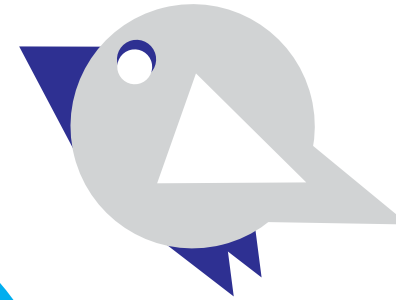


# Trend report 2014-2015

## *Technology compass for education*



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@KN\_Innovatie #kntrendrapport.  
Or e-mail us at [innovatie@kennisnet.nl](mailto:innovatie@kennisnet.nl).



To our international readers,

This trend report describes technological innovations worldwide and considers their usefulness in addressing challenges in the field of education. These are challenges that have arisen in the Dutch educational system, but those working in education in other countries will undoubtedly recognise them.

Most of the 'recommended reading' tips and practical examples in this report refer to Dutch sources. They have been retained in this English-language edition because they offer useful additional information that can be accessed using an online translation tool.

# Foreword

This report is meant as a guide for school boards and management in primary and secondary education and vocational education. We asked a number of school board members and managers to tell us which challenges they believe they will be facing in the next five years. This trend report describes the potential of new technologies with a view to these challenges, which we take to be relevant ones. It also considers the associated risks.

What is the best way to read this report? If you are a school administrator, it should make you think. The outside pressure to 'do something with modern technology' can be enormous, after all. While decision-makers in education cannot afford to ignore the opportunities offered by technology, they also cannot afford to make expensive mistakes or take unnecessary risks. This report supports informed decision-making. Technology must fit in with the educational concept that you are applying in your own school organisation or organisations.

The report does not provide answers, but it will help you find your way around what are sometimes complicated ICT dilemmas (which is why we refer to it as the 'technology compass for education').

Each school or educational institution must allow for a unique set of considerations, and each one takes decisions that reflect, as closely as possible, the vision it has of education and the options at its disposal at that moment. Technology must support or help you achieve your vision of education. This report offers guidance in making well-informed, conscious decisions concerning the implementation of new technologies.

This trend report is mainly intended for school administrators, but teachers will undoubtedly also find it interesting to read about technology trends, although we do not offer any immediate practical solutions that can be applied immediately in their lessons. We can imagine that others may also be interested in this report – for example educational consultants, government and commercial parties.



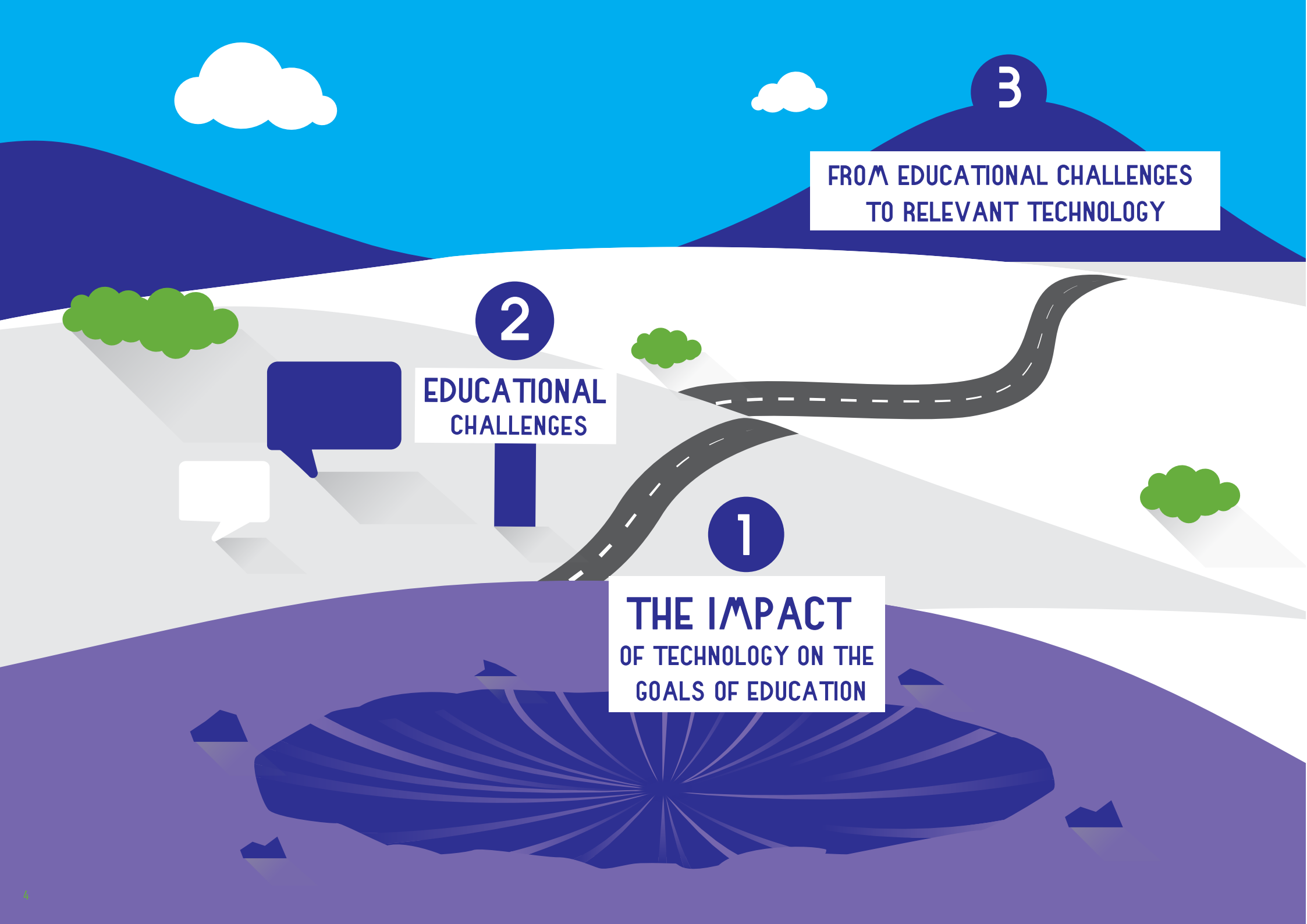
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EDUCATIONAL  
CHALLENGES

3

FROM EDUCATIONAL CHALLENGES  
TO RELEVANT TECHNOLOGY

1

THE IMPACT  
OF TECHNOLOGY ON THE  
GOALS OF EDUCATION

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# Introduction

The subtitle of this Kennisnet trend report 2014- 2015 is Technology compass for education. That is precisely what this report intends to be: a compass. It reviews technology trends that Kennisnet expects to play an important role in Dutch education in the next five years. The report explains and analyses those trends, for example by examining the opportunities they present, their weaknesses, and the educational challenges that they will impact most. This report does not tell schools which technologies they should be introducing. That is something each one must decide for itself. What this report does do is try to guide this process by mapping out the various strategic considerations for each trend. It is up to schools to chart their own course based on their own vision of education, and using this report as their compass.

There is nothing novel about the idea that new technologies influence education. Examples from the past include the invention of the printing press and educational television. New technologies offer new options and change preconceptions. The same is true of ICT and the Internet. Although the form and content of education change when we embrace new technologies, its core functions remain the same. And although schools and other educational institutions differ, they appear to have many similarities

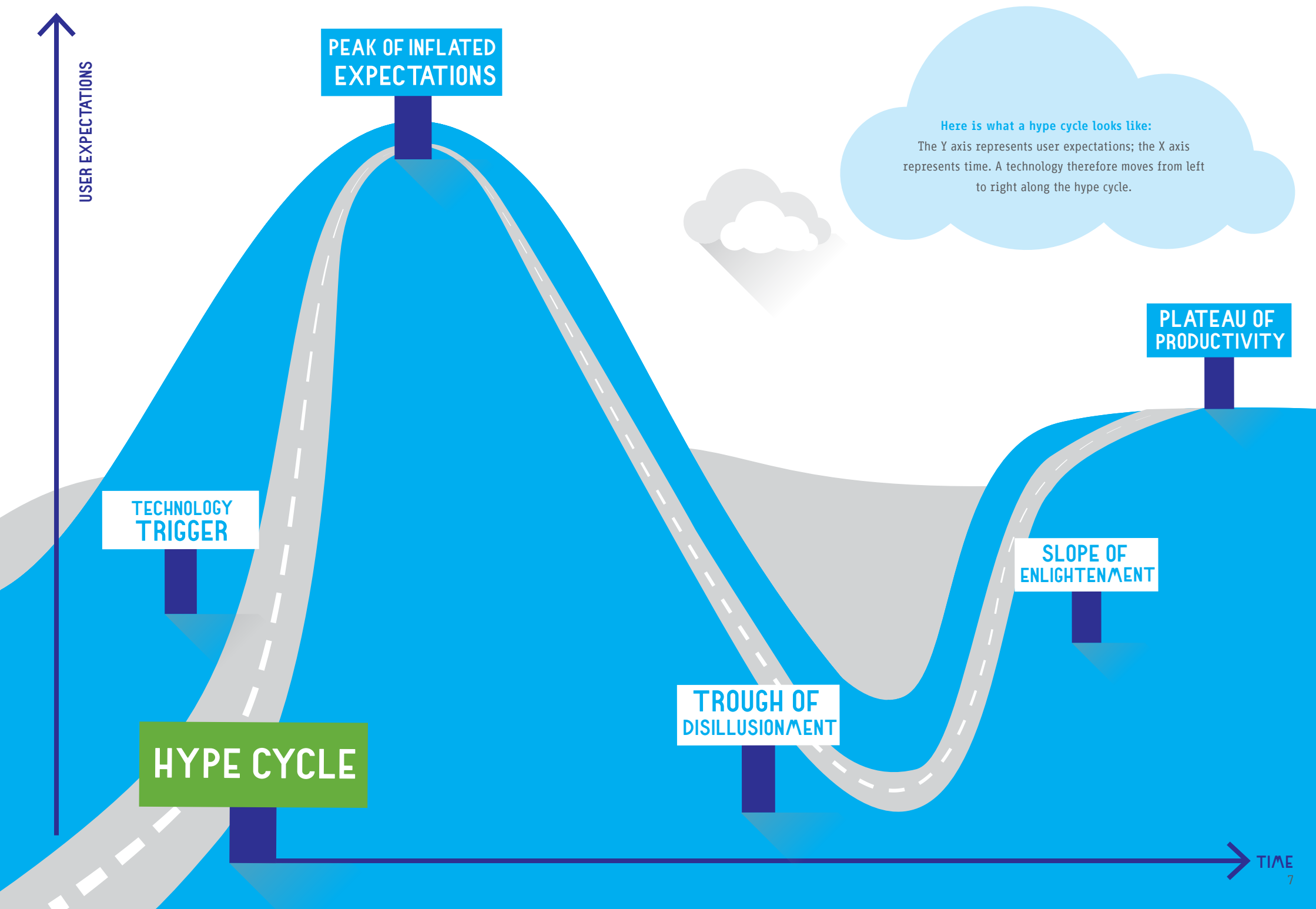
when it comes to the key challenges that their administrators expect to face in the years ahead. Technology can play a significant role in tackling those challenges.

## How useful is a new technology?

It isn't always clear right from the start how useful an emerging technology will be in everyday life. For example ([kn.nu/mobiel1999](http://kn.nu/mobiel1999)), in 1999, before mobile telephones became common, many people could not have imagined what an important role smartphones would be playing in our lives 15 years later. It takes time for the usefulness and impact of a new technology to become manifest, and its potential becomes clear only after we start making practical use of it. At first, we use it to optimise existing processes and activities. We then realise that we can use the technology to overhaul those processes and activities. The next stage is transformation. This is how the World Wide Web developed from a library of digital advertising flyers to a complete online shopping mall that we can browse through without leaving our homes.

Every new technology goes through a similar process of evolution in terms of both the expectations that people have of it and its adoption and impact on society - or on education. Some technologies evolve more rapidly than others in this respect. For

example, tablets penetrated Dutch living rooms and classrooms at lightning speed, whereas the interactive whiteboard took much longer. We can depict this evolution as a graph, known as the 'hype cycle'. The hype cycle, a concept developed by the information technology research and advisory firm Gartner ([gartner.com](http://gartner.com)), shows whether a technology is very new and unknown or farther along in its evolution. The closer a technology is to the 'maturity' phase, the clearer its strengths and weaknesses and the better we understand its impact on education.



## Hype or trend?

As soon as a technology makes its entrance (Technology Trigger), expectations can in some cases rise to unrealistic levels (Peak of Inflated Expectations). When it becomes clear that the technology cannot live up to (all) these inflated expectations, user acceptance and expectations plummet (Trough of Disillusionment). Then slowly, the true advantages become clear and the technology rises along the Slope of Enlightenment to the Plateau of Productivity. At the end of this cycle, the technology is 'mature'. Some technologies disappear from the hype cycle before they reach the Plateau of Productivity because they 'fail' or are superseded by other innovations. Virtual worlds such as Second Life are good examples of a superseded technology. Their legacy can be found in simulations and gamification, i.e. the application of gaming principles in digital learning tools and the organisation of learning activities. The technology itself has been marginalised, however.

This is where a trend distinguishes itself from a hype. A hype is something new that attracts a lot of attention in the short term, but is quickly considered passé. A trend indicates a general direction over the longer term, often owing to the convergence of several mutually enhancing developments. For example, Hotmail, an Internet e-mail environment, was introduced in 1996 and

the Dutch Postbank began its online banking services in 1998. We now consider these typical examples of cloud computing. Today, Google offers complete video-conferencing facilities that require only a browser and an Internet connection. The rise of cloud computing almost 20 years after the introduction of these initial examples was made possible by faster Internet connections and the widespread availability of inexpensive mobile devices (e.g. tablets and smartphones) that are capable of retrieving data and applications on demand from the cloud. We can only decide whether something is a trend or a hype after the fact. This report reviews a selection of technologies that Kennisnet believes are trends, not hypes, based on informed reasoning. Our aim is to minimise the risk that schools will make poor investments (i.e. in hypes).

## Hype cycle for Dutch education

Given the challenges that the education sector is facing in the coming five years, Kennisnet has supplied Gartner with information allowing its analysts to identify relevant technologies. These technologies were then used to plot the hype cycle for Dutch education. (*Gartner, 'Speed Up Your Innovation Process by Quickly Creating Interactive Strategic Technology Prioritization Maps From the Education Hype Cycles', Jan-Martin Lowendahl, 5 December 2012.*)

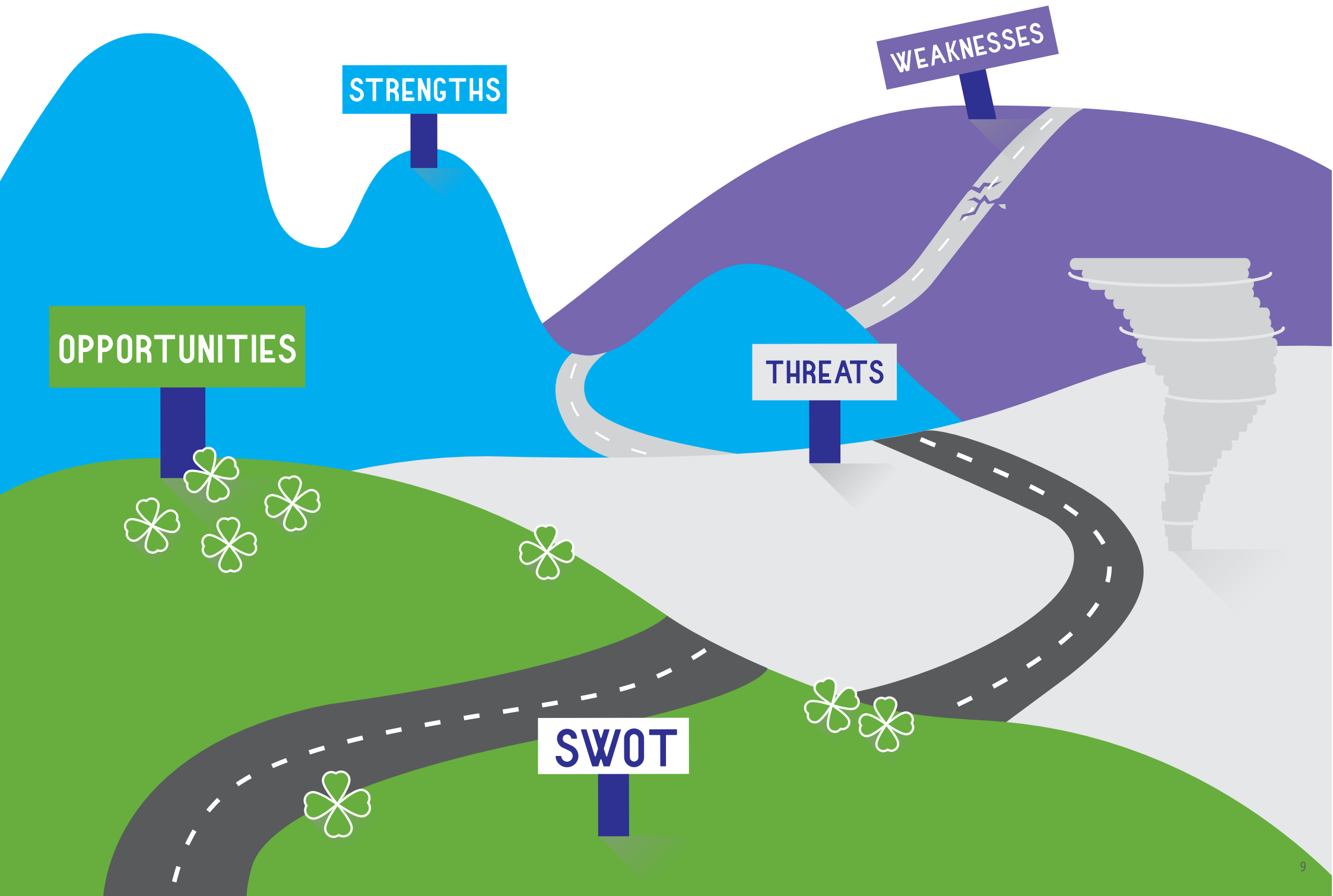
The purpose of this exercise was to determine the speed at which these selected technologies are evolving and what impact they will have. Four trends emerged from this hype cycle, i.e. clusters of interrelated and mutually reinforcing technologies. The four technology trends are discussed and analysed in Chapter 4.

