes in STEM and other subjects at primary, secondary, and post-secondary levels. STEM competencies are of growing importance in a world where the pace of change and the need for technological advances have become critical to our survival.

3 Theoretical framework

3.1 Play-based pedagogy

In the project **AutoSTEM**, we use a relational play-based pedagogy (Hedges & Cooper, 2018) and a dynamic learning concept (Broström, 2017). According to Friedrich Fröbel (1887, p. 57), the inventor of the Kindergarten, play is 'the highest expression of human development in childhood, for it alone is the free expression of what is in a child's soul.' Lev Vygotsky (1978, p. 102) supported this view by stating, 'In play, a child always behaves beyond his average age, above his daily behaviour' and 'Play always leads to a more advanced level of development.' That means the children explore their, 'Zone of Proximal Development' (ZPD) in play, but it will only happen when the play environment challenges the children to cross their ZPD (Van der Veer & Valsiner, 1991). Thus, Early Childhood Education and Care (ECEC) teachers play an important role. Their task is to challenge the children and encourage them to create new meanings and understandings (Broström, 2017).

This approach is child-centred but not entirely child-directed. Child-centredness means, 'emphasizing the importance of teaching academic concepts in an engaging and developmentally appropriate manner, expanding on children's interests, and utilizing play-based strategies that match children's abilities' (Pyle & Danniels, 2017, p. 286). Play-based pedagogy with its method 'guided play' is a middle ground between direct instruction and free play. It 'melds exploration and child autonomy with the best elements of teacher-guided instruction' (Weisberg et al., 2016, p. 177). It has been shown that guided play helps children to a better understanding of academic concepts than direct instruction (Han et al., 2010; Stipek et al., 1995) or free play alone (Chien et al., 2010; Honomichl & Chen, 2012).

3.2 Guided play

There are two forms of guided play (Weisberg et al., 2016). Both can be used while working with automata.

1) One form starts with children's free play. The teacher observes child-directed activities and enriches the children's play by making comments, encouraging children to question or extending children's interest. For example, the teacher may introduce the *Balloon-car* after having seen that the children like to play with cars.

2) In the second form of guided play, the teacher designs a setting that is focused on a learning goal. In contrast to direct instruction, the teacher ensures that the children have the autonomy to explore the academic concepts in their own ways within the given setting. Examples for this approach in **AutoSTEM** are the *Always-come-back-machine* and the *River Nile Scenario*.

In either form, the teachers act as 'commenters, coplayers, questioners, or demonstrators of new ways to interact with the materials involved' (Pyle & Danniels, 2017, p. 275) in order to enhance the children's learning experiences while the 'children direct their own learning within the established play context' (ibid.). This ensures that play-based learning is contextualized learning.

Figure 3: Play is the highest expression of human development in childhood

4 The pedagogical concept

4.1 Steps to implement AutoSTEM

An **AutoSTEM** project usually has three general phases.

1) First, the ECEC teacher observes the children in order to identify what catches their attention and interests. The teacher chooses an automaton that satisfies the children's curiosity.

2) In the second phase, the teacher presents the automaton to the children. This can be done in three different ways;

    a) The teacher presents an automaton that is directly related to children's free play (e.g. the *Eco-car*). The children are inspired to make their own automata. While they are engaged in practical work, the teacher scaffolds and introduces STEM concepts that are needed to complete the task.

    b) The teacher presents a scenario (e.g. the *River Nile Scenario*) that incorporates one or more automata. In interacting with the scenario, the children discover an automaton and that interests them to want to make their own. While they are engaged in the practical work, the teacher scaffolds and introduces STEM concepts that are related to both the context of the scenario and the construction of the automaton.

    c) The teacher presents an automaton that shows a surprising movement but has a mechanism that is hidden (e.g. the *Always-come-back-machine*). This is usually an automaton that is too complicated for the children to build by themselves. This initiates the children to immediately start with the third phase.

3) In the third phase, the children play with the automata in their own way, and explore, discover and experience STEM concepts while doing so. Some children will be inspired to design their own automata by adapting and modifying the prototype.

4.2 Children's activities

In order to make an automaton, children have to follow a series of activities that entail the acquisition of skills. The skills are (1) observing and analysing, (2) conceiving, (3) experiencing and constructing, (4) playing and (5) reflecting.

4.2.1 Observing and analysing an automaton

The starting point for the work with automata in the classroom is the observation and analysis of an automaton. The children observe the movement of the automaton and explore the mechanisms in order to discover and understand how it works.

4.2.2 Conceiving their own automata

Before the children can construct their own automata, they have to conceive the automaton they want to build. This starts with defining the materials, colours, and size. It continues with identifying, looking for, and collecting the materials (e.g. recycled materials). Finally, the children have to design the mechanisms and the construction process. It depends on the children's age and maturity how much of this can be done in an exploratory and child-directed way.