## Detailed analysis: SWOT

Every school and every educational institution must determine for itself whether technology can help it achieve its vision or tackle the educational challenges that it is facing. This report helps school administrators decide which technology trends offer the most support in pursuing their vision and targets.

We discuss each of these trends based on a SWOT analysis. In other words, we provide a table for each technology trend listing the Strengths and Weaknesses of the technology, the Opportunities that it offers education, and the Threats that it poses. For each trend, we then look at the strategic considerations that an educational institution must take into account when introducing (or planning to introduce) a new technology in order to ensure its effective and successful introduction utilisation in education. Finally, we offer examples of each trend and references to background information.






A stylized landscape illustration with a bright blue sky, white clouds, and dark blue hills. In the foreground, there are white dunes and green bushes. A large, dark blue, fan-shaped object, resembling a lotus leaf or a stylized flower, is positioned in the lower half of the image. A white rectangular box with dark blue text is centered over this fan-shaped object. Above the box, a dark blue circle contains the number '1'.

1

# THE IMPACT OF TECHNOLOGY ON GOALS OF EDUCATION



The introduction of new technologies alters the form and content of education, although it might take some time before the full impact becomes clear. That has always been the case. The invention of the printing press democratised access to knowledge and its dissemination; television brought events from around the world into the classroom. The Internet is having an even greater impact because it gives us immediate access to information, allows us to contact anyone at any time, and makes it possible to share up-to-the-minute news and events worldwide.

Although technology may alter the form and content of education, its core functions remain the same. Different sources may use slightly different definitions or emphasise other aspects of the core goals of education, but the following three task categories are generally recognised:

- acquisition of knowledge, skills and an enquiring attitude
- socialisation, i.e. developing capable citizens
- talent development and guidance in finding a place in society

*(Sources: Sturen van vernieuwende onderwijspraktijken ([kn.nu/vernieuwendeonderwijspraktijken](http://kn.nu/vernieuwendeonderwijspraktijken)), Onderwijsraad 2007; Nationaal Onderwijsakkoord 2013 ([kn.nu/onderwijsakkoord2013](http://kn.nu/onderwijsakkoord2013)))*

Below we explain the impact of technology on each of these three core goals.

### **1.1 Acquisition of knowledge, skills and an enquiring attitude**

What the education sector teaches younger generations is decisive for the future of society. In the first place, it passes on in-depth knowledge of an occupation, profession or discipline. In addition, it imparts skills, which are indispensable in today's knowledge-driven society. This is not only true in the case of the technical skills needed to work in various professions and occupations, but it is also true of social and communication skills and being able to work in a team. Every employer, whether private or public sector, stresses these skills. All this requires dedication and motivation, recognition of the current complexity of professional life in every sector of society, and the opportunity to continue learning!

But education also serves other purposes. Children's natural curiosity should be stimulated at the earliest possible age. Their enquiring attitude – as described in the Dutch education sector's National Education Agreement 2013 – provides the basis for the innovative and creative society that

the Netherlands wishes to be. We stimulate curiosity and creativity by looking beyond the boundaries of our abilities, our knowledge and our culture, but also beyond our geographical borders.

There is nothing that comes close to the internet for removing boundaries. It surmounts the barriers to simultaneous communication created by physical location, time and distance and offers access to knowledge and instruction. The volume of information that everyone can access within seconds has grown explosively, and continues to grow at lightning speed. People around the world can talk to one another live, in real time, whenever they like, with or without video and for very little money.

In other words: access to information and communication are no longer tied to a particular time or place. YouTube, Wikipedia and educational marketplaces such as the Khan Academy are easy-access environments where anyone can obtain information, learn, practise or seek guidance, alone or in a group or classroom, and locally or internationally. Many universities and other knowledge institutes are making educational modules available (often free of charge) in the form of Massive Online Open Courses or MOOCs.

Enthusiastic teachers are setting up their own YouTube channels with instructional videos (often self-produced). Pupils can watch these at home, leaving more time in the classroom for in-depth questions or individual guidance (often referred to as 'flipping the classroom'). More and more pupils at other schools also watch these videos, sometimes on their own initiative and sometimes at their teacher's recommendation.

Wireless network technology (e.g. Wi-Fi and 3G/4G networks), affordable mobile devices (e.g. smartphones, tablets and laptops) and applications and data in the cloud ensure easy access, regardless of time or location. Social networks and communities connect people so that they can quickly organise themselves into learning communities in which they learn with and from one another. Because the Internet removes barriers to information and communication channels, pupils often spend time applying what they have learned above and beyond their 'regular' lessons.

For example, as people learn how to program, they immediately use logical thinking and other mathematical skills in a way that is meaningful to them. Instead of learning a language as a subject, they talk to actual

native speakers on Livemocha (an online community for learning foreign languages). This type of learning, in which pupils are intrinsically motivated to build knowledge and gather information anytime, anywhere through online platforms, is known as non-formal learning. The rise of non-formal learning means that schools are no longer always the obvious place to go to learn something.

## 1.2 Socialisation, i.e. developing capable citizens

Socialisation is the process whereby an individual adopts the values, norms and other cultural traits of his or her group, whether consciously or unconsciously. Education offers a fertile context for socialisation, and is therefore a powerful channel for promoting social cohesion. Education can help children develop into capable citizens by teaching them how society is organised, what laws and rules it enforces, and how people should treat one another. The digital society is changing the concept of citizenship; by creating new sorts of contacts and supporting more dynamic (international) groups, it influences and changes users' norms and values. Digital skills are becoming more and more important. Today, capable citizens must also know how to treat others in the digital society. The

term 'media literacy' has come to stand for the skills that pupils and teachers should master to deal effectively and safely with information technology.

The rapid pace of innovation in information technology means that media literacy has become a moving target. Some years ago, it stood for information skills, i.e. being able to find one's way through the flood of information, not all of it equally valuable or authentic. Now, however, society is increasingly being moulded by 'programmable' objects – computers that are no longer recognisable as such. This happening at a time when the basic building blocks needed to assemble such objects ourselves are growing cheaper and more powerful by the day. We can only march confidently into this engineered, programmable world if 'media literacy 3.0' includes the right introduction. Education, with its long tradition of tinkering with things together and solving brain teasers, can make a valuable contribution to this.

If we look beyond media literacy, we use the term '21st-century skills' to indicate what the information society and, within that society, the knowledge economy requires of its citizens and workers. Active participation

in the information society requires such skills as creativity, communication, teamwork, critical thinking and problem-solving ability. Education can play a major role here, not by setting up 21st-century skills as a separate subject, but by organising the learning process in a way that pupils can practise and apply those skills in their everyday lives.

But to be able to work openly on this, we must first engage in a bit of myth-busting. The myth is that the younger generation came into the world as 'digital natives', fully equipped with all the necessary digital skills. This is a dangerous misconception. Dexterity with a keypad or touch screen should not be confused with actual skill. Pupils continue to require the help and support of teachers when it comes to sizing up the digital environment, the information it contains, and the impact of their own actions. Teachers, in turn, are often labelled 'digital immigrants', newcomers to the digital world, and unfamiliar with tweets, 'likes', DM-ing and tiny keypads. This is an unfair attack on teachers' self-confidence. Their research and assessment skills are no less relevant – they may in fact be even more relevant – in the glut of digital media and new communication tools.



### 1.3 Talent development and guidance in finding a place in society

The world of work is not what it was fifty – or even fifteen – years ago. Technology has made certain types of work unnecessary. The industrial revolution eliminated the need for heavy manual labour. The information society is eliminating the need for clerical jobs and intermediaries that make information or services available in supply chains, such as libraries or travel agencies. Today, we look up information and book our own holiday flights online. Production processes have been computerised and the division of labour has been globalised to a certain extent. For example, clothing or furniture designed in the Netherlands is manufactured in Pakistan, China or another low-wage country and then shipped to the Netherlands or elsewhere. Workers in India staff the call centres and helpdesks of big corporations. And the post office has cut back on the number of days that it delivers mail, since most correspondence is now conducted digitally.

Many of the professions that have survived now include a technology component. For example, today's car mechanics have to be familiar with electronics (automatic folding side mirrors; parallel parking software). Middle level occupations are under the most pressure, with middle level industrial and clerical jobs disappearing. This is less the case for lower level jobs, which are difficult to automate and often require local execution. On the other hand, there is growing competition in that segment from the Netherlands' neighbours as the single European labour market continues to evolve. Upper level jobs that involve cognitively challenging work are under less threat, but feel a different type of pressure owing to rapid advances in the knowledge economy. In addition, new and different professions have emerged, for example web developer, app builder, game designer, community manager, webcare officer and, in just a short while perhaps, virtual attorney, social network psychologist or vertical farmer (*Source: De Tijd, 10-2-2010, [kn.nu/10beroepen](http://kn.nu/10beroepen)*).

These are occupations that did not exist when the workers of today were still in school. Whatever changes the future brings, there is no denying that knowledge will continue to provide the basis and that 21st-century skills will become ever more important. Those skills include teamwork, creativity, ICT literacy, communication, problem-solving, critical thinking and social and cultural skills.

In addition, it is essential to be engaged, enterprising and curious. The Dutch economy has fewer routine production and clerical jobs and a growing number of occupations that require a unique, distinctive approach. This is all the more reason for education to focus on the talent development of every child, in addition to passing on basic knowledge and skills. Focusing on talent development will require the education sector not only to differentiate according to cognitive talent and personal learning preferences, but also to personalise instruction according to the pupil's learning requirements. Individual talent – the

capacities that differentiate one child from the next – must be recognised at the earliest possible age and given room to develop. That is the best way to give young people a head start in the economy of the next few decades. That economy will welcome trained professionals who can use their unique skills in practical ways to shape our society, and knowledge workers who can bring their individual talents to bear in international teams and projects.

## 1.4 Choosing technology that supports the school's vision

Although the core functions of education remain the same, the arrival of new technologies alters its form and content. These new technologies give the education sector a number of powerful tools to enhance learning. The biggest challenge that the sector faces is to review and reshape its core goals so that they live up to the expectations and requirements of pupils, parents, and the world beyond education. In essence, then, technology exercises two types of influence on education:

- Information technology is innovating rapidly and impacting the way we deal with information and knowledge generation and how we communicate and work with one another. By definition, then, information technology influences the core goals of education. Schools must consider carefully what this means for their vision of education.

- As a tool, information technology offers us new ways to support schools and educational institutions as they work towards achieving their vision of education. The trick is for them to take that vision as a basis for deciding how to use innovative information technology to redesign their organisation, communication and repertoire of learning tools in a way that gives them maximum support in achieving their targets. The main question is: how will schools use technology to help pupils learn as effectively as possible, to help teachers focus on the essence of teaching (and not on time-consuming recordkeeping, for example) and to help the school organisation operate with flexibility and efficiency?

## 1.5 Balanced support

As they integrate technology into their teaching, innovate their teaching with the aid of technology, and deal with the changes that this brings about on various fronts, teachers need – and have a right to – the following support:

**Direction:** This should be crystal clear.

‘Which way are we headed? What’s expected of me?’

**Leeway:** The freedom to simply get down to work. ‘I can tackle things on my own, in my own way, because I have access to the resources I need.’

**Backup:** ‘I feel supported and validated, appreciated and encouraged by the school for my efforts and progress, and not just for my pupils’ results’.

School boards and management are responsible for supporting teachers and creating circumstances conducive to these three elements.

*(Source: Duurzaam leren voor innovatieve werknemers, Theunissen en Stubbé 2011, [kn.nu/duurzaamleren](http://kn.nu/duurzaamleren)).*

These three aspects of support must be evenly balanced. Too much direction and not enough leeway would indicate a very hierarchical school organisation that gives teachers little scope to do things differently. Too little direction and too much leeway, on the other hand, might lead to uncertainty; teachers may feel that they are being left to sort out everything themselves, and not all of them will be happy with that. Too much direction and too little backup can seem patronising if there is too little leeway. Too much leeway and too little backup may make teachers feel unnoticed and unheard, causing them to withdraw. It is precisely the combination of the three elements that ensures proper support.





2

# CHALLENGES IN EDUCATION



**Education is tailor made. Each school chooses its own path in that regard. Nevertheless, school administrators indicate that there are many similarities between them.**

Looking ahead to the next five years, we see that school administrators consider the following challenges of overriding importance when it comes to the potential of technology to provide support:

- personalised learning
- collaboration with the environment
- quality and testing: output-based approach
- efficiency and manageable costs

### **2.1 Personalised learning**

One of the most significant challenges facing education today is the individual differences among pupils. Bringing out the best in each child requires every pupil to receive an

education that is adapted to their individual talent, learning style and capabilities. The new system of inclusive education will only widen the gap between pupils in a group or class. More and more emphasis is being placed on nurturing excellence and budget cuts mean more pupils in every class.

There are various initiatives under way in primary and secondary education meant to support and accelerate the introduction of personalised learning, for example the 'Leerling 2020' ([kn.nu/leerling2020](https://kn.nu/leerling2020)) and 'Onderwijs en ict doorbraakproject' ([kn.nu/doorbraak](https://kn.nu/doorbraak)). In vocational education, the introduction of a new qualifications

structure with electives will ensure more individual learning paths. These are more in line with trends in the labour market and opportunities for students to develop their own talents.

Differentiation, inclusive education and support for excellence all fall under the term 'personalised learning'. Personalised learning is a broad development that places the pupil at the centre and involves close monitoring of pupil performance and adapting instruction accordingly. All this gives both teachers and pupils more freedom of choice and makes it possible to introduce more variety into education. Every aspect of a pupil's personality and all his or her competencies are taken into account in seeking the best way to guide him or her to positive results.

### Relationship with school's vision of education

Personalised learning can take shape in a variety of ways, depending on the school's vision of education. The 2013 Four in Balance survey ([kn.nu/fourinbalance2013](http://kn.nu/fourinbalance2013)) distinguishes three general approaches to education: 'Teacher-driven learning', 'Independent learning' and 'Self-organised learning'. The survey report describes the necessary ICT support for these three approaches.

- In **teacher-driven** learning, pupils are divided into groups by level of knowledge and the lesson material is adapted to each group's level. The teacher supervises the group learning process. This approach is predominant in the Dutch education system, with 80 per cent of all schools applying the teacher-driven approach to learning.
- **Independent learning** is based on the individual pupil's learning requirements (in terms of order and pacing). However, there are pre-determined attainment aims and the teacher guides the learning process.
- In **self-organised** learning, pupils have the opportunity to learn at their own level, at their own pace and in their own way, based on their interests, passions and ambitions. This approach to personalised learning focuses on the learner, who is responsible for his or her own learning process.

ICT makes a major contribution to personalising learning. It gives teachers the tools they need to track, coach and motivate pupils. To help them analyse a pupil's progress and truly differentiate between pupils, teachers must have access to top-quality adaptive digital learning materials that can be tailored to suit a particular pupil's needs.

ICT also helps organise and manage this personalised approach. It does this by relieving teachers of burdensome paperwork and by presenting them with information in context so that they can take faster, more accurate, and better informed decisions.

### 2.2 Collaboration with the environment

Schools operate in a changing, dynamic environment. More than ever, they are expected to respond to changes in society.

- **Demographic changes:** Schools are affected by population shrinkage or by temporary population growth, depending on the composition of the local community.
- In a growing number of families, both parents work outside the home. This affects school hours and the extent to which schools can call on parents to help out. Schools are having to take over some childrearing goals, and more and more parents want a say in their children's education.

- Increasingly, children also learn new things outside school. Schools are no longer the only source of knowledge for pupils. \*  
Change in government attitude: On the one hand, government is encouraging schools to operate independently; on the other, it is making more and more demands on education, for example compulsory final tests in primary education, mathematics tests in secondary education, anti-bullying programs, social skills lessons, guidance on alcohol and drugs, and on sexuality and sexual diversity.
- Changing expectations for school-leavers: The labour market wants different skills than it did a number of years ago.
- Rapid changes in the world of work: Almost no one has a job for life anymore; many of today's occupations did not exist a few years ago, causing uncertainty about the future careers of current pupils; more and more people are self-employed and enter into flexible contracts on a project-by-project basis; increasingly, work is no longer tied to a particular time or place, and close colleagues sometimes work elsewhere in the Netherlands or abroad.

Education has no choice but to keep up with this dynamic environment; after all, it is a vital link in the chain that runs from the family to society and the economy. Schools must work with their communities to define their position with respect to changes in

that society and the labour market. They can do this, for example, by entering into flexible alliances with other schools on a managerial or municipal level so that they can respond rapidly to changes in pupil numbers. A growing number of parents will offer their assistance and commitment based on their specific expertise and interests (guest lectures, projects), in addition to their everyday volunteer activities.

Much more can and is being done at home in terms of supplementary digital learning tools; understanding this and coordinating it with what happens at school can do much to improve the effectiveness of the learning process. This requires schools and parents to work together in new ways.

The business sector can contribute to what is being taught at school and how lessons are organised, for example by giving guest lectures, providing examples from everyday practice for lessons, or hosting excursions. Vocational institutions are increasingly co-producing curriculums with businesses so that participants learn about 'state-of-the-art' developments. The Centres for Innovative Expertise ([kn.nu/vakmanschap](http://kn.nu/vakmanschap)) bring together businesses and educational institutions to work on bridging the gap between education and the labour market. In other words, the school and its surrounding community will be cooperating even more

closely in future. Technology can and must serve as a facilitating factor in this cooperation by offering communication channels that are not tied to a specific time or place. These channels will help intensify cooperation in a way that remains workable for everyone in the hectic reality of everyday life.

### 2.3 Quality & testing / output-based approach

In essence, the quality of education reveals itself in pupils who are well prepared for life, work and learning later on. For schools to actually deliver this 'performance', quality assurance is essential. Quality assurance requires the closest possible match between the demand for learning and learning requirements on the one hand, and the supply of people and resources on the other. This is an ongoing process in which the educational institution continuously reviews and analyses its own results and available data as the starting point for step-by-step improvement. For example, in 2013 the vocational education sector introduced a successful pilot project involving the intake process. This involved collecting and analysing data on students in order to understand which personal success and failure factors play a decisive role in academic performance. Such insight can be used to help students choose a programme of study and to assess the risk of their dropping out. For quality assurance to work

well, the targets, aims and standards must be clear. In order to assess the performance of the educational institution and identify points for improvement, it is vital to have relevant management information at different levels. Such information supports an output-based approach and helps improve the quality of education and of the school. With digital tools providing increasing support for the learning process and the way learning is organised, ICT makes it possible to collect and sort management information without requiring any extra effort. ICT also helps educational institutions account for their efforts by making the results actually achieved comprehensible, transparent and comparable. This also facilitates benchmarking between educational institutions.

With the new Dutch law on Inclusive Education due to go into effect in primary and secondary education, the various parties involved will need to share a great deal of information, not only for management and accountability purposes, but also to communicate with one another in the search for additional support for certain pupils. Applying a digital tracking system can ensure rapid and low-threshold information-sharing and mutual coordination without increasing the administrative burden of the schools and alliances involved. Starting in 2014, primary schools also have a safe and reliable way

to share their pupil files with one another and with secondary schools through the Education Transfer Service (Overstapservice Onderwijs, OSO ([overstapserviceonderwijs.nl/](http://overstapserviceonderwijs.nl/))). The possibility of also improving digital data transfer between secondary schools and vocational institutions is currently being explored, based on the vocational education digital registration process.

### 2.4 Efficiency & manageable costs

Efficiency and cost control have always been important challenges for school boards and management. These challenges have become even more critical in an age of austerity. Efficiency is of particular interest for schools whose pupil populations are shrinking. With fewer and fewer pupils living in their catchment area, these schools have trouble filling their classrooms. Having fewer pupils also means that they receive less funding. This can have an impact on the quality of education. Schools with shrinking pupil bodies will have to adapt to the new circumstances if they are to survive.

Society has a vested interest in education and expects greater transparency regarding the way public money is spent. Government and society expect the education sector to deal scrupulously with its finances.

Platforms such as 'Vensters PO' ([scholenopdekaart.nl/](http://scholenopdekaart.nl/)), 'Vensters VO' ([venstersvo.nl/](http://venstersvo.nl/)) and 'MBO Transparant' ([kn.nu/mbotransparant/](http://kn.nu/mbotransparant/)) make it possible for schools to show the world beyond the sector how they are performing.

It is not easy to demonstrate a causal relationship between effort and resources on the one hand and the quality of education and educational output on the other (see Monitor Trends in Beeld: Doelmatigheid van OCW ([kn.nu/doelmatigheid/](http://kn.nu/doelmatigheid/))). Measuring efficiency requires having a broad understanding of costs. Every element that costs money should be considered: pupils, classes, teachers, methods, the ICT infrastructure, the building and the interaction between all these elements. The questions that should be asked in each case are:

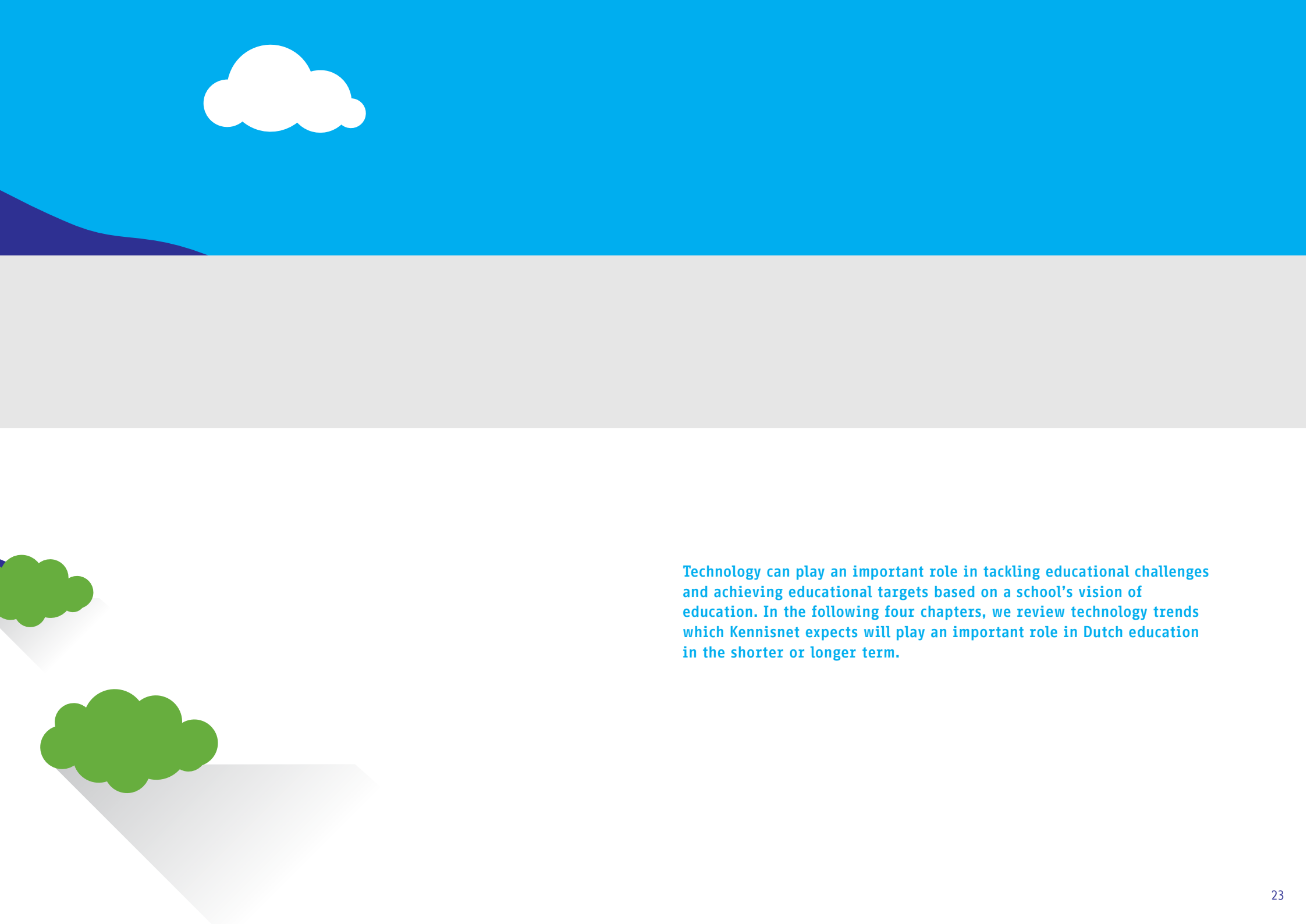
- Do we really need this?
- Can we do it less expensively?
- Can we do more with less money?

Using ICT can help cut costs, for example because teachers spend less time checking pupils' work, because there is less manual clerical work to do, and because coordination with colleagues within and outside the educational institution is faster. The cost of ICT itself can be lowered by using cloud computing or by having pupils and/or teachers bring their own devices to school.



3

# FROM EDUCATIONAL CHALLENGES TO RELEVANT TECHNOLOGY



Technology can play an important role in tackling educational challenges and achieving educational targets based on a school's vision of education. In the following four chapters, we review technology trends which Kennisnet expects will play an important role in Dutch education in the shorter or longer term.

### The Kennisnet Innovation Hype Cycle for Dutch education

Of all the emerging technologies evaluated by Gartner information technology research and advisory firm, Kennisnet has selected the nine most relevant ones for Dutch education. We based our selection on the following criteria:

- the **relevance** of the technology for current educational challenges and how much support it provides towards achieving educational targets
- the expected or actual **impact** of the technology on education
- the **life cycle** stage of the technology: is it still evolving or is it already mature? In other words, can the technology already be implemented on a broad scale in Dutch education?

The combination of these nine technologies could have a major impact on Dutch education. If we view them from the perspective of the educational challenges discussed in the previous chapter, we recognise four technology clusters that are mutually reinforcing and together offer ways to resolve those challenges. We call such clusters 'technology trends'. As we discussed in the introduction, a trend indicates a general direction over the longer term, often owing to the convergence of a number of mutually reinforcing developments.

Every educational institution will naturally have to decide for itself whether or not to follow a technology trend. Which ones should they choose, and which ones can they ignore (for now)? Which ones offer them the best support given their vision of education, their aims and the challenges they are facing? It is important to strike the right balance between the opportunities that a technology can offer and the timing of its introduction. An early introduction allows the school to benefit as soon as possible from the advantages of the

new technology trend, but it also represents a bigger risk because the downside of the technology is not yet clear and the criteria for successful application are still unknown.

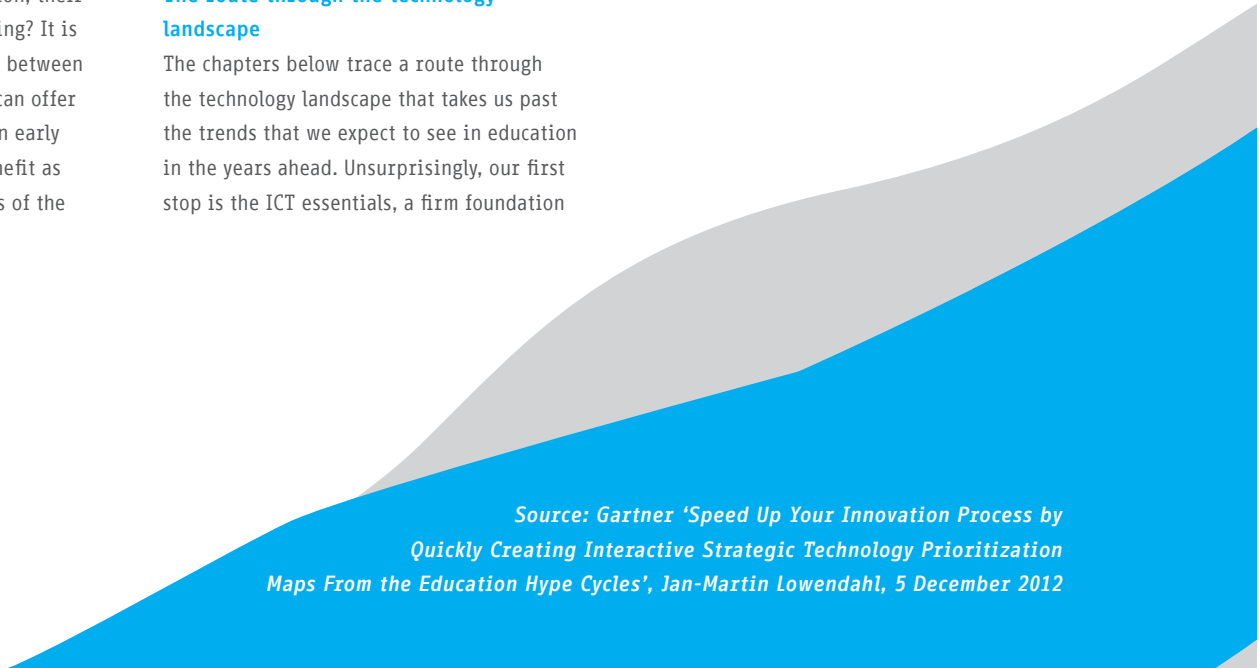
Our review of the nine technology trends in subsequent chapters should help school administrators decide whether and at what point each trend will support them in achieving their vision and aims. After first describing the trend, we summarise its pros and cons by listing the relevant SWOTs. The section on strategic considerations is meant to stimulate the right sort of discussions among school boards, school managers and school administrators, i.e. concerning feasibility and criteria for using the technology successfully in education.

### The route through the technology landscape

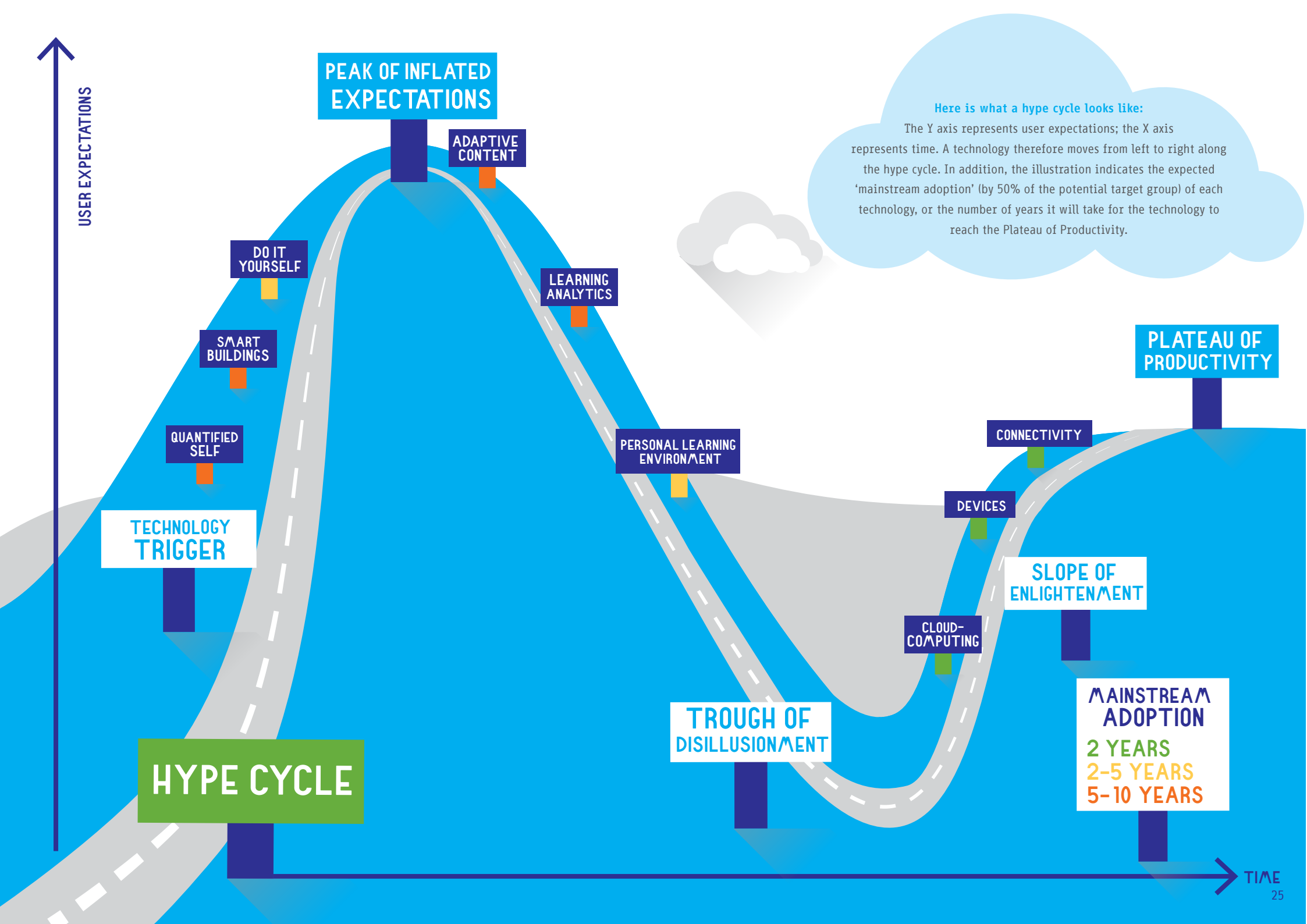
The chapters below trace a route through the technology landscape that takes us past the trends that we expect to see in education in the years ahead. Unsurprisingly, our first stop is the ICT essentials, a firm foundation

for follow-up innovations. That is where every journey begins.