4.2.3 Experiencing STEM content while constructing the automata

The most engaging, motivating and interesting part of the project is the construction of the automata. While constructing the automata, the children have many experiences with STEM concepts and ideas. The teacher supports this by scaffolding and making the children aware of the STEM content.

4.2.4 Playing with the automata

Playing with the automata is important in many respects. One motivation for constructing the automaton is the wish to play with it afterwards. As mentioned before, play is 'the highest expression of human development in childhood' (Fröbel, 1887, p. 57) and 'leads to a more advanced level of development' (Vygotsky, 1978, p. 102). While playing with the automaton, it becomes meaningful for the child. The child puts it in a context, explores its properties, movements and relationships to the environment and the story. The context can be directly related to a given scenario and storyline, or

freely dreamt up by the child. In any case, the children will have experiences with STEM content because of the STEM context the automaton is related to and because playing itself is one of the six fundamental mathematical activities (Bishop, 1988, p. 183).

4.2.5 Reflecting on the work developed

While interacting with the environment, the automata, the scenario, the story, their fantasy, the children have experiences with STEM concepts and content. However, experience alone does not lead to learning. It is not enough to just have experiences. Children have to reflect on their experiences because reflection directs experience to learning and deeper insights. According to John Dewey (1933, p. 17), reflection 'emancipates us from merely impulsive and merely routine activity […] It converts action that is merely appetitive, blind and impulsive into intelligent action' and it 'gives an individual an increased power of control' (ibid., p. 21).

4.3 The teachers' role

4.3.1 Identifying children's Zone of Proximal Development

As mentioned before (see step 1 in paragraph 4.1), projects in early childhood education should always start with the children's interests and initiative. Thus, the teacher's first task is to observe the children in order to find out what catches their interest and what their precursor knowledge is, in this field of interest. That means the teacher has to identify the children's Zone of Proximal Development (ZPD).

4.3.2 Choosing learning objectives

There are two different approaches to early childhood education (OECD, 2006). In the Nordic and a number of Central European countries, we find a social pedagogy approach. It is child-centred and holistic, emphasising the concepts care, play, relationships, activity and development, and sees children as agents of their own learning. In other countries, we find an early education approach that focuses on teaching, learning, curriculum, content, methodology, and emergent literacy and numeracy (Broström, 2017). Teachers who follow the early education approach have to

identify learning goals for every lesson they teach. Curricula that follow the social pedagogy approach do not state learning goals for children. They have only objectives for the teachers, e.g. the Norwegian ECEC curriculum claims, 'kindergartens shall enable the children to […] build constructions from different materials and explore the opportunities offered by tools and technology' (Ministry of Education and Research, 2017, p. 52). However, Gunnestad (2019, p. 95-96) shows that those objectives are implicitly related to learning goals for the children. Thus, even when following a social pedagogy approach, the teacher has to choose a learning goal when planning an activity for the children. For example, the objective 'to enable the children to build constructions', is related to subject-specific skills, i.e. *procedural knowledge* (Krathwohl, 2002), e.g., 'the child is able to build a scissors arm'. The same activity, however, can be used to develop the children's conceptual knowledge as well, e.g., 'the child understands the concepts of contraction and expansion'.

4.3.3 Planning the activity

As described before (see paragraph 4.1), there are different possibilities of how to start an **AutoSTEM** activity. Regardless of which approach is chosen, the activity has to be planned. When it comes to the construction of the automaton, the teacher has to choose a pedagogical approach that is suitable for the children and serves the learning goals. The two major approaches are inquiry-based learning and direct instruction.

When taking an inquiry-based approach, the teacher shows an automaton to the children. The children observe its movement and formulate hypotheses about how the movement is possible. Then they test their hypotheses by constructing their own mechanisms that eventually show the same movement. A precondition for this approach is that understanding the mechanism lies within the children's ZPD. That means the children need some precursor knowledge and prior experiences with mechanics.

For younger children, the teacher will probably choose direct instruction as the most suitable approach. Doing so, the teacher starts by introducing individual items that create the movement and then guides the children to the assembly of the automaton, according to the desired movement. Even though the teacher uses direct instruction to guide the children through the construction of

the automaton, the children will experience STEM concepts and ideas in an inquiry-based way (see paragraph 4.3.5).

4.3.4 Scaffolding the production of the automata

Regardless of the chosen pedagogical approach, the teacher has to help the children during the construction work – both physically and intellectually. Different automata require different fine motor skills. The younger the children are the more physical help they need. Moreover, the teacher should help the children to reflect on and think through the related STEM concepts in order to find a useful mechanism to the movement that they want to realize. Wood, Bruner, and Ross (1976) call this support 'scaffolding'. Scaffolding 'refers to the steps taken to reduce the degrees of freedom in carrying out some task so that the child can concentrate on the difficult skill she is in the process of acquiring' (Bruner, 1978, p. 19).