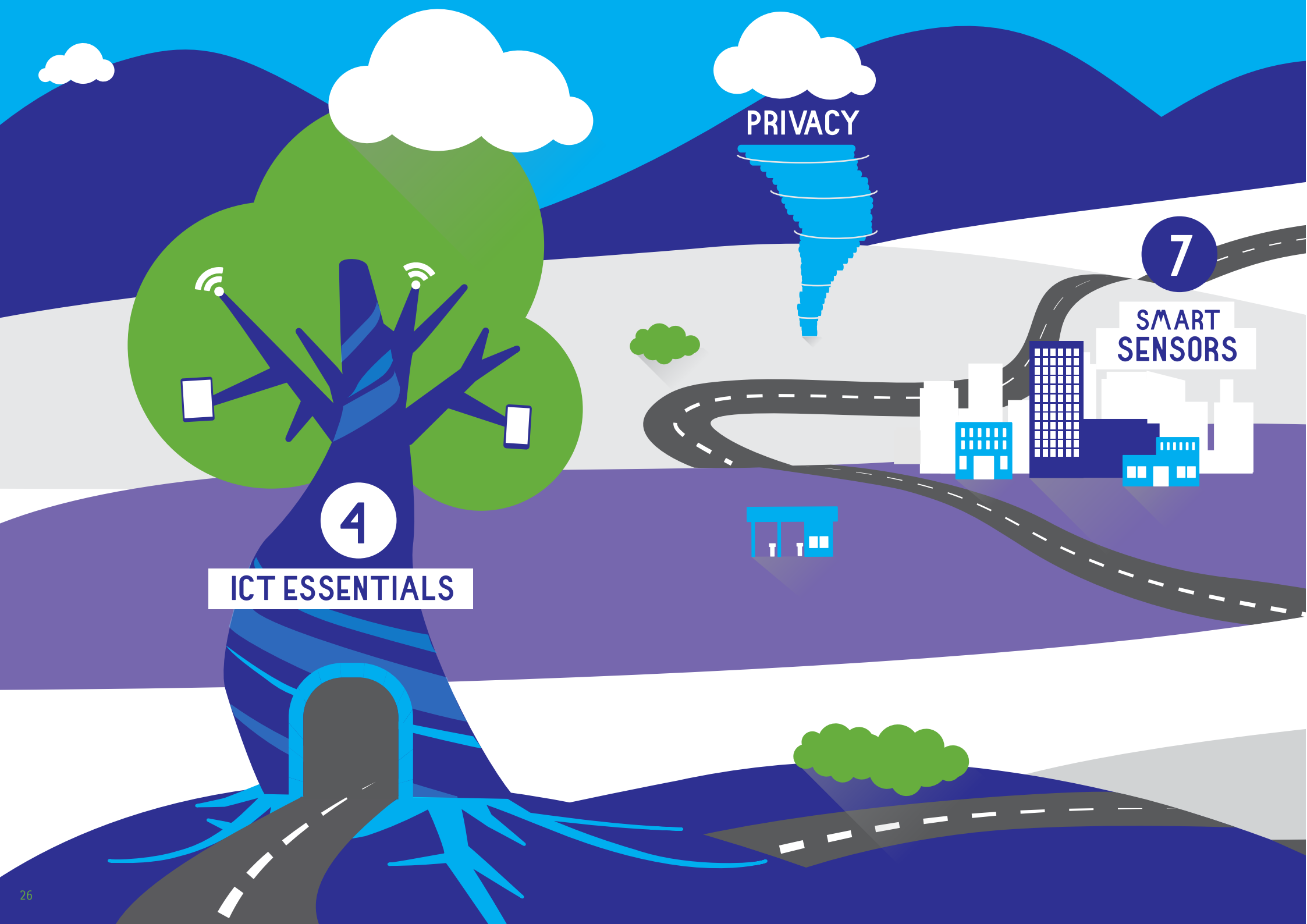
Shortly thereafter, we come to data-driven education, which is still evolving but is already being applied in practice in personalised learning. Somewhat further along the route is Do It Yourself (DIY) technology, a promising trend that in time may make an important contribution to more practice-based education, with its focus on new (digital) skills. Smart sensors are the furthest removed from any practical application. Experiments are under way with sensors in buildings and public spaces, and there has been a steady stream of commercial applications devoted to health and wellbeing. The precise meaning of this trend and its potential role in education are still unclear.



Source: Gartner 'Speed Up Your Innovation Process by Quickly Creating Interactive Strategic Technology Prioritization Maps From the Education Hype Cycles', Jan-Martin Lowendahl, 5 December 2012







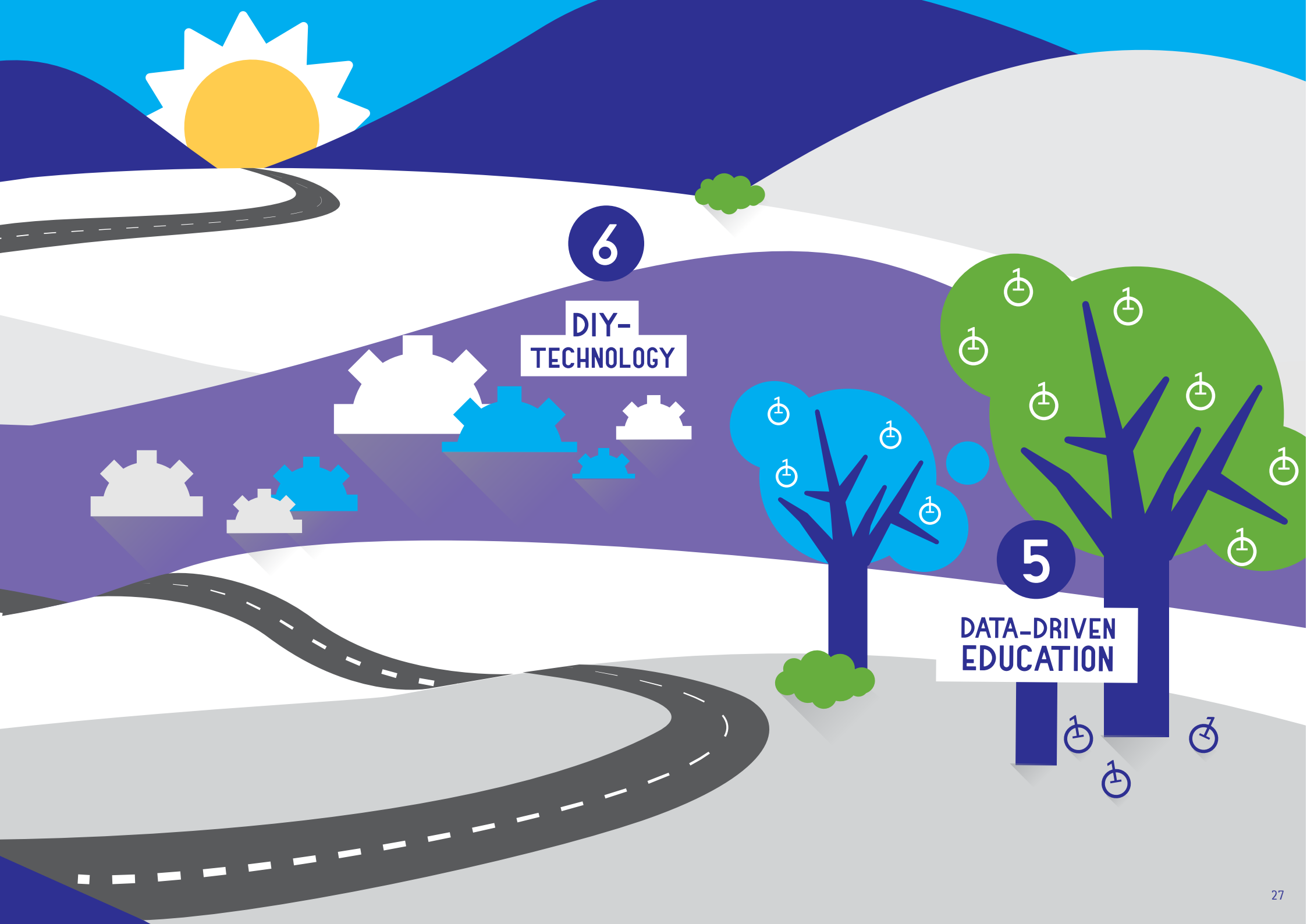
PRIVACY

4

ICT ESSENTIALS

7

SMART  
SENSORS

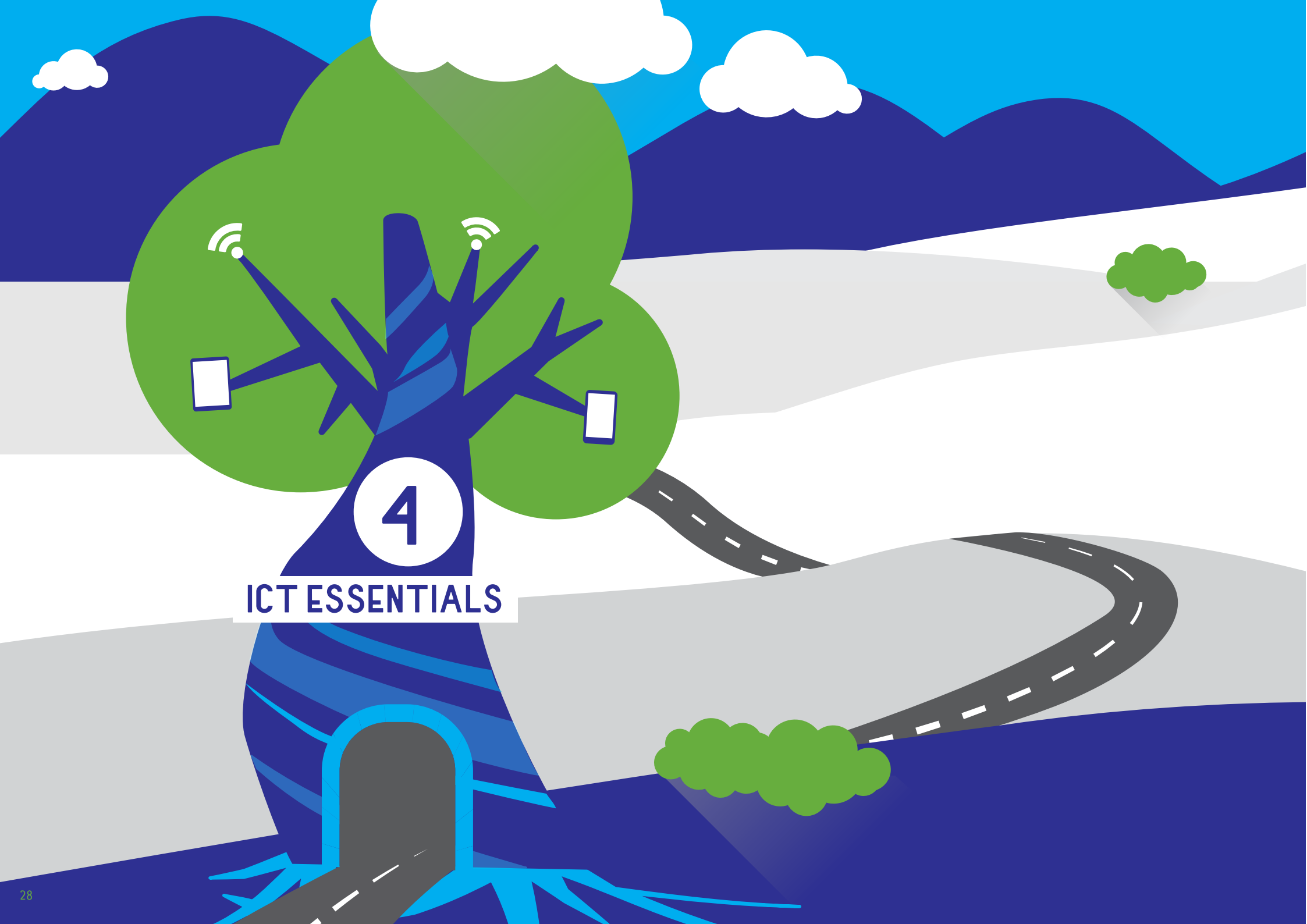


6


DIY-  
TECHNOLOGY

5

DATA-DRIVEN  
EDUCATION



## 4 ICT ESSENTIALS



**It seems contradictory to discuss the ICT essentials in a report that is supposed to be about new, innovative trends. Nevertheless, there are two good reasons to devote an entire chapter to what is rightly regarded as a basic resource.**

To begin with, even familiar and widely used software is still undergoing continuous innovation; the impact of this is huge and merits our attention.

Second, innovations often build on an existing, stable basis; without that stable substructure, they cannot flourish. In short, if the foundations are good, then all the ingredients are in place for the successful introduction of new and innovative applications.

The building blocks that underpin innovative ICT applications are:

- **cloud computing** as a safe, stable environment within which applications and learning materials that support the educational process can be accessed anytime, anywhere;
- reliable, affordable, personal devices for every pupil and teacher; **devices** that complement the way in which pupils learn and the environment within which teachers work;
- reliable and flexible **connectivity** to ensure that users can quickly and safely use the necessary applications on the available devices, regardless of time or location.

These building blocks are the basis for every new use of ICT in education. Utilities such as electricity ensure that innovative electronic devices can be plugged in and used almost without thinking. In the same way, cloud computing ensures that a new application can be used worldwide from the very day that it is released. Flexible, personal devices offering stable online connectivity ensure that every pupil and every teacher can try out the application whenever and wherever it suits them best.

## 4.1 Cloud computing

Cloud computing is the collective name for software that can be run via an Internet connection. The software is available online, and so is the data that it uses. They can be accessed anywhere, anytime, as long as the user has a device and an Internet connection. As is often the case with trendy new words or technologies, the label 'cloud computing' is often pinned on all sorts of new and existing products, correctly or not. We will therefore begin by differentiating between the various types of 'cloud', describe how they differ and how they can be applied most effectively in education.

The best way to differentiate between the various types of cloud is to look at the target group for each one:

**Public cloud.** Broad cloud-computing services that are available to everyone. Users and individual schools can do little to influence their functionality (what a service does and does not do) or the conditions under which applications are provided. In terms of meeting user needs, public cloud-computing applications are aimed at the largest common denominator. Examples are Google's Gmail, Docs and Drive, Microsoft's Outlook.com, Office 365 and SkyDrive, and Apple's iWork and iCloud. Other public cloud-computing services include online banking and tax services.

The education sector already makes full use of public cloud-computing services (sometimes without being aware of it). Virtually every electronic learning environment and critical administration system (ParnasSys, Magister, AFAS and Exact) is available (often exclusively) as a cloud-computing service.

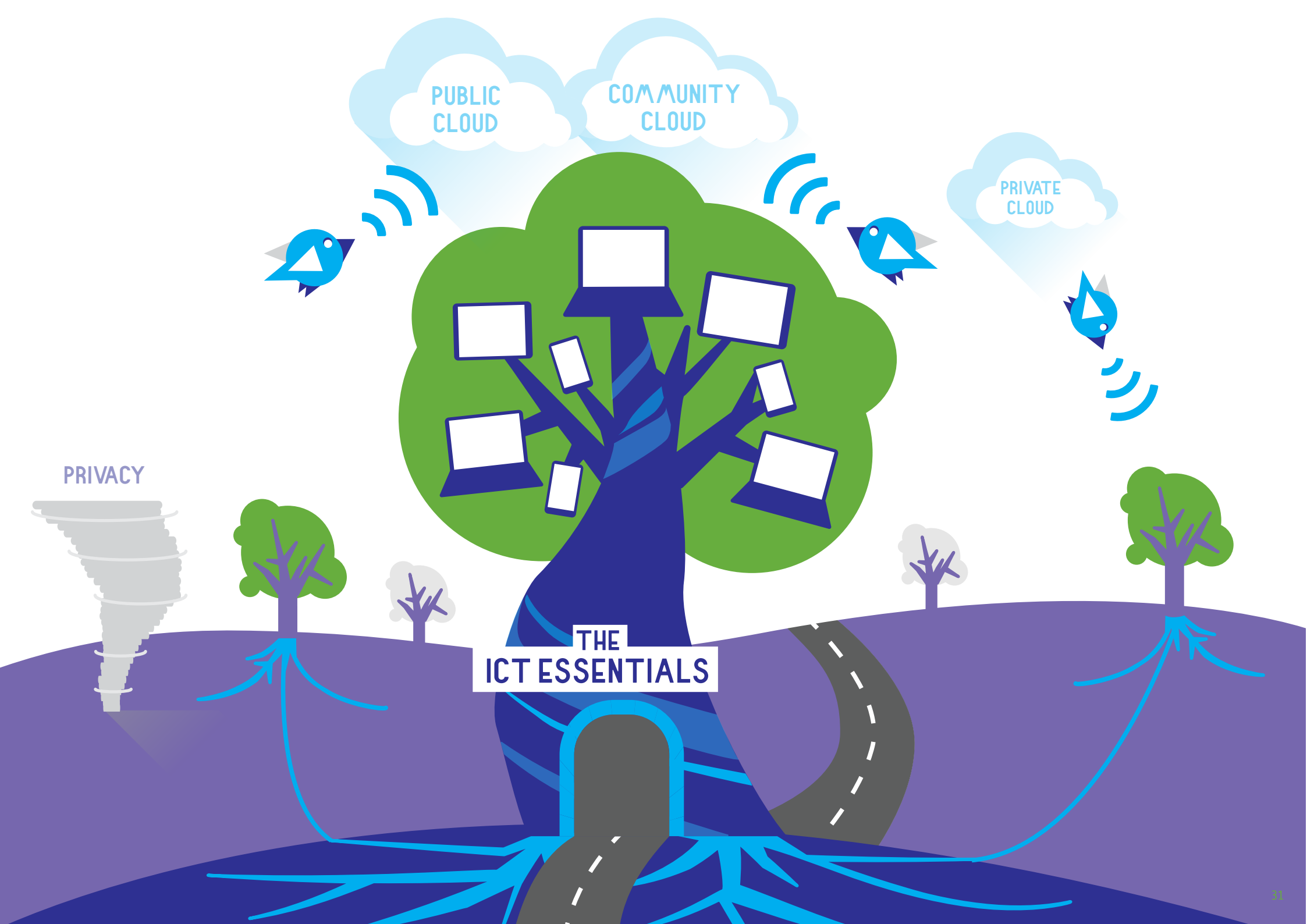
**Private cloud.** If a public cloud offering lacks a crucial functionality or the terms of use are too objectionable, an organisation can set up its own cloud. A private cloud-computing service adheres to the same principles as a public one (access anytime, anywhere), but has its own specifications with respect to data location, ownership, privacy and functionality. While this not as cost-effective as the public cloud, educational institutions that gain an essential functionality and/or are able to meet critical requirements in this manner are making sensible use of their money. Choosing to set up a private cloud therefore involves taking a deliberate decision to pay for the facilities lacking in the public cloud, and recognising that they are worth the extra expense. A private cloud is similar to the data centres that organisations used to or still have.

**Community cloud.** This is a private cloud set up by a group of organisations – for example the Dutch education sector or a governing board within that sector – that satisfies specific common requirements.

It can be a 'best of both worlds' solution, with the participants being able to control functionality and terms and conditions as in a private cloud, but with the cost-effectiveness closer to that of a public cloud. The Kennisnet cloud, for example, is a community cloud for the Dutch education sector that offers such services as 'Vensters voor Verantwoording', 'Teleblik', 'Acadin' and 'Wikiwijs'. The servers are located on Dutch territory and are therefore subject to Dutch legislation. This also means that Kennisnet can rule out any inappropriate use of data and guarantee user privacy and ownership of the learning materials and user data.

**Personal cloud.** Many users, and in particular pupils, use the same applications across multiple devices. For example, they access their e-mail and other communication tools, their list of contacts, their calendars and timetables, and document folders on different devices (phone, tablet, laptop, PC), depending on where they are and when they require access. A recent addition is the automatic synchronisation across devices of browser tabs, 'to read' lists or even bookmarks in e-books or audio/video files. At the moment, personal cloud-computing services consist of sections of the public cloud that contain personal information and are therefore distributed across different cloud platforms by different parties. User control is thus limited for now.

As more and more personal data is being uploaded or synchronised from smartphones, activity trackers and other 'wearables' (smart sensors that people wear on their bodies, described in more detail in Chapter 6), the demand for user control is growing rapidly. A truly personal cloud is still a fantasy, but the need to protect users' digital identities is likely to result in a sort of digital personal data locker.



## SWOT ANALYSIS FOR CLOUD COMPUTING

### STRENGTHS

#### Strengths of the technology

1. Cloud applications are managed by the provider. The user need not worry about disruptions, viruses or breaches of security, or about installing the latest software updates and upgrades.
2. Cloud-computing services are flexible; in other words, capacity (in terms of number of users, amount of storage space) can be quickly and easily expanded or reduced according to need, without the school having to involve itself in major investments or disinvestments.
3. Cloud applications are available anytime, anywhere. The only requirement is an Internet connection. Every device (smartphone, tablet or computer) can function as a workplace, regardless of brand or type. Users always have access to the latest information (e-mail and chat messages, calendar, sources and documents).

### WEAKNESSES

#### Weaknesses of the technology

1. Cloud applications are standardised; customisation is only possible to a limited extent. Users are forced to compromise on functionality. Functional and other types of upgrades are externally driven and coordinated; users must rely on the provider (and the provider's own timeline).
2. Cloud applications store data online and confusion may arise concerning ownership of the data. In many cases, once the data is stored it can only be accessed through the application; direct access (to the 'database') is no longer possible.
3. Cloud computing is not rooted in the physical location of the application and data, whereas legislation is based precisely on that physical location. This can lead to complicated discussions concerning the ownership of personal data in cloud applications and the related privacy matters.

### OPPORTUNITIES

#### Opportunities for education

1. Cloud computing saves time (i.e. the time normally spent on systems management), which can then be used to perform functional goals of more direct relevance to education.
2. When applications and digital learning tools are available online 24/7, the school building becomes only one of many locations where pupils and teachers learn and work with the applications. They have greater flexibility and the school no longer has servers or software on the premises, lowering costs and simplifying building maintenance.
3. Introducing or terminating the use of a cloud application does not require the school to invest in tools, technical know-how or system management goals. This creates flexibility, lowers the threshold to change and encourages innovation in education. Functional selection, data management and support naturally remain crucial and can be given the attention they require.
4. Cloud applications facilitate internal and external cooperation (online) because all users have access to the same functionality (i.e. the same versions) as well as to shared data storage, regardless of their location.

### THREATS

#### Threats to education

1. The power of cloud computing poses a threat to local systems administrators. It can be difficult to arrive at a compromise on functionality because the implications (extra cost, extra effort) of insisting on 100% functionality are often unclear (extra costs not transparent) or intangible (it doesn't affect me). This makes it hard to weigh up functionality against costs objectively, resulting in suboptimal decision-making.
2. Schools have statutory duties and obligations, including how they deal with pupil and other data. If they decide to use applications in the cloud, they need to make firm agreements about who is responsible for what. After all, authorised individuals must retain full access to the data and be able to alter it when appropriate.
3. Educational institutions have less control over which applications are used. Every individual – every pupil, teacher or staff member – can use a cloud application without needing permission to do so.
4. With dependence on ICT applications growing, anyone who wants to use cloud-computing services must have an adequate Internet connection wherever and whenever they work.

## Strategic considerations

■ For educational institutions to benefit from cloud computing, an objective discussion must take place concerning functionality and criteria. The SWOT analysis shows that there are two points of concern in such a discussion:

1. **Possible conflict of interest:** Cloud computing is advantageous (in terms of cost) because it cuts down on the workload of systems administrators and puts limits on their discretionary powers. At the same time, however, they are experts and are often called in to decide (or help decide) whether to introduce cloud computing.
2. The standardisation inherent in cloud applications means **compromising** on functionality (the 80/20 rule: developing the final 20% of functionality generates 80% of the cost) and focusing on what is actually needed. Insisting that 100% of one's demands be met will drive up the cost. In many cases, that extra cost and the necessary time and effort involved will be passed on to a support department and will not be visible or tangible to users (or their representatives). That makes it difficult for the organisation to assess matters properly.

■ An objective, informed discussion that considers cost versus functionality requires internal guidance and coordination.

Because departments often have conflicting interests, this will not happen on its own. One way of making this discussion more explicit is to enforce a 'use or explain' guideline. This gives people the leeway to act autonomously while sticking to the rules, and improves the effectiveness of the educational institution. However, any exceptions to the rule must be requested and properly argued in advance, so that deliberate decisions can be taken concerning extra investments. A guideline of this kind fosters explicit discussion of the design or continuation of its own services if the public cloud does not suffice. One argument might be that the missing functionality provides essential support for the teaching-learning process, or meets one of the organisation's critical requirements (for example to comply with privacy legislation). If there are no acceptable exceptions, then the rule dictates that standardised ICT solutions and cloud-computing applications be used at all times, for cost and efficiency reasons. The question should be: 'Where can we best spend our ICT budget or systems management hours to contribute to good and affordable education?'

■ If the standard public cloud-computing services do not satisfy the needs of educational institutions, and if the systems

are complex and the costs high, then it might be best for school boards to work together or with the rest of the sector in a community cloud solution. In that case, like-minded organisations can set up a cloud-computing system that meets all of their specific requirements; by cooperating, they can gain both scale and cost advantages. Such opportunities are common enough at sector level and within governing boards and partnerships that share the same targets and underlying principles.

■ Increasingly, decisions concerning the use of cloud-computing services can be taken at lower levels of the organisation. Staff do not need a budget or (technical) support to use a free cloud-computing service; they can decide to do so whenever they like and start immediately. This reality must be acknowledged by putting easy-to-use guidelines and rules into place that stipulate how to deal with data on pupils, their progress and their performance. Every organisation should also comply with the statutory guidelines set out in the Dutch Data Protection Act, with contractual guarantees being required.

The following examples should make this clearer:

1. **Conclude contracts** with the providers of cloud-computing services that almost all pupils and staff members use (or

wish to use). Examples include Google's cloud offering or Microsoft's Office 365. Kennisnet has already laid the basis for such contracts in cooperation with SURF.

2. **Stipulate terms** concerning applications that staff have chosen themselves, for example by limiting the budget that they can spend. Forbid staff to enter anything other than their own personal details into such applications – in other words, no information about their colleagues or pupils. After all, that is prohibited by law. A ban of this kind limits the organisation's liability and allows staff to take the initiative within clearly prescribed boundaries.
3. Set **requirements** for the data that should be included (or produced) by cloud applications in the teaching-learning process. Where possible, use direct data transfers and data import or export. Agree on which format should be used when entering data into the school's existing systems. For example, make this explicit in the administrative feedback format requested of a teacher about pupil performance in his subject/lesson, and stipulate how that performance is to be documented, transferred and filed.



## Recommended reading

### Kennisnet cloud computing site

Cloud-computing services can offer schools important advantages. This site provides information on cloud computing.

[kn.nu/themasitecloudcomputing](http://kn.nu/themasitecloudcomputing)

### Cloud computing in het onderwijs, publication

A publication that explains all the aspects that need to be considered in cloud computing.

[kn.nu/publicatiecloudcomputingonderwijs](http://kn.nu/publicatiecloudcomputingonderwijs)

### Aan de slag met cloud computing, information pack

Step-by-step instructions to help educational institutions take decisions about cloud computing and set up a project to introduce and use cloud-computing services, covering every aspect from business case to commissioning.

[kn.nu/informatiemapcloudcomputing](http://kn.nu/informatiemapcloudcomputing)

## Practical examples

### Practical example of a learning environment in the cloud

This site provides information on the 'cloud school' initiative, in which various educational institutions participating in a learning community have joined together to create their own electronic learning environment in the cloud.

[kn.nu/cloudschool](http://kn.nu/cloudschool)

### Study on the benefits of using cloud computing in education

What were the benefits of working in the cloud with MS Sharepoint and Live@edu for school managers, teaching and support staff, and pupils at the comprehensive school De Verenigde Scholengemeenschap Alberdingk Thijm (ATscholen)?

[kn.nu/cloudatscholen](http://kn.nu/cloudatscholen)

### Article on choosing between Google or Microsoft cloud applications

This article from InformationWeek (in English) gives practical examples from schools based in the USA to explain the difference between Google's Applications for Education and Microsoft in Education.

[kn.nu/keuzecloud](http://kn.nu/keuzecloud)

These and other examples  
can also be found at  
[kn.nu/voorbeeldencloud](http://kn.nu/voorbeeldencloud).

## 4.2 Personal devices connected to the Internet

Anyone wanting to make use of digital applications needs a computer. On the one hand, this is perfectly obvious and has always been the case; on the other, things are changing rapidly in this regard. Cloud computing ensures that applications are available anytime, anywhere, but it also requires devices that offer the best user experience in different contexts (everywhere). We check our e-mail and our calendar on our smartphone while en route; we use a tablet or laptop while in a meeting or sitting in the train; and we may even use a PC with a large screen at home or at school. Mobility and flexibility are key concepts in current discussions of devices, in part driven by cloud computing (access to applications anytime, anywhere).

Devices have grown cheaper and more powerful in the course of time. Today's smartphones are more powerful than the supercomputers of 25 years ago. Most pupils and teachers now have one or more devices of their own (smartphone and/or tablet and/or laptop) that give them trouble-free access to applications in the cloud. It is the widespread availability of affordable devices combined with the easy access that they provide to

applications and information that has led to the Bring Your Own Device (BYOD) concept. The question is whether educational institutions should continue making devices available to their staff and pupils. What do schools hope to achieve by doing so?

So far, schools have set up computer rooms for shared use, or installed a few computers in each classroom. There has been some experimentation with tablets or laptops, but in 2013 95% of the computers purchased by primary schools were still desktops. To keep the cost of system administration low, all these computers run the same software and have the same settings. Pupils are often prohibited (or prevented) from installing programs themselves or even from saving their own work on a school desktop - a prohibition that contrasts sharply with pupils' ability to download and install applications that they find useful or fun on their own device, according to their personal preferences and wishes.

The main question, however, is: how should the education sector respond to this situation? Ignoring it is not an option. After all, we have agreed that we want teaching and instruction to reflect how young people experience the world and their personal interests and

talent. The degree to which BYOD or personal devices provided by an educational institution (often tablets or laptops) can be usefully deployed depends on the extent to which pupils are allowed to work with learning materials and applications in an order and/or at a pace of their own choosing. A school's attitude towards instruction therefore clearly underpins its decision-making about BYOD and personal devices. Another, more general advantage of personal devices is that when they are combined with cloud applications, learning becomes truly independent of time and location. As a criterion for an individual learning path (in terms of order and/or pacing), mobile, flexible personal devices (whether or not part of a BYOD system) can be an interesting and challenging addition to the ICT essentials.

We have already observed that access to cloud applications always requires an Internet connection. A device is therefore only useful if it is permanently connected to the Internet. The nature of that connection varies, depending on the location where learning and working take place:

### 1. At school, at home, or another 'fixed' location

A fixed location must have its own broadband Internet connection with registered user

access. Wi-Fi (local area wireless technology) provides mobile access to the Internet; increasingly, it is the only option available. All smartphones and tablets and laptops are Wi-Fi capable. Some workplaces have wired networks with cables to attach mobile devices; traditional workplaces are almost always equipped with a fixed network connection.

### 2. 'En route' between locations

In order to access cloud applications while en route, we use Internet-enabled mobile devices. We may install applications locally, i.e. on our smartphone or tablet, but most applications still require access to data stored in our personal cloud. When smartphone users hit the road, they access the Internet via their data plan or via public or paid Wi-Fi. Some tablets have mobile data connectivity (so do laptops, but to a lesser extent). Increasingly, people are using their smartphone to create a personal hotspot that connects their device to the Internet when public or paid Wi-Fi is unavailable.

## SWOT ANALYSIS OF PERSONAL DEVICES CONNECTED TO THE INTERNET

### STRENGTHS

#### Strengths of the technology

1. Users can install applications and data on their personal devices as they see fit and in line with their individual needs.
2. A personal device is always available and provides access to communication tools, applications and relevant sources (both on the device itself and on the Internet) on demand.
3. Personal devices can connect to the Internet almost from any location; the school's organisational responsibilities do not impose any restrictions.

### WEAKNESSES

#### Weaknesses of the technology

1. When pupils and teachers make mass use of personal devices, wireless networks and Internet connections may have trouble coping with peak demand.
2. The use of personal devices also means an enormous variety of different applications and information sources will be used, making it more difficult to create a common basis available to all.
3. The costs, responsibilities and liabilities are less clear in the case of personal devices, especially when schools apply the BYOD concept.

### OPPORTUNITIES

#### Opportunities for education

1. Pupils who have personal devices can follow their own learning path at their own pace using applications and materials that cater for their preferences. This makes it possible for teachers to approach each pupil in a highly personal way.
2. Pupils who have personal devices can continue using the same applications and materials even outside of school (and school hours). That makes it easier to involve parents in their children's learning process. The teacher can keep track of and guide the pupil's digital work remotely and make more flexible use of physical lessons with pupils, whether or not in a classroom setting.
3. Applying the Bring Your Own Device concept means that schools can reduce their investment in devices and focus instead on providing a good network infrastructure.

### THREATS

#### Threats to education

1. The transition to individual, Internet-enabled devices makes new capacity-related demands on the educational institution's facilities and therefore requires it to invest more and establish guidelines for use.
2. Being able to work anytime, anywhere means that pupils and teachers will spend more time learning and working outside the school. It is then more difficult for teachers to keep a close eye on pupils' learning process, on group processes, and on the details of any problems that may arise.
3. The use of personal devices, whether or not in accordance with the BYOD concept, may be confusing: where do the educational institution's responsibilities end and where do those of pupils and parents begin? What happens if a device breaks, is stolen or malfunctions?

## Strategic considerations

- It only pays to have pupils use personal devices if the school can make a varied supply of digital learning materials available that satisfies the differing needs of pupils. To achieve this, the school needs a carefully constructed long-range policy on learning tools whose implementation is timed to coincide with the introduction of personal devices for pupils. The way teaching is organised, the school's vision of education and the teachers' working methods are all decisive factors. As long as traditional, whole-class teaching methods are used, personal devices will not be effective. The personal device makes it possible for pupils to work at their own pace and in their order of preference, but it is really nothing more than a prerequisite. The introduction of personal devices must be timed carefully and should depend on the school's evolving vision of education and the availability of differentiated materials.
- The large-scale use of personal devices by pupils and teachers makes new demands on the capacity of the school's wireless network infrastructure and Internet connection, its software policy and its support for users. It means making major adjustments to the way ICT services are organised, not so

much because everything has to remain properly controlled in the new situation, but precisely because formal support can (and should) be taken down a notch in order to create the necessary leeway. The most important question when developing the ICT infrastructure is what the educational institution is responsible for organising and offering (and thus paying for) itself, and what it can ask pupils and teachers to take from the public cloud using their personal devices. In the latter, the key question is what agreements should be made concerning security. An example of such an agreement is to insist that users always lock their devices with a password or PIN code.

- One issue that has become more pressing with the growing use of mobile devices is the availability of an affordable Internet connection. It is true that mobile data networks are becoming faster and cheaper, making them a convenient option. But what is even more interesting for the education sector is for schools to share wireless Internet facilities. That has led, for example, to eduroam, a community-driven solution in which educational institutions open up their Wi-Fi infrastructure to one another based on open technology standards and firm agreements setting out responsibilities.

- The use of personal devices has also led to discussions concerning which tablets or laptops should be used and what brands are preferable. Such decisions naturally depend on how the devices are used. A tablet, for example, is very suitable for consuming information and interacting with online media. A laptop is less handy in those areas, but more suitable for writing longer texts, creating complex graphics, and so on. All sorts of requirements can be set, but the final choice should be based on the objective functional need. The same goes for discussions concerning brands or models. Which applications are vital for the teaching-learning process? What brand or model of device supports that process best?

- As with cloud computing, personal devices make the individual user responsible for choosing applications, which they do at Appstores, huge collections of applications – many of them free of charge – where users can select those that offer them the functionality they need. How will we deal with this? After all, too much diversity will make it difficult to organise and support shared learning activities. Broad deployment can be ensured by agreeing to use open standards; HTML5-based apps, for example, can be run on every brand and every device.

Evernote, Dropbox and Twitter also offer client applications that run on every common platform. These criteria can help schools select suitable applications.

## Recommended reading

### Kennisnet laptops and tablets site

Site with information on using laptops and tablets in education, including Bring Your Own Device (BYOD).

[kn.nu/themasitelaptopstablets](http://kn.nu/themasitelaptopstablets)

### Kennisnet ICT infrastructure site

This website helps schools select the right hardware for their ICT infrastructure, for example cables, switches and modems. The decision-making process is broken down into four steps.

[kn.nu/themasiteictinfra](http://kn.nu/themasiteictinfra)

### Kennisnet publication Hoe? Zo! BYOD

This Dutch publication explains how a vocational institution can benefit from introducing the BYOD concept and what arrangements it will need to make internally.

[kn.nu/byodhoezo](http://kn.nu/byodhoezo)

### ICT infrastructure for schools (leaflet)

This leaflet briefly describes the steps that schools should go through to create the right ICT infrastructure.

[kn.nu/ictinfra brochure](http://kn.nu/ictinfra brochure)

### Cost calculation for a BYOD network in secondary education.

This example indicates the cost involved in setting up a BYOD network at a secondary school..

[kn.nu/byodrekenvoorbeeld](http://kn.nu/byodrekenvoorbeeld)

### Perception study on BYOD at Liemers Comprehensive

Study on perceived benefits of BYOD in terms of parent involvement and learning output at Liemers Comprehensive.