Bruner has chosen the term 'scaffolding' in order to emphasise that this is only a supportive frame. It does not solve the problem for the child. Scaffolding is a structured interaction between the teacher and the child that helps the child to achieve a specific goal almost on its own. The purpose is to allow the child to achieve higher levels of development. Thus, scaffolding is strongly related to Vygotsky's ZPD.

4.3.5 Link the construction process to STEM content or other subjects

All the automata that we present in the AutoSTEM project can be used as a tool for teaching STEM content from subjects including mathematics, physics, and biology. Some content is related to the construction process, some to the analysis of the mechanism and some appear when the children play with the finished automaton. In addition, some automata can be used to work on other subjects as well, e.g. literature or foreign languages.

4.3.6 Working with a scenario or story

As introduced under step 2b in paragraph 4.1, the automata can be integrated within a scenario or story. Teachers who want to do this have to choose a scenario or story that meets the children's interests and is related to the chosen STEM content and automata.

The difference between a scenario and a story is that a scenario is presented by a scenic installation while a story is presented just orally or with support of pictures. The scenario might be prepared by the teacher or developed together with the children. In the latter case, the construction of the scenario might start from a story and has to be guided by the teacher.

4.3.7 Collecting feedback

Ongoing evaluation is an essential part of every project. During the whole project period, the teacher will ask, 'Where are we?', 'Where should we be?' and 'How can we get on track again?' (Lewis, 2000, p. 185). The evaluation enables the teacher to keep track of the children's learning progress and to know when the learning goals are reached. In order to obtain this feedback, the teacher can use informal observation and 'Learning stories' for documentation (Carr & Lee, 2012). During the observation, the teacher takes photos and writes down notes. Afterwards, the teacher creates a story, reads the story to the child, and shares it with the child's family. Key elements of a learning story are the teacher's interpretation of the child's engagement, intentionality, relationships, competencies, and learning dispositions such as courage, curiosity, and perseverance. Children should be seen as 'skillful communicators, experts in their own lives, rights holders and meaning makers' as well as 'social actors who are "beings" rather than "becomings"' (Clark &Moss, 2011, p. 6 and 8). Therefore, a learning story highlights what the children can do, and are doing, rather than what they cannot do.

Materials that are provided by the **AutoSTEM** project include an observation guide, as well as a group interview guide and a questionnaire. These can be used for collecting feedback. During the piloting of the **AutoSTEM** project, we would be happy if you share your collected data with us. This would help us to further develop and improve the project materials.

4.4 An interdisciplinary approach to learn STEM through automata

Working with automata allows children to explore concepts, ideas, and topics from different STEM areas. We have already explained in paragraph 2.2 that we are promoting an interdisciplinary approach. Detailed information about the related STEM content is

provided in the material for each automaton and each scenario. In the following, we give just a broad overview of possible content. This list is not comprehensive. Figure 4 provides an overview.

4.4.1 Technology

A commonly accepted definition of technology comes from the American sociologist Read Bain (1937, p. 860) who wrote, 'Technology includes all tools, machines, utensils, weapons, instruments, housing, clothing, communicating and transporting devices and the skills by which we produce and use them.' Since automata are simple machines, they are technology by definition. Working with automata teaches children skills on how to produce such simple machines.

4.4.2 Mathematics

In order to structure the mathematics content, we use Bishop's six fundamental mathematical activities locating, designing, counting, measuring, explaining and playing (Bishop, 1988).

- ⚙ *Locating:* Spatial relations (left, right, front, rear, top, bottom, in front, behind, outwards, inwards, though, up, down, outside, inside, …) and spatial imagination (to visualize how the parts will fit together)

- ⚙ *Designing:* Shapes (circle, triangle, rectangle, square, …) and their properties (round, pointed, oblong, symmetrical, corner, side, …)

- ⚙ *Counting:* Tallying, using objects to record, compare and order discrete phenomena, and using number words (five wooden sticks, four bottle tops, three straws, two skewers)

- ⚙ *Measuring:* 'measure-words' (long, short, high, low, wide, narrow), comparison and ordering (longer, shorter, as long as, twice as long as), using body parts as measuring units (fingerbreadth, span, foot), and using standard measuring devices such as rulers

- ⚙ *Explaining:* Finding ways to account for the existence of scientific phenomena (Why are wheels round? How can a rubber band or a balloon power a car? Why do the scissors arm stretch?) This, of course, is important in all of science, not only mathematics.

⚙ **_Playing:_** Models, rules, procedures, strategies, hypothetical reasoning and prediction

4.4.3 Science

Biology/zoology

Some of the automata are directly related to animals and can be used to teach about biology.

⚙ **_The Jellybird:_** Birds' body parts, how birds fly, wing shapes, murmuration, flocks

⚙ **_The Talking Elephant:_** Elephants' body parts, physical characteristics (skin, nose), movement, eating habits

⚙ **_The scissors arm:_** Crocodiles, dinosaurs, hippos …

Sustainability and protection of the **_environment_** are other relevant biological topics.

Physics

Since automata are mechanical toys, working with automata provides experiences with physical phenomena and concepts. Some automata (e.g. the _Eco-car_, the _Wind turbine_ and the _Always-come-back-machine_) are designed with a special focus on specific physical concepts.

⚙ **_Energy:_** elastic, potential, kinetic, thermal energy, work, conservation of energy

⚙ **_Force:_** doing work by applying force, friction, levers

⚙ **_Mass:_** weight, centre of mass, balance, gravity

Geology

Especially when using a scenario, different geological content can be integrated.

4.4.4 Engineering

The word engineering derives from the Latin noun 'INGENIUM', which means _gift, talent, aptitude_, and _ability_, or the Latin verb 'INGENERE' or 'INGENERARE', which means _to infuse_, _to implant_, and _to inspire_. According to the Engineers' Council for Professional Development (1947), engineering is 'the creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them

singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property.' Engineering can be understood as the application of science and mathematics in order to create new technology. The Hungarian-American mathematician, engineer and physicist Theodore von Kármán once said, 'Scientists study the world as it is, engineers create the world that never has been' (American Society for Engineering Education, 1970, p. 467). Thus, engineering provides a practical link between all other STEM subjects and in addition to the creative arts (Bjerklie, 1998).

When it comes to automata, **mechanics**, **art** and **designing** are the most important topics.
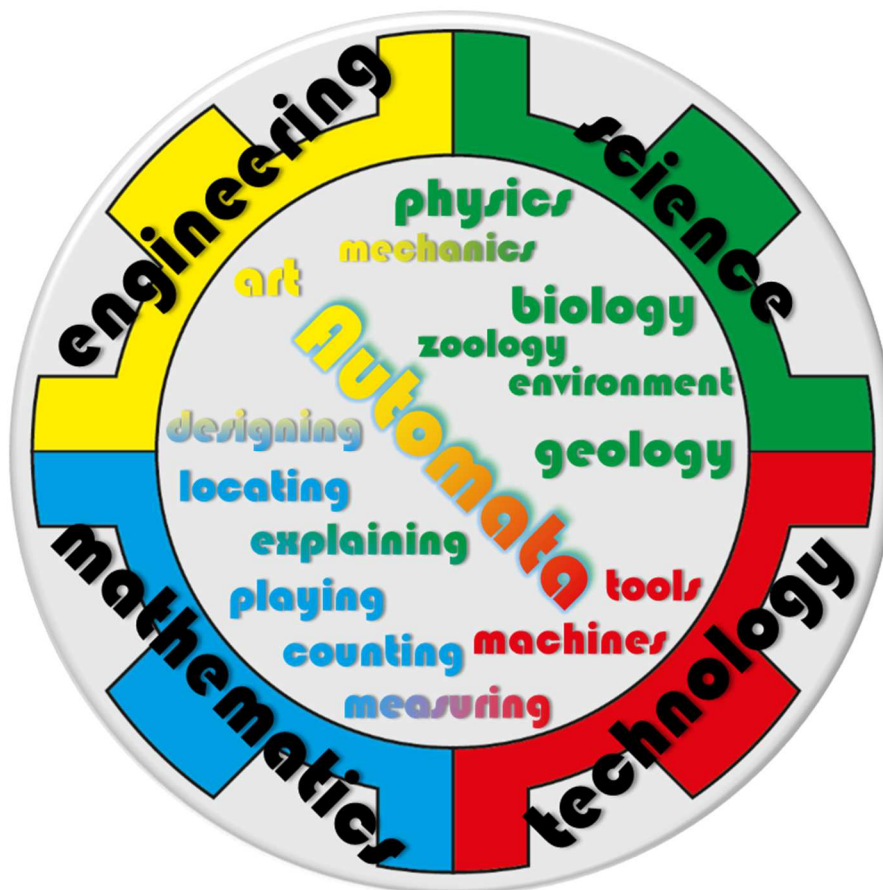
Figure 4: Related STEM subjects and content

5 Key concepts for automata construction

When constructing automata, different mechanisms and power sources can be considered. In the following, we present some examples of the fundamental mechanical concepts.