[kn.nu/onderzoekbyodliemers](http://kn.nu/onderzoekbyodliemers)

### Eduroam

Information on eduroam, a free international service for educational institutions that have a Wi-Fi network. Eduroam gives pupils and staff free Internet access at all participating institutions.

[www.eduroam.org](http://www.eduroam.org)

## Practical examples

### Christelijk Lyceum in Zeist works with MacBooks

Christelijk Lyceum Zeist, co-initiator of the iScholengroep, explains its approach to laptop-based instruction. Pupil videos illustrate how this works out in practice.

[kn.nu/zeist](http://kn.nu/zeist)

### Digital learning at IJburg Comprehensive

This article, from Vives (2012), describes how IJburg Comprehensive in Amsterdam has set up its ICT essentials as an IP network that operates on the principle of Bring Your Own Device and uses Digital Media Suite (an ELE pathway with a multimedia, wireless communication system).

[kn.nu/ijburgdigitaal](http://kn.nu/ijburgdigitaal)

### Wi-Fi at Christelijk Lyceum Zeist

This case study at Christelijk Lyceum secondary school in Zeist explains why the school chose to use laptops and Wi-Fi in instruction and how it implemented its network.

[kn.nu/wifizeist](http://kn.nu/wifizeist)

### Using Chromebooks

Teacher and ICT coordinator Arco de Bonte has produced a video on using Chromebooks at a primary school.

[kn.nu/arcochromebooks](http://kn.nu/arcochromebooks)

### Corlaer Chromebooks

Corlaer secondary school in Nijkerk works with Chromebooks. In this document, the school describes the advantages of this system in terms of teaching and hardware management.

[kn.nu/corlaer](http://kn.nu/corlaer)

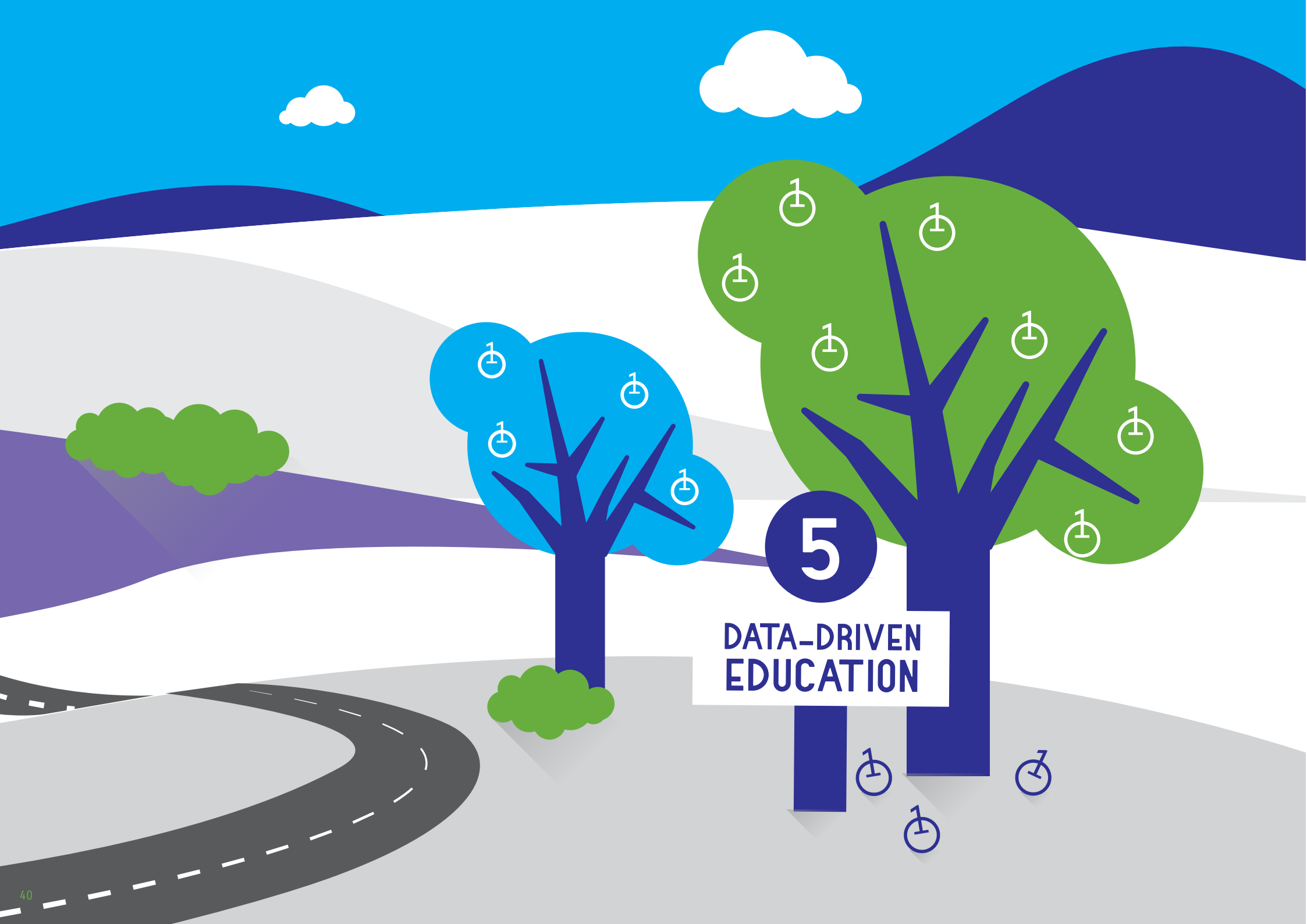
### Introducing BYOD at ROC A12

ROC A12 in Gelderland has begun introducing Bring Your Own Device (BYOD); digital teaching methods are used automatically in everyday lessons. Find out here how the school went about it.

[kn.nu/byodroca12](http://kn.nu/byodroca12)


These and other examples  
can also be found at  
[kn.nu/voorbeeldendevices](http://kn.nu/voorbeeldendevices).





5

DATA-DRIVEN  
EDUCATION



**People tend to avoid using the term 'data-driven education'. That's understandable in one sense, but in fact it describes what we are already doing in education.**

Test scores are a decisive factor in education today; they help pupils, teachers and parents choose the next step in pupils' academic careers, mark the transition from one year to the next, and serve as the main criterion for deciding whether or not to intervene. There is a downside as well, however: tests are administered only infrequently, and at times when pupils are already overstrained, muddying the results at times. The way they are set up also means that they only deliver data on simple, quantifiable aspects of learning.

With support for learning rapidly being digitised, however, we now have access to an abundance of high-frequency data on a pupil's learning process and output. That data comes from the use of digital learning materials which consist of digital exercises and tests in a digital learning and working environment. In an adequate digital process, the available data is easy to collect, categorise and share, resulting in a more subtle, profound and complete picture of a pupil's progress. This phenomenon is sometimes referred to as 'Big Data', the use of large volumes of data generated by the digital process. Although such data is meaningless at first, if it is properly interpreted it can offer valuable insights into the learning process. The aim is not only to describe and explain **what** has already happened, but above all to understand **why**. Based on that understanding,

it ultimately becomes possible to work proactively, for example to prevent pupils from dropping out or from having to repeat a year. Teachers and parents have a more complete picture of the pupil's performance and the context in which it takes place.

Data-driven education certainly does not mean that the teacher's role becomes superfluous or less relevant. In fact, the opposite is true. Because technology does what it is best at (collect data on the individual and group learning processes and then analyse and present that data in a comprehensible manner), the teacher can focus on the essentials of proper education (teaching, making connections, asking questions, coaching pupils, and encouraging and guiding individual learning processes). 'But why can't teachers monitor a pupil's learning process themselves?' many people wonder. Yes, teachers certainly can supervise a pupil as he or she works, but they also have 29 other pupils in their class. The technology

of data-driven education supports teachers in their work and helps them achieve the goal of every teacher: to acknowledge the differences between pupils by applying a differentiated approach.

Another key advantage of data-driven education is that it is easy to record all sorts of data on pupil progress in a digital environment. With the right preparation, this can lighten the teacher's administrative load considerably. At the same time, the data can help schools analyse their own performance as educational institutions. It can reveal how effective the learning materials are, whether those materials are suitable for various pupils, how staff can be deployed more effectively, and how both pupil and teacher performance has evolved over time. In other words: data of this kind makes it possible to improve output and work consistently on better pupil, teacher and school performance.





The technology of data-driven education has three closely interrelated components: learning analytics, adaptive digital learning tools and the personal learning environment. Learning analytics represents the engine, whereas the other two make use of that engine in differing ways.

### 5.1 Learning analytics

Learning analytics is the process of measuring, collecting, analysing, reporting and communicating about data on pupils and their context, the purpose being to understand and optimise learning and the environment in which it is taking place. Following such analysis, feedback can lead to teachers, pupils, school boards and, for example, developers of learning materials taking more effective action. Learning analytics is about discovering trends and patterns in large quantities of data (Big Data in education) in order to make more personalised learning possible.

There are two forms of learning analytics that support differentiation at differing levels:

#### Embedded analytics

Embedded analytics come into play while the pupil is actually learning. This particular form ensures that the data on a learning activity is used immediately to adapt exercises to the pupil's proficiency in a

subject or task. The technology controls the adaptive learning material without any human intervention. For example, if a pupil is able to solve a certain type of problem correctly in an adaptive (practice) program, he or she will be given more difficult problems to solve. If the pupil makes repeated errors, he or she will be given more explanatory material or easier exercises.

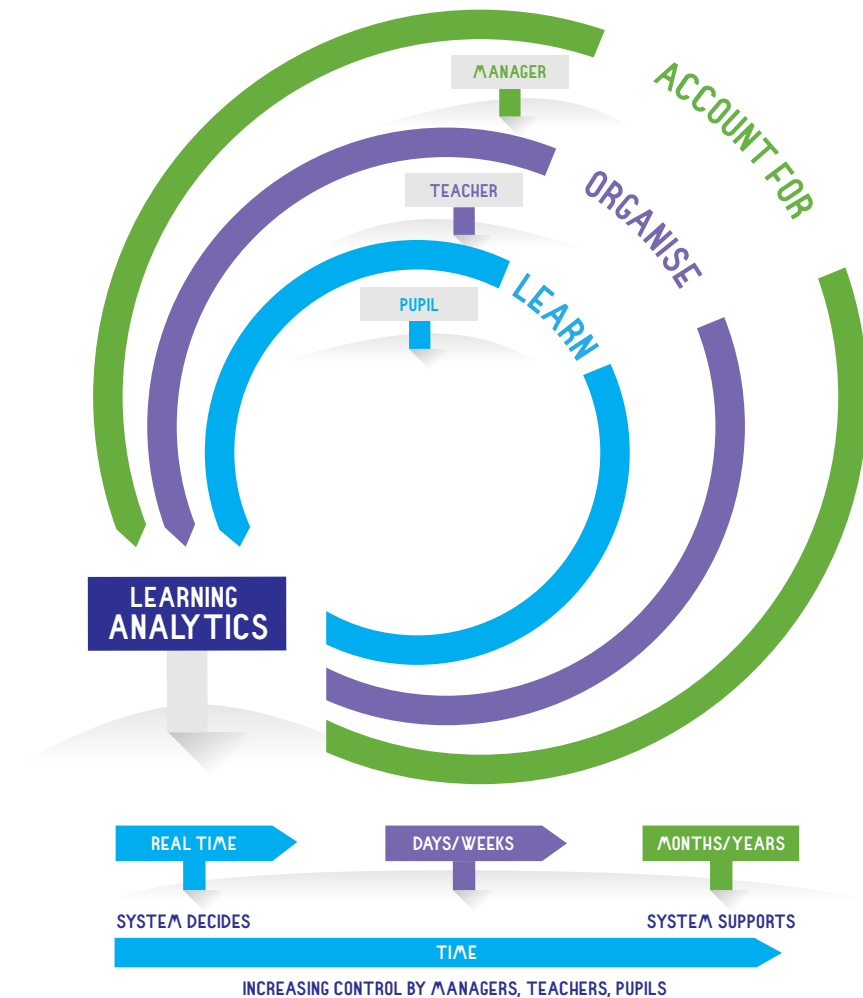
#### Extracted analytics

This comes into play after the learning activity is finished. It is a reflective tool. It helps teachers see, on a daily or weekly basis, how a pupil or a class are faring in a particular subject using a particular teaching method. Extracted analytics does not influence the learning process directly; there is time to reflect and consider additional factors, with the teacher providing any necessary intervention. Taken to a higher level of abstraction, this approach also helps school managers and school boards assess the performance of the educational institution as a whole (and how that performance fluctuates).

Learning analytics is promising because it can make more differentiated, personalised education possible. By monitoring the learning process continuously instead of testing progress every so often, it is easier to identify problems in good time and to

predict how well a pupil will do. In addition, feedback on how learning materials are being used and how effective they are will also help developers improve the quality of their products.

All this means that learning analytics can make an important contribution to improving the output of education on multiple fronts while also lightening some of the administrative burden.



## SWOT ANALYSIS FOR LEARNING ANALYTICS

### STRENGTHS

#### Strengths of the technology

1. When applied in the digital learning process, learning analytics facilitates high-frequency registration of the learning process and therefore lightens the administrative burden.
2. Learning analytics categorises large quantities of educational data and helps analyse and present/visualise them. This gives pupils, teachers and schools a rich source of useful information.
3. Learning analytics helps make the complex learning process of individual pupils comprehensible. This allows education professionals to offer a group of pupils specific, personalised interventions.

### WEAKNESSES

#### Weaknesses of the technology

1. Not every aspect of learning is (easily) quantifiable. Not all digital learning materials can meet the demand for data on the learning process.
2. At the moment, data is largely collected in interaction with the digital learning materials. There are many more meaningful indicators for the quality and progress of a learning process.
3. The data is still spread out over different locations and not all of it is of the same type. The result is fragmentation, with information not being used as comprehensively as it might to build a complete picture of the learning process.

### OPPORTUNITIES

#### Opportunities for education

1. **Pupils** come to understand their own activities, interactions and learning process, encouraging self-reflection and the development of study skills.
2. The **teacher** can monitor the learning process continuously for the entire class and spends less time writing and updating progress reports. He or she has more time to guide and supervise and has better tools for early problem identification.
3. **The school head and/or school board** are supported in their efforts to streamline the organisation. Learning analytics makes it possible to identify threats at an early stage so that proactive steps can be taken (for example to prevent pupils from dropping out). It is also easier to benchmark the school's or board's performance.
4. **Developers** have a better understanding of how their learning materials are being used and how the quality of their products can be improved.

### THREATS

#### Threats to education

1. Collecting, sharing and using so much data about a **pupil** increases the risk of privacy infringements owing to third-party use of that data.
2. As yet, **teachers** do not have sufficient access to digital learning materials that offer learning-analytics functionality. Teacher training and work experience do not include the analysis, interpretation and application of educational data.
3. **School and/or school boards** face difficult choices in an immature market with technically complex products. There is a need for objective experiential data to support good decision-making; at the moment, the technology is being hyped.
4. **Developers** are very aware of the value of the data produced by their products, and are therefore not inclined to simply make that data available.

## Strategic considerations

■ Everything can be measured and registered in a digitally supported teaching-learning process. The question, however, is which data is relevant and how it should be interpreted in order to say anything meaningful about the pupil's learning process, the teacher's performance, or the school's output. The market has no understanding of which data is relevant, and so schools must themselves think hard about the aspects (i.e. variables) of the learning process and their own organisation that they wish to measure and register. Which data and insights can support the school as it implements its policy and strategy? Which data is available? For example, which data is registered in a pupil tracking system? Which additional information and analyses would the school like to have? The first step in introducing learning analytics in education is for a school to state explicitly what it expects and what it needs to achieve its targets.

■ Big Data and how the education sector uses it in learning analytics also mark a paradigm shift. Whereas recording data on the learning process used to be time-consuming work, leading to resistance, today it is mainly a question of deciding what we want to record. Without imposing any restrictions on themselves, educational institutions, teachers and school boards can consider which information they would ideally like to have to achieve their targets as efficiently as possible. It is good to be aware of this and it makes for well-informed discussions with the providers of digital learning tools and platforms.

■ As many public cloud-computing services have shown, providers are acutely aware of the value of data concerning how their services are used. Google earns an annual 50 billion dollars from profiles that it constructs based on the way we use its free service. The business strategy of paying with data has proved highly successful in

the digital economy. Data on pupil learning processes is very valuable to the education sector – something that has not escaped the notice of providers of digital learning materials and platforms. The sector must therefore make crystal-clear demands on the availability of data generated by using digital learning tools and platforms. It must make these functional demands to support differentiation in education, but for reasons of economy it is equally relevant to work consistently on improving performance and, in turn, output. In short, controlling data concerning the teaching-learning process and making demands on learning-analytics support will be important agenda items in negotiations with providers over the next few years.

■ Besides access to data, another important success factor is to be able to integrate that data from different sources. A more all-round view of the pupil's learning process across different subjects and different

aspects supports effective instruction and helps get the most out of the teaching-learning process within the school. The need to comply with the Personal Data Protection Act and respect the privacy of pupils, their parents and teachers also makes it important to keep a firm grip on the data. In terms of privacy, an educational institution will benefit by pointing out how the data is being used in the interests of the pupil, the teacher and the school. Once the added value of using the data is clear to the individuals concerned, they will be more willing to make the information available for that purpose.

## Recommended reading

### Big Data makes its mark on schools - for better or worse

A blog on InBloom: 'Education advocates for years have marveled at the potential of Big Data. Schools collect so much information on students and their educations. The challenge has always been how to pool that data in a meaningful way to improve learning.'

[kn.nu/edtechbigdatainschools](http://kn.nu/edtechbigdatainschools)

### Andrew Keen - Keen On ... So what's the big deal about Big Data?

Andrew Keen interviews the authors of Big Data: A Revolution That Will Transform How We Live, Work and Think: Viktor Mayer-Schonberger, Oxford University, and Ken Cukier, The Economist.