5.1 Mechanisms

5.1.1 Levers

A **lever** is a simple machine, perhaps the simplest machine. It can be used to move (often to lift) an object (called the *load*) because it reduces the force (called the *effort*) that is needed to do that. Archimedes once said, 'Give me a lever long enough and a fulcrum on which to place it, and I shall move the world' (Handley, Coon & Marshall, 2013, p. 76). Every lever consists of a rigid body (e.g. a beam or rod) that is pivoted at a fixed hinge (called the *fulcrum*) so that it can be rotated around that fixed point.

Based on the location of the fulcrum, load, and effort, we can distinguish three different types of levers.

Figure 5 shows a **type 1 lever**. It has the fulcrum between the load and the effort.
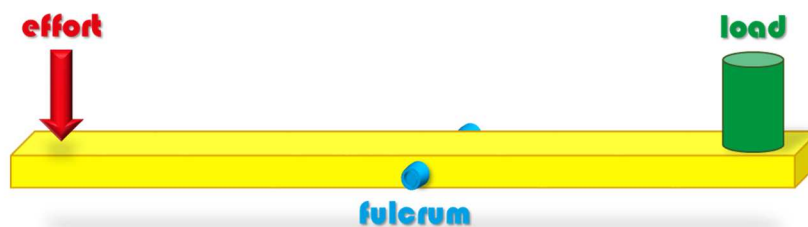
Figure 5: A type 1 lever

Usually, the load has a shorter distance to the fulcrum than the effort. This allows moving a heavy load with a small force. Examples are a crowbar, an oar, and scissors. On a seesaw, we can adjust the distance on either side of the fulcrum in order to balance different weights. For a classical beam balance, it is essential that the distance is the same on both sides because we want the effort (the standard weight that we use for measuring) to be the same as the load (the unknown weight that we want to measure).

Figure 6 shows a **type 2 lever**. It has the load between the effort and the fulcrum.
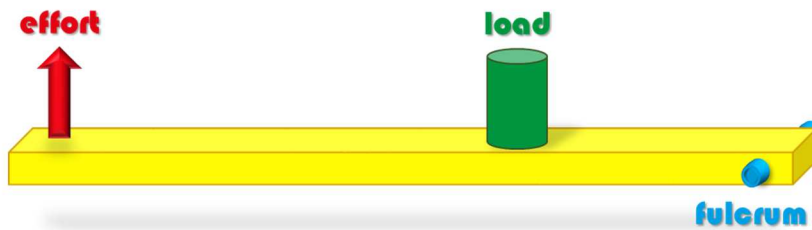
Figure 6: A type 2 lever

The effort has a larger distance from the fulcrum than the load. Therefore, the force needed to lift the load is smaller than the weight of the load. Examples are a wheelbarrow, a nutcracker, a bottle opener, and our *Drawbridge,* shown below.
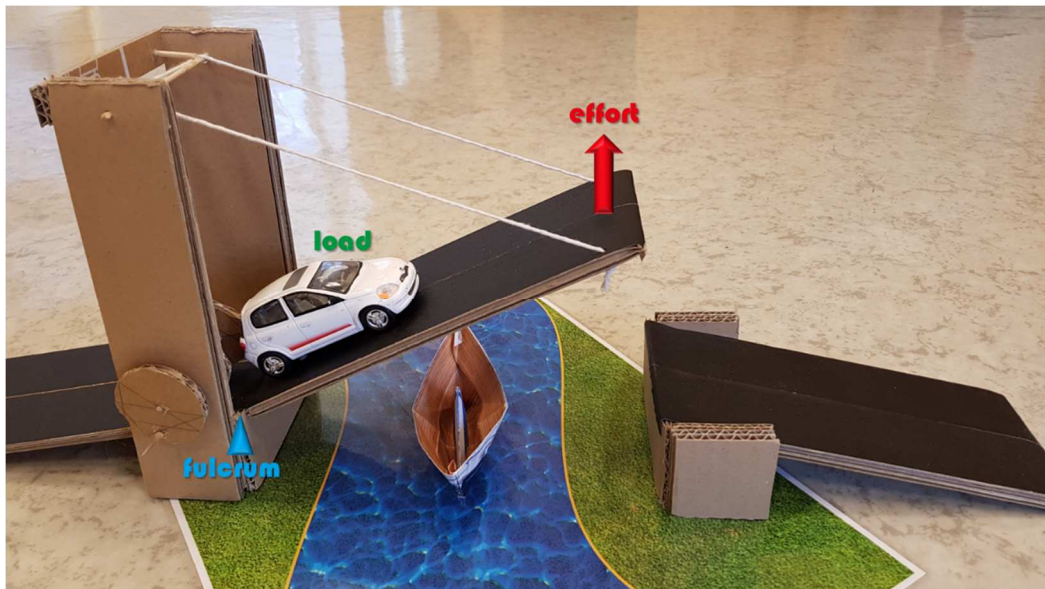

Figure 7: A drawbridge

Figure 8 shows a **type 3 lever**. The effort is between the load and the fulcrum.