[kn.nu/bigdealbigdata](http://kn.nu/bigdealbigdata)

### Why Big Data is not truth

New York Times piece that takes a more nuanced look at the debate and hype about Big Data.

[kn.nu/newyorktimesbigdata](http://kn.nu/newyorktimesbigdata)

### Kennisnet Innovation site on learning analytics

A collection of blogs, sources, animations and infographics.

[innovatie.kennisnet.nl/learninganalytics](http://innovatie.kennisnet.nl/learninganalytics)

### Special Interest Group Learning Analytics

SURF has set up a special interest group (SIG) on Learning Analytics. A SIG is a community of educators and researchers who focus on a specific theme related to ICT innovation, specifically with a view to knowledge-building and knowledge-sharing.

[kn.nu/surfgroepla](http://kn.nu/surfgroepla)

### Society for Learning Analytics Research (SoLAR)

The Society for Learning Analytics Research (SoLAR) is an inter-disciplinary network of leading international researchers who are exploring the role and impact of learning analytics on teaching, learning, training and development.

[solaresearch.org/](http://solaresearch.org/)

### LASI 2013 resources (Learning Analytics Summer Institute)

Resources and YouTube videos of a two-day conference of the Society for Learning Analytics Research (SoLAR).

[kn.nu/lasiamsterdamresources](http://kn.nu/lasiamsterdamresources)

### Masterclass Learning Analytics OU

Dr Eric Kluijfhout talks to Erik Woning (Kennisnet) about learning analytics.

[kn.nu/ericenerikoverla](http://kn.nu/ericenerikoverla)

### Learning Analytics Community Exchange (LACE)

LACE brings together European experts in the field of Learning Analytics (LA) and Educational Data Mining (EDM) and focuses on knowledge-building, knowledge-sharing and gathering evidence of the benefits of LA and EDM.

[laceproject.eu](http://laceproject.eu)

## 5.2 Adaptive digital learning tools

The adaptive digital learning tool is a recent development. It aims to offer pupils a dynamic learning environment by immediately adjusting the content to the learner's knowledge level, based on the data generated by learning analytics during the learning process. How does that actually work?

Pupils' interaction with the digital content produces data. A good example would be the time a pupil spent on a particular problem? What strategies did he use to solve the problem? Is his solution correct or incorrect? Did he find it easy or difficult? All this **data** can be collected and stored, and the system then **analyses** it including other existing data about the same pupil. This results in an automatic **intervention**. In an adaptive digital learning system, the analysis takes place immediately, in real time. The content is adjusted automatically, by the system itself. For example, the system may make subsequent problems harder or easier, give the pupil a different sort of problem to work on, or provide remedial instruction, perhaps by advising him to work with another pupil who has mastered the material better. When the pupil resumes working with the tool, the cycle repeats itself. Learning analytics is the engine driving the adaptivity of the system.

These and other examples  
can also be found at  
[kn.nu/voorbeeldenla](http://kn.nu/voorbeeldenla).

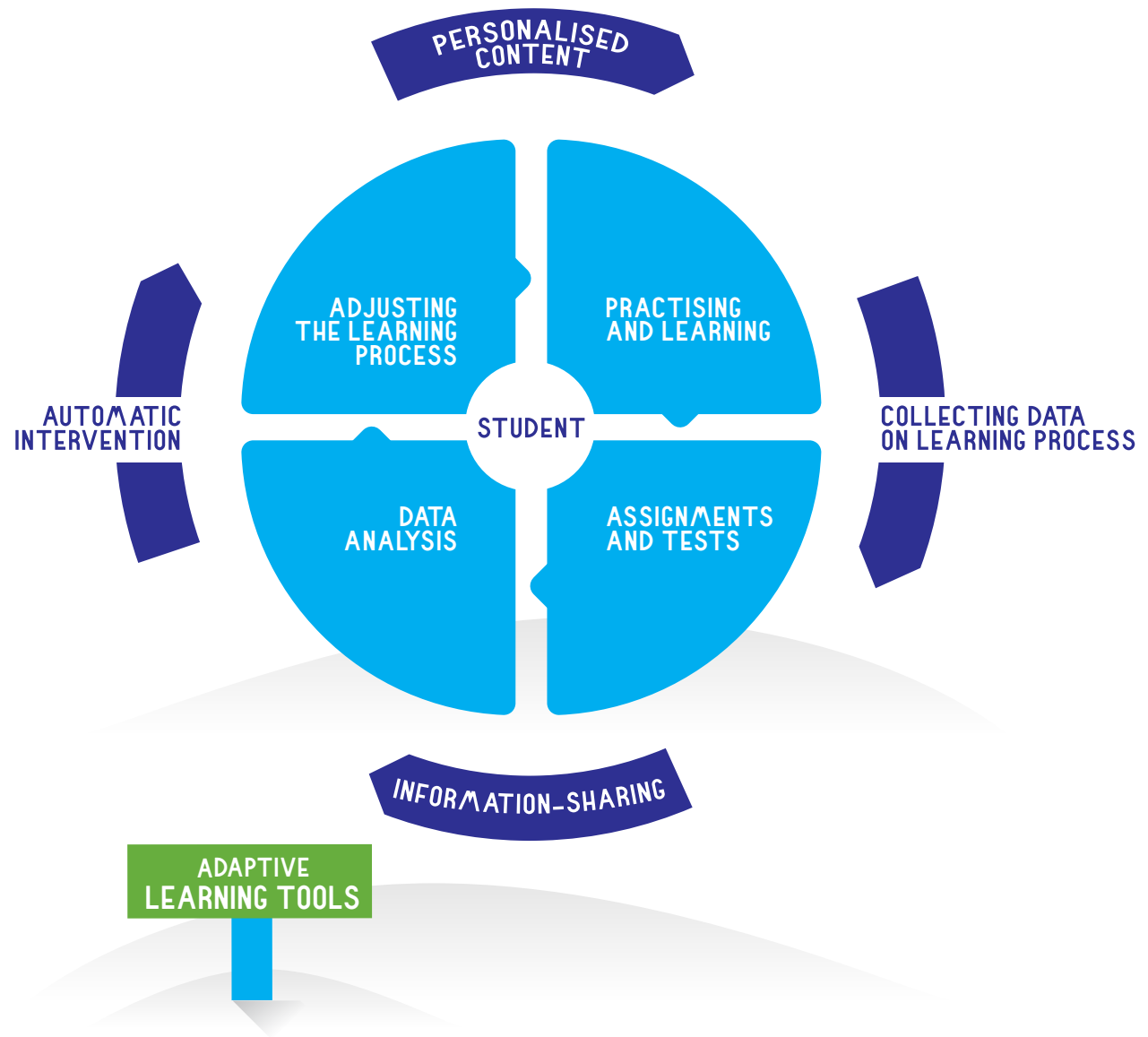
The analysis itself (and the adaptation) takes place **while** the pupil is learning.

Adaptive digital learning tools consist of three elements:

**1. Digital learning material.** The material is divided into short pieces of information that describe a single learning activity in detail. The descriptions, known as metadata, define its use within a particular learning pathway and the level, pace, interests and any other features that serve to tailor learning to an individual pupil's specific needs.

**2. Data about learning.** This is a detailed data set that offers a complete picture of how an individual pupil learns, based on the way he or she uses the digital learning material. The data set is a record of the learning process, how the pupil practises and applies the material (formative testing) as well as summative testing of whether the pupil has mastered the material and is ready for the next step.

**3. Processes and algorithms.** This refers to the method used to analyse the data about learning. This analysis produces a detailed description of the individual pupil's learning needs. That description can be used to modify the learning process dynamically by making adjustments to the digital learning material while he or she is learning – in other words, by creating adaptivity.



## SWOT ANALYSIS FOR ADAPTIVE DIGITAL LEARNING TOOLS

### STRENGTHS

#### Strengths of the technology

1. It is possible to develop different versions of a learning tool without compromising in advance on its suitability for the majority of the group.
2. Progress in learning is already recorded as a function of the system's adaptivity and does not need to be registered separately. This lightens the administrative load in education.
3. The combined user experiences of pupils make it possible to rank content elements by difficulty. Adaptive digital learning tools gauge their own level of difficulty in this way and can align themselves more closely to each pupil's needs.

### WEAKNESSES

#### Weaknesses of the technology

1. There are no useful open metadata standards available for adaptive learning tools. Such metadata is required to be able to offer pupils the right alternatives within adaptive learning tools and platforms for personalised learning.
2. Creating metadata for digital learning tools is a complex, labour-intensive process.
3. As yet, we have no real idea which dataset provides a representative picture of the progress the pupil is making in his or her learning process. The data needed as a basis for analysis and then adaptivity is still open to discussion and study.

### OPPORTUNITIES

#### Opportunities for education

1. Adaptive tools can offer every pupil a learning experience that matches his or her individual level of knowledge, pace of learning and interests. By challenging the pupil at the right level, he or she will feel more motivated and the learning process will be more effective.
2. Pupils can work with these tools on their own and receive customised content. The teacher monitors the group's progress and differences within the group in that regard. He or she has time and the right information to give pupils specific extra support.
3. Pupils can work with adaptive tools outside the classroom or school. The teacher can use the limited instruction time to discuss how to interpret and apply the material.
4. The teacher can use the record of each pupil's learning process to decide which interventions would be effective for each one. Adaptive digital learning tools facilitate and support differentiation.
5. The pupil and his or her parents can be informed about progress and results at the desired level of abstraction. Direct and regular feedback will improve the quality of the learning process and the pupil's performance (and the dialogue concerning these topics).

### THREATS

#### Threats to education

1. Expectations of adaptive technology are inflated beyond what current products can deliver.
2. Working independently with adaptive learning tools evokes the image of an aloof, isolated learning situation that is dictated by the data. The aversion that this evokes may give people a distorted view of the value of this tool.
3. Not enough people recognise the technology as a tool (and only a tool) for facilitating independent learning in order to create time/leeway for differentiation within groups.
4. The technology is used in the classroom (only). Schools should take more advantage of the fact that such tools can be used anytime, anywhere and that they therefore free up time for other things during face-to-face lessons.
5. Data collected to support adaptivity can also be used by other parties and/or for other purposes, raising concerns about the teacher's and the pupil's privacy.

## Strategic considerations

- Educational institutions must consciously develop and implement a policy on the collection, classification and security of all data on learning processes used in all their digital learning tools and records. Mandatory use of open standards is important in that regard.
- Digital learning tools and learning environments can cut down on the time spent registering/recordkeeping and facilitate a differentiated, more personalised approach, but that will only happen if successful strategies are developed to counteract data fragmentation and data-sharing problems. Every single building block that goes into a digital learning system must be compatible with all the other components and with the overall structure. This requires a firm, institution-wide policy that provides a framework for selecting digital learning tools.
- The teaching team must be involved in deciding on the right positioning, the importance and the role of data and adaptive digital learning tools within the teaching-learning process. The emphasis should be on using ICT specifically to free up valuable time for individual guidance and on benefiting as much as possible from

the insights that a detailed record of the learning process can offer. That involves looking at the balance between data & analysis on the one hand and observation & professionalism in teaching on the other.

- The market is still evolving and current products reflect a variety of different opinions about adaptivity and strategies for creating it. These range from a specific solution for a single school subject or topic to a generic platform that aims to offer adaptivity for all school subjects. Limited, small-scale experimentation is the way to begin here; the market has not yet settled down enough to embark responsibly on broad implementation.

## Recommended reading

### Effects of practising with the Rekentuin tool

A study on the pupil traits that correlate with positive effects on arithmetic skills when using the Rekentuin tool.

[kn.nu/onderzoekeffectenrekentuin](https://kn.nu/onderzoekeffectenrekentuin)

### Comments about Taalzee

Article from COS on Taalzee, an adaptive tool for language learning, including what teachers and pupils think of it.

[kn.nu/costaalzee](https://kn.nu/costaalzee)

### EdSurge list of adaptive learning tools

Long list of adaptive learning tools.

[edsurge.com/adaptive-learning](https://edsurge.com/adaptive-learning) (in English)

### Market scan of digital learning tools

Examples of adaptive systems and tools.

[kn.nu/marktscandigitaleleermiddelen](https://kn.nu/marktscandigitaleleermiddelen) (in Dutch)

[kn.nu/marktscansystemen](https://kn.nu/marktscansystemen)

### Proefluin Examens

Pupils can use this adaptive exams trainer to quickly prepare for their final examination. A list shows them which material requires more attention.

[proefluinexamens.slo.nl](https://proefluinexamens.slo.nl)

## Practical examples

### FIER uses ICT to cope with shrinking schools

This video shows how the FIER educational group uses the Snappet, Rekentuin, Taalzee and Got-it tools to personalise learning for pupils in combined classes.

[kn.nu/maatwerkfier](https://kn.nu/maatwerkfier)

### Personalised learning at Hondsrug Comprehensive

The video shows how Hondsrug Comprehensive in Emmen introduced personalised learning using the PulseOn platform.

[kn.nu/hondsrug2020](https://kn.nu/hondsrug2020)

### Adaptive learning tools at Panta Rhei Comprehensive

Video in which a teacher at Panta Rhei Comprehensive in Amstelveen talks about using the StudyFlow system and what benefits it has for the school.

[kn.nu/pantarhei](https://kn.nu/pantarhei)

### Adaptive learning in primary school

Practical example of adaptive learning in the classroom.

[kn.nu/adaptiefmettablets](https://kn.nu/adaptiefmettablets)

These and other examples  
can also be found at  
[kn.nu/voorbeeldenadaptief](https://kn.nu/voorbeeldenadaptief).



### 5.3 Personal learning environment (PLE)

Children learn in many different places – at home, at school, while traveling, or when visiting relatives or friends. Learning does not begin or end at the school gate. But with the advent of digital learning tools and thanks to online communication, sharing and cooperation, the learning that is organised within the school walls is becoming less dependent on a particular time or place. There is thus a need to bring learning together (whether physically or virtually).

The NMC Horizon Report: 2012 K-12 edition (<http://www.nmc.org/pdf/2012-horizon-report-K12.pdf>) introduced the concept of the 'personalised learning environment' (PLE), which describes how learning comes together virtually. The personal learning environment is not a single system that can be purchased ready-made; that would not fit in with the diversity that is a hallmark of everyday life. The personal learning environment is a collection of digital tools that a pupil assembles on his own to optimise his path through instruction. The collection consists of formal (planned or organised by the school) and informal (self-selected, improvised) components.

This may sound rather abstract, but it will become clearer when we describe the various functions of the personal learning environment:

- The pupil, teacher, school, parents and other stakeholders in education need **communication tools** to collaborate during the learning process. The personal learning environment will have different versions of such tools, from WhatsApp groups that pupils set up themselves to free online collaborative environments (for example Google Docs with Hangouts), to formal channels established by the educational institution such as pupil recordkeeping systems, e.g. Magister in secondary education and vocational education. The PLE analyses data on the use of these communication tools to track and evaluate processes and collaboration and, based on this information, makes recommendations for a group's composition, for example.
- To track the learning path (individually or not), it is important to have a **planner** that keeps track of 'where I left off and what my next action should be'. An administrative or portfolio function is needed to record progress and results. Records on results will be formal in nature because of the need for reliability and fraud-resistance. A **portfolio function** would ideally facilitate feedback between pupils on one another's results, which is a very valuable part of the learning

process. Blogs, YouTube video channels and other online publication platforms will play an increasingly important role in this respect. PLEs use the data that has been collected and analysed during the learning process to adapt the learning path, recommend follow-up steps, and advise specifically on suitable resources and other elements designed to meet the individual's needs. Teachers working through a variety of platforms can recognise and validate a pupil's learning with a badge. Meanwhile, the teachers use their own dashboard to keep track of all the products they have assessed, even though they are distributed across the Internet.

- Pupils have all sorts of **resources and tools** to help them acquire knowledge and skills. Some of these will be provided by the school, but increasingly, the resources will be ones that the pupil has found on the Internet, in some cases structured into MOOCs (Massive Open Online Courses). Tools have always consisted of a mixture of school and private property, for example diaries, notebooks, pens and so on. This repertoire will be extended by the BYO (Bring Your Own) concept for devices, Internet connectivity, software and applications (many of them available free of charge) and various types of cloud platforms, as described in the chapter on

the ICT essentials. The PLE can analyse the resources and categories that best meet the pupil's learning needs, based on his or her previous results.

In other words: the personal learning environment is a digital substitute for the old-fashioned school satchel that contains everything that pupils – and teachers – need, although it goes quite a bit further by also linking pupils and teachers. The precise contents will vary depending on the school's educational concept. The emphasis will probably shift away from formal components towards informal ones. Educational institutions can and will focus increasingly on the components requiring formal safeguards. This trend can also be seen in the business sector, where employees do their work and simultaneously pursue lifelong learning. Increasingly, they are thus able to organise their own environment and equip it with tools, support and content, no doubt building on the environment that they assembled during their training.

## SWOT ANALYSIS FOR PERSONAL LEARNING ENVIRONMENT

### STRENGTHS

#### Strengths of the technology

1. The combined formal and informal components clustered in a PLE are diverse and therefore better suited to meet the needs of individual pupils and reflect their experience of the world.
2. With a complete online learning and working environment available, the learning process for a number of learning activities no longer depends on a particular time or location, allowing pupils and teacher to plan, work and collaborate more flexibly.
3. There is plenty of opportunity to share information, resources and results with the environment, or even to involve the environment in the learning process.

### WEAKNESSES

#### Weaknesses of the technology

1. The informal components of the technology are harder to grasp/control. We cannot be certain that these components will remain available; neither do we know how they will evolve in future.
2. A PLE is less standardised and has less structure and fewer formal safeguards than a school environment, increasing the risk of misunderstandings, disruptions and privacy incidents.
3. The (closed) market for formal educational support systems fears competition from informal systems available free of charge. It is therefore proving difficult to create links between informal and formal systems and the necessary open standards.