Figure 8: A type 3 lever

Since the distance between the load and the fulcrum is larger than the distance between the effort and the fulcrum, a stronger force is needed to move the load. Thus, the aim of the type 3 lever is not to decrease the force but to increase speed, the speed of the load.

5.1.2 Linkages

A linkage is a rigid element with a hinge at each end to connect it to other elements. Linkages are used to link different elements together and to transfer motion from one place to another. There are several different types of linkages.

Figure 9 shows a **reverse motion linkage**. If a linkage has a fixed pivot point in the middle, one end moves in the opposite direction than the other end.
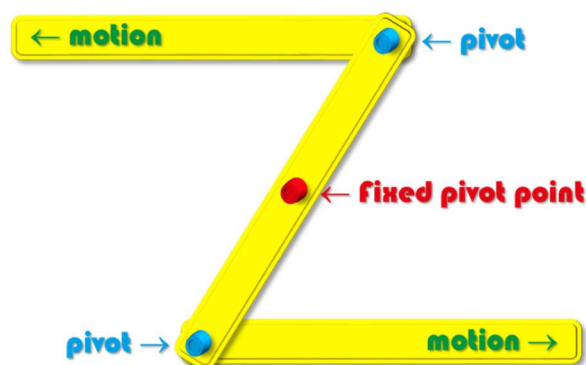
Figure 9: A reverse motion linkage

Figure 10 shows a **parallel motion linkage**. If two linkages have a fixed pivot point each and are linked by a third linkage as shown in the figure, they will always move parallel to each other. The motion of the right rod has the same direction as the motion of the left rod.
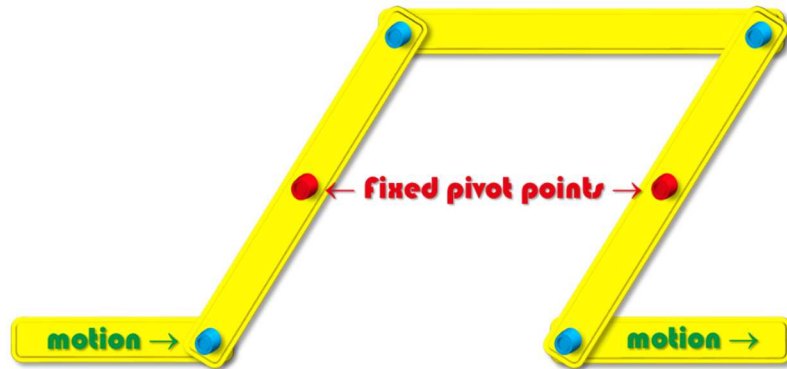
Figure 10: A parallel motion linkage

Figure 11 shows the **linkage of the scissors arm** that we used for *the Snapping Crocodile*. It is a combination of the reverse motion and the parallel motion linkage but has no fixed pivot points. When you move the ends of the two rods on one side against each other, the other side moves away (the arm stretches out) and the ends on the other side move against each other, too (the crocodile snaps).
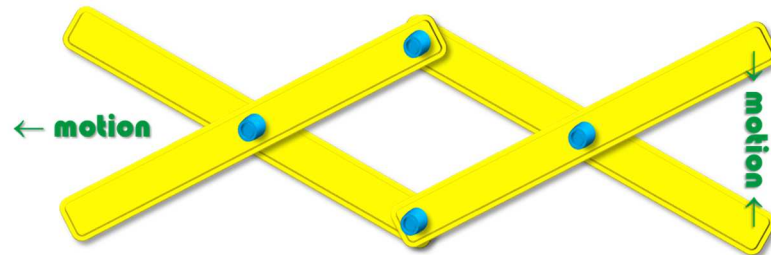

Figure 11: The linkage of the scissor arm

Figure 12: A scissors arm hippo

Figure 13 shows a **bell crank linkage**. It is used to convert vertical motion into horizontal or vice versa.
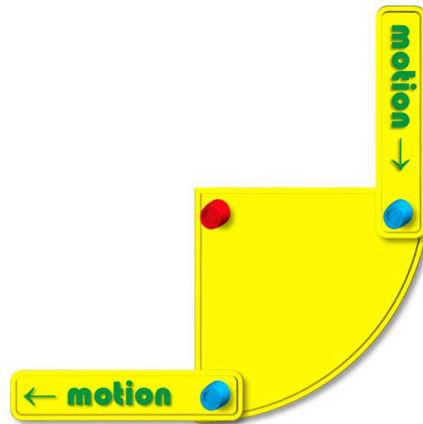
Figure 13: A bell crank linkage

Figure 14 shows a **crank and slider linkage**. It is usually used to convert rotary (rotational) motion into reciprocating (alternately forward and backward) motion. In the figure, the shorter rod can only rotate around the fixed pivot point. The longer rod moves forwards and backwards in a slider.
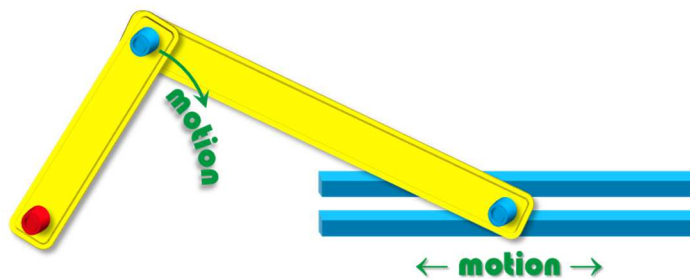
Figure 14: A crank and slider linkage

Figure 15 shows the *scissor lift* that uses a slider linkage.

Figure 15: The scissor lift uses a slider linkage

5.1.3 Cam

A cam provides another possibility to convert rotary motion into reciprocating motion of a follower. There are two main differences between a crank and slider linkage and a cam.

1) A crank and slider linkage can create a reciprocating motion in any direction (up and down, right and left, back and forth). A cam with a follower usually creates only an up and down motion because the follower has to be pushed down on the cam by its weight. There is no linkage between the cam and the follower.

2) A crank and slider can only create a homogeneous reciprocating motion because the length of the rotating arm is fixed. With a cam, we can create all kinds of inhomogeneous up and down motions (e.g. slowly up and fast down) by using cams of different shapes. The shape of the cam is called the *cam profile*. Figure 16 shows various cam profiles: a) eccentric, b) snail-shaped, c) egg-shaped, d) elliptical, e) round, and f) hexagonal.
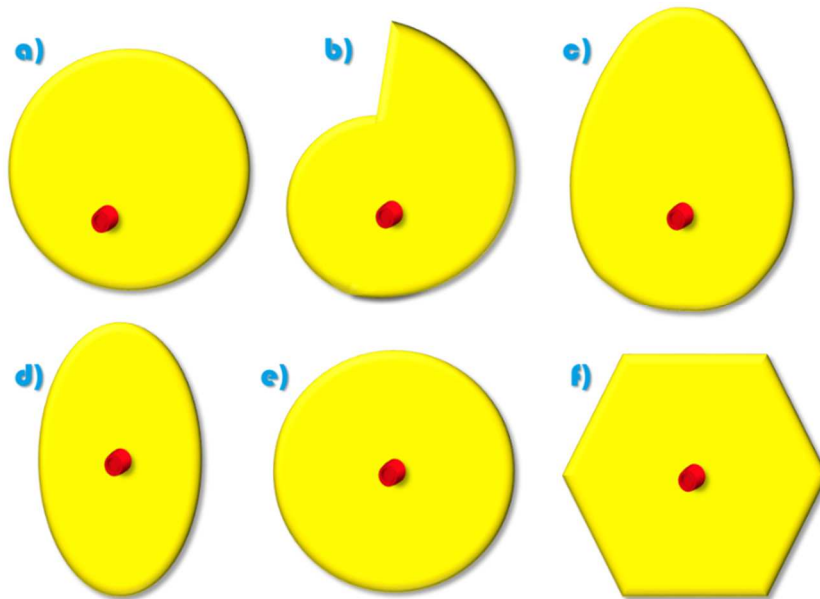
Figure 16: Different cam profiles

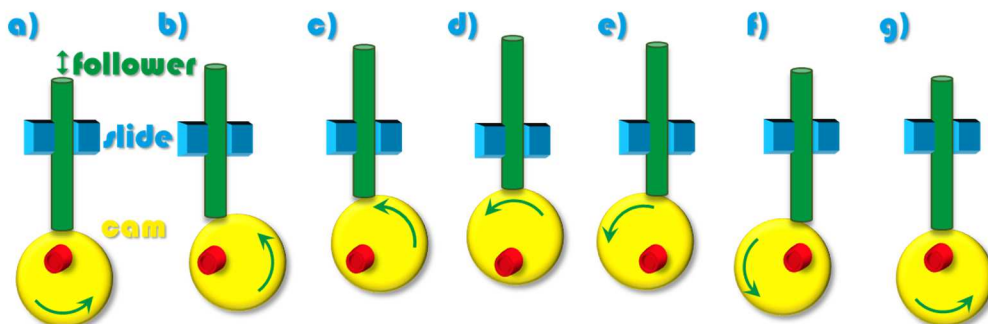Figure 17 shows the movement of an eccentric cam.

Figure 17: The movement of an eccentric cam

5.1.4 Friction drivers

A round, non-eccentric cam does not cause an up and down motion, but it can be used as a friction driver. Figure 18 shows a friction driver that converts rotary motion with a horizontal axis into rotary motion with a vertical axis. The *Dancing doll* uses this mechanism (see figure 19).
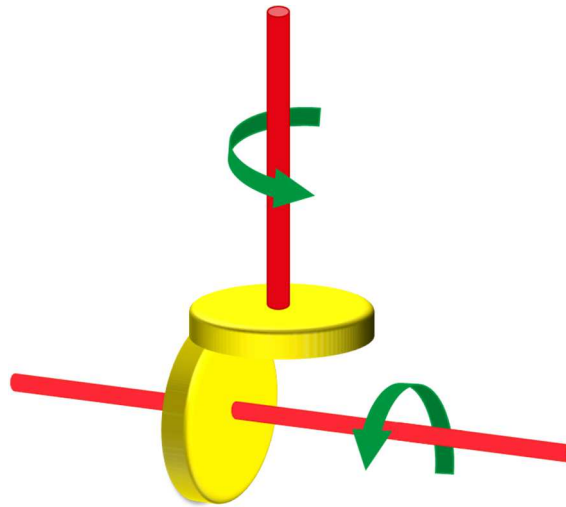
Figure 18: A friction driver

Figure 19: The Dancing doll uses a friction driver

Figure 20 shows a friction driver with an eccentric cam. It creates an interesting movement: The follower goes up and down while it turns around.
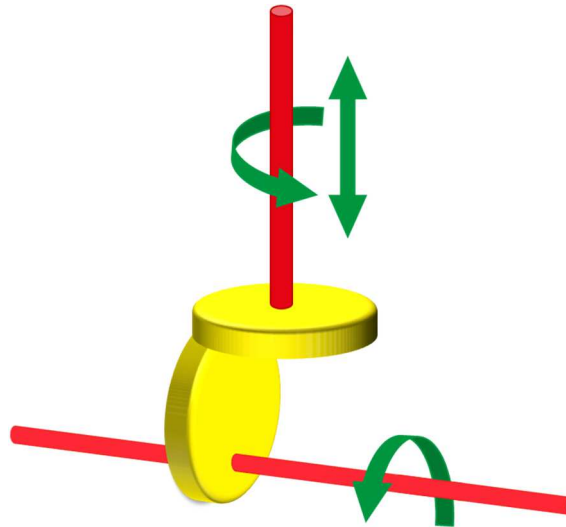
Figure 20: A friction driver with an eccentric cam

5.2 Power sources

There are several possibilities for power sources that make the automata move. The simplest is that the children themselves provide the power. They can do this by using a ***turning handle*** (e.g. the *Dancing doll* and the *Drawbridge*) or a ***simple lever handle*** (e.g. the *Snapping Crocodile* (scissors arm) and the *Talking Elephant*).

A fun power source is ***elastic energy*** that can be stored in a rubber band (e.g. the *Eco-car 1* and the *Always-come-back-machine*), a plastic straw (e.g. the *Eco-car 2*), or a spring. Our *Drawbridge* uses a spring to pull it down again because gravity is not strong enough. We can use gravity power as well if we increase the weight.
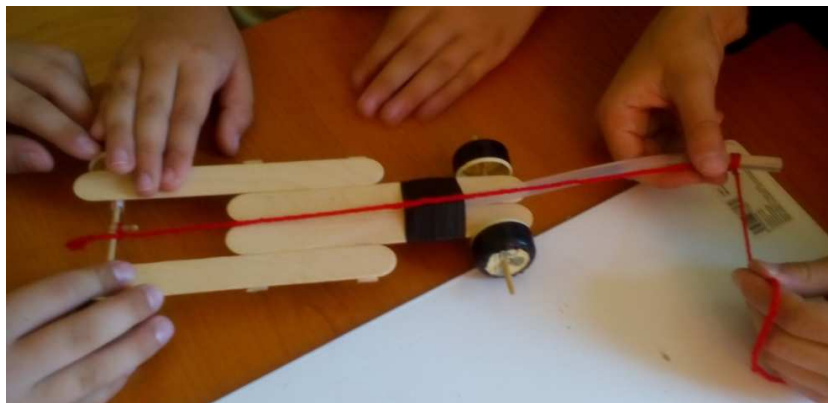

Figure 21: The Eco-car 2 uses the power of a plastic straw

There are many different types of mechanisms that use **gravity power**. When using a lever, the load will push it down as soon as we stop applying the effort. If we coil a string around an axle and attach a mass to the other end, gravity will pull the mass downwards, causing the string to unwind, and the axle to turn around.

Water power that sets a turbine into motion is another type of gravity power because it is gravity that makes the water run downwards. A turbine is used for **wind power**, too. The *Wind Turbine Race* uses wind that is artificially created by a hairdryer.

Figure 22: The Wind Turbine Race

The *Balloon boat* uses a jet engine, a different type of **air power**.

Figure 23: A balloon boat uses air power

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