### OPPORTUNITIES

#### Opportunities for education

1. Where interaction and (mutual) feedback is desirable for the learning process, the PLE – and especially its informal elements – lowers the threshold to participation for pupils.
2. The flexibility and dynamic nature of the PLE also makes it possible to respond quickly to changes in technology and the environment in which education is situated, and to respond more rapidly to society's changing demands (on education).
3. The PLE provides a flexible framework for supporting personalised learning and for adapting facilities to the personal preferences and needs of the individual pupil.
4. Schools can give conscious thought to which PLE functions require formal safeguards; all the remaining functions can be filled by tools that are freely available. This will cut down on the cost considerably.

### THREATS

#### Threats to education

1. The pressure (regulatory and otherwise) in education to perform makes it difficult to adopt the vulnerable, open approach required by a PLE by combining formal and informal components.
2. The PLE is more concept than complete product with specifications and guarantees. It is therefore difficult to 'sell' internally at the educational institution. ICT providers – which often also advise schools – will gain nothing if the school adopts freely available systems, and they will therefore not be keen to collaborate.
3. As the informal part of the PLE expands and the learner becomes more independent, the role, function and added value of the educational institution will be called into question.

## Strategic considerations

■ It is a complex task to develop a long-term ICT policy for an educational institution. The right balance must be found between facilities that are centrally controlled and supplied by the board or back office, and functionality that is ideally set up locally. Needs and requirements should be leading in this process. Administrative systems that furnish accountability vis-à-vis central funding bodies and inspectorates are often set up centrally or in any event standardised; that is the primary aim and therefore where control should be exercised. Applications that support the primary teaching-learning process directly need to be flexible enough to adapt to a specific type of educational programme, to local circumstances, or to the methods that the teaching team has developed. The primary aim in this case requires flexibility at the local level. As long as the educational institution's ICT policy clarifies the need for data-sharing between local systems and central administrative systems, things will work perfectly well in practice. The personal learning environment adds another

dimension to such considerations: which systems should the educational institution itself set up and which ones can it allow teachers and pupils to select and use themselves? The school's ICT policy should once more provide a framework for deciding which ICT services the school should organise itself and which ones it merely needs to oversee or guide. If the educational institution can focus on the need for added value in the interest of supporting the learning process, it will generate more cost awareness and ultimately achieve cost savings in ICT.

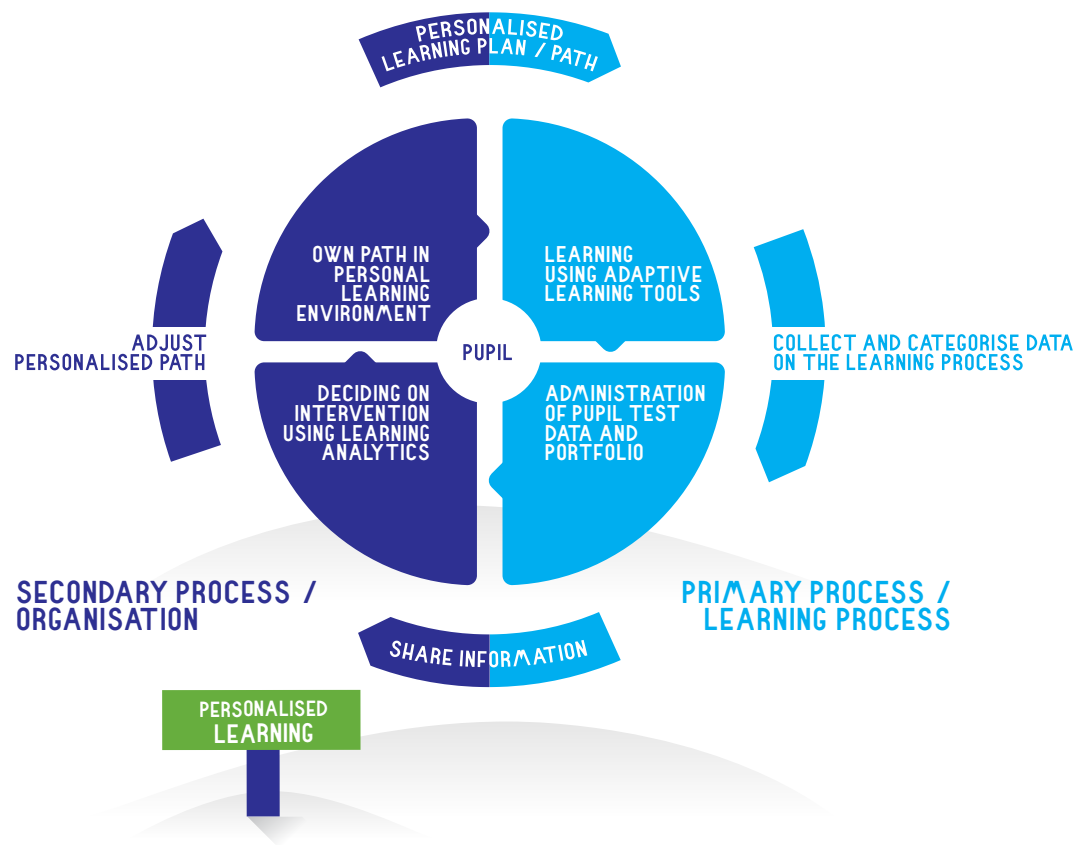
■ The actual effectiveness of ICT applications is subject to critical scrutiny, and rightly so. One common complaint is that ICT does not in fact live up to its promise in terms of reducing the administrative burden or saving time. This is often because ICT systems are not properly coordinated or compatible with one another. When users are left to solve the problems on their own, for example by having to enter the same information twice, it is no wonder that they grow frustrated. That is why it is important

to look at how the formal components connect and work together and – within the context of the PLE – how compatible they are with the most common informal components, such as collaborative cloud platforms furnished by Google, Apple and Microsoft as well as various social media platforms. One requirement when selecting, implementing and delivering new building blocks for the ICT infrastructure is that they should be compatible with the surrounding systems. Where that is the case, there will be no overlaps between systems or any need to restore broken links manually. This sets the stage for ICT that makes a real contribution to education while lightening the administrative burden, saving time, and facilitating a learning process that invites cooperation and mutual feedback.

■ ICT support staff often resist the transition from centralised control to growing freedom for end users in choosing, setting up and using ICT systems. They fear that this will give rise to huge problems and questions that they will not be able to address, given the available staffing levels and resources.

Firm agreements will remove some of these worries, but what is also needed is a change in culture among ICT staff. They are used to being in control of all the available services, but will now have to resign themselves to exercising less control. Nevertheless, they can make an important contribution by offering users expert advice and guidance. The user (teacher or pupil) has more leeway to select and use ICT services in this new situation, leading to a better match with local processes and individual needs.

■ In addition to weighing up formal versus informal ICT applications, the school must also reassess its policy on digital learning tools. Once again, the point is to choose which tools the school will provide itself and which ones it recommends that pupils use (optionally), and to decide how to manage the tools that pupils themselves take along or use during their learning process. For example, pupils are often forced to purchase dictionaries but make scarcely any use of them nowadays. What conclusions can we draw from this?



## Recommended reading

### Mozilla Open Badges

Open Badges can be used by an organisation or individual to recognise and verify learning, either within or outside a formal system.

[openbadges.org](http://openbadges.org)

### Horizon Report 2012 K-12 Edition

Report (2012) by the New Media Consortium on the personal learning environment and its relevance to education (pages 24 - 27).

[kn.nu/horizon2012k12](http://kn.nu/horizon2012k12)

### Technology Enhanced Learning

Wilfred Rubens' blog on the PLE, covering research, personal experience and tooling.

[kn.nu/Wilfred](http://kn.nu/Wilfred)

### E-learning papers Open Education Europe

Research reports and examples of various aspects of PLEs, such as personalised badges and scenarios for location-based learning in smart cities (no. 35, Nov. 2013).

[kn.nu/openeducation](http://kn.nu/openeducation)

### PLE based on Microsoft Sharepoint

Paul Wertenbroek created a PLE based on Sharepoint for SintLucas trade school in Boxtel.

[kn.nu/sintlucasplo](http://kn.nu/sintlucasplo)

## Practical examples

### Personalised digital portfolio

Nieuwste Pabo teacher training college in Sittard uses Simulise for student portfolios that allow authentication through an informal system.

[kn.nu/ervaringengepersonaliseerdportfolio](http://kn.nu/ervaringengepersonaliseerdportfolio)

### Master class on Learning Everywhere

Blog post with presentations and stories about PLEs and how they can be adapted.

[kn.nu/masterclassoveralleren](http://kn.nu/masterclassoveralleren)

### Personal learning environment in vocational education

Description of how three vocational institutions tackled PLE and how they implement it in everyday practice.

[kn.nu/persoonlijkeleeromgevingmbo](http://kn.nu/persoonlijkeleeromgevingmbo)

### Non-formal learning environments

Blog post with examples of non-formal learning environments and how they relate to formal education.

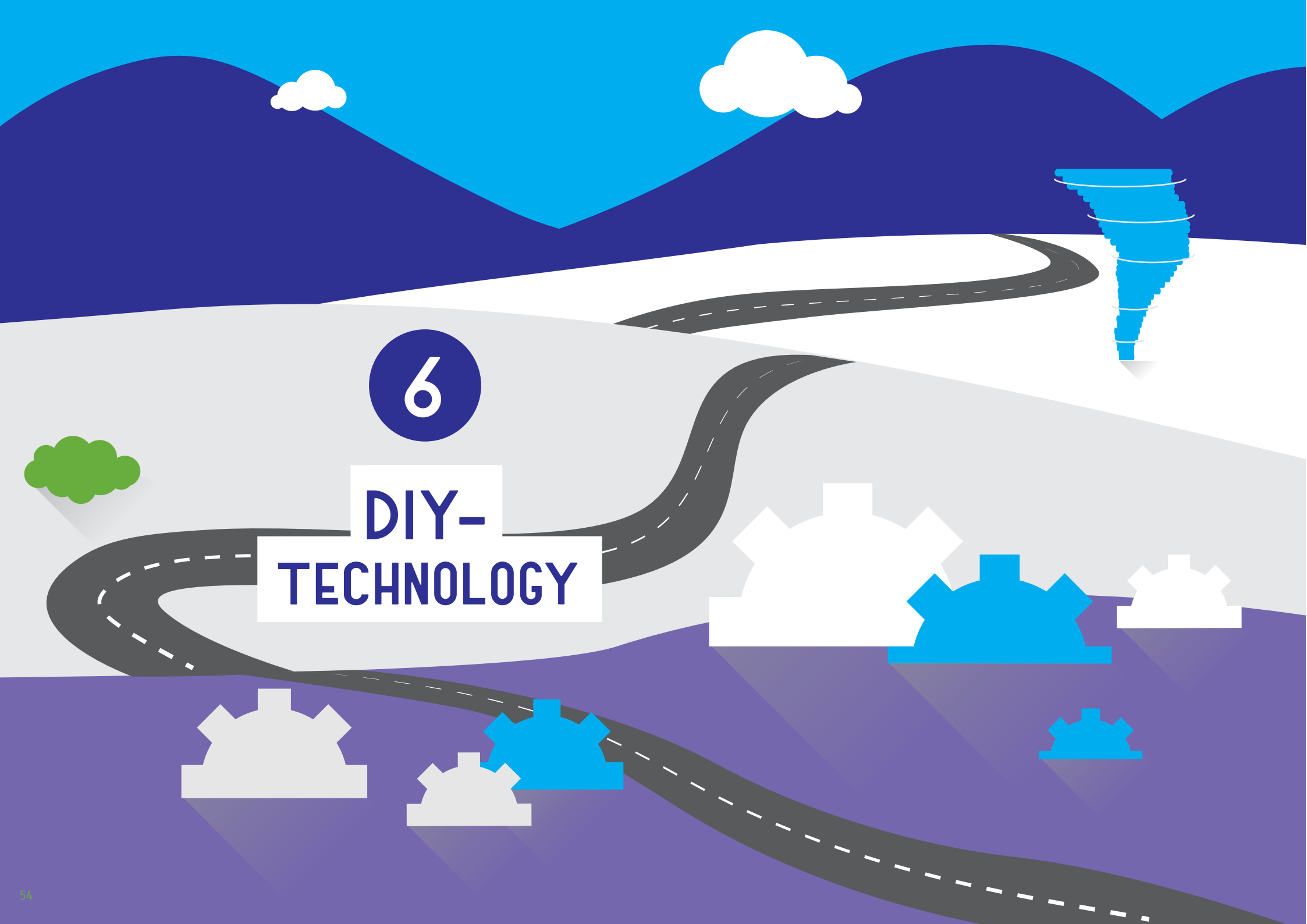
[kn.nu/lerenbuitenschoolom](http://kn.nu/lerenbuitenschoolom)

### Creating a PLE with Symboloo EDU

Pupils at Pontes Comprehensive in Goes transform their webpage of online learning materials into a PLE.

[kn.nu/pontessymboloo](http://kn.nu/pontessymboloo)

These and other examples  
can also be found at  
[kn.nu/voorbeeldenplo](http://kn.nu/voorbeeldenplo).



6

DIY-  
TECHNOLOGY



**Technology has made deep inroads into our daily lives in recent decades. Electronics make many of our everyday utensils and appliances much easier to use.**

Even high-speed trains and automobiles are full of microprocessors, with the interesting side effect that they regularly require 'rebooting' to continue operating. We are growing ever more dependent on technology; at the same time, a worrying gap has opened up between it and ourselves. Technology is no longer something visible and tangible; it is produced in other countries for little money, and our interest in how 'things' work is fading. For example, an iPad is a 'black box' that we use constantly, but we have

no idea how it works: we can't look 'under the bonnet' and change or replace parts, and we're not even interested in doing so. It is becoming difficult to find enough well-trained, technically proficient people to keep our society running; businesses are calling for more engineers and technicians and stressing the need to get young people to enrol in technical training programmes. But young people aren't interested in technology; it isn't 'fun', or 'cool'... How do we break this impasse?

### Learning by making

Fortunately, technology itself is creating opportunities that may turn the tide. Recent years have seen the rise of 3D printers, part of a new trend known as Do It Yourself (or DIY) technology. DIY technology also refers to affordable open hardware such as Arduino and Raspberry Pi, whose freely available specifications allow anyone to copy, adapt or improve them. Even someone without a technical background can buy a toolkit full of electronic components, build a piece of hardware with them, and write the necessary instructions for it to work (known as 'programming'; see below).

Why should that be an interesting development? Well, human beings have always designed and built tools. DIY technology gives us building blocks that allow us to 'tinker' with previously incomprehensible technology and to learn how that technology works. We can design an object and immediately print a 3D model of it to see where it can be improved. And after tinkering for an hour with an Arduino kit and taking a few wires, a circuit board, some sensors and LEDs to build a device that measures the temperature, noise or air quality of their classroom, pupils will look at technology in a whole new way. 'Learning by making' also encourages an enquiring attitude, whose importance was emphasised in the Netherlands'

National Education Agreement 2013 ([kn.nu/onderwijsakkoord2013](http://kn.nu/onderwijsakkoord2013)).

Not every child has to become an engineer, but it would be better for our society if we were less in awe of the technology that is there to serve us, and understood at a basic level how things work and where the weaknesses lie. 'Media literacy' describes a similar attitude, but then with regard to digital media, i.e. information and communication. DIY technology extends this idea by adding the concept of 'technology literacy'.

Some commentators view DIY technology as the overture to the next industrial revolution, a manufacturing industry based on widely available, inexpensive building blocks and the power of the Internet, making it possible for people to develop concepts together and to share designs. It has once again become possible and affordable to design innovative products on a smaller scale and manufacture them in limited quantities. Production of larger volumes can be outsourced at a mere keystroke. The World Wide Web has democratised the publication and dissemination of information; DIY technology does the same for the design and production of physical products.

The main drivers behind DIY technology are the personal needs of people and their inspiration. DIY technology considerably narrows the gap between feeling a need or being inspired by an idea on the one hand and developing it by trial and error into a product or service on the other. The cost is no obstacle. The enormous popularity of smartphones has ensured that sensors are being produced in huge quantities and have therefore become much cheaper. The price of 3D printers is also falling and they are getting easier to use; in only a few years' time, we will be able to print parts and components at home as easily as we now print documents and photographs. Those who cannot afford their own 3D printer or do not wish to purchase one can have designs – whether their own or someone else's – printed commercially. Besides 3D printing, companies such as Shapeways also allow designers to offer objects that they have designed for sale; the company takes the orders, prints and ships them, and the designer takes his share of the profits.

### Learning to program

One big difference between old-style and new-style tinkering is that the building blocks today are actually tiny computers, i.e. microprocessors. Microprocessors collect data using a range of sensors and then use the Internet connection on our mobile phone

(which we always have handy) to send signals by vibration, sound or light to the person or device of our choosing, whether local or remote. Anyone who doesn't tinker with technology can easily get the impression that these computers and sensors are intelligent objects. They are not, of course; they simply execute the instructions they are given by human beings. The process of issuing them with instructions is known as 'programming', and it too can be a creative and challenging component of making things. How do you instruct a device that you have assembled yourself? How do you analyse the data it has collected? At what point (value) should the device perform an action? Under which circumstances should it do so? By trying this out ourselves, we quickly discover how susceptible programming is to human error. We also see that the behaviour of a device is definitely dictated by people.

Once again, not every pupil has to become a programmer, but they should grow into adults who understand how the technology that surrounds them works, so that they think about their role and influence more critically, approach it more critically and use it more creatively.



DO IT YOURSELF



The gap between ourselves and technology can be narrowed if, instead of being awed by it, we have a basic understanding of how it works. We can demystify technology in this way, and help pupils who are gripped by a passion for technology become aware of their talent and interest at an early age. Children will not be drawn to study technology by television adverts but by using their creativity and experiencing the fun of making things with others.

But can children learn to program? Yes, absolutely! There are fantastic tools available for every age, from LEGO WeDo and Kodable to Scratch (developed by the Massachusetts Institute of Technology), GameMaker and Domo.

### The Maker Movement

Beyond education, the 'Maker Movement' has already begun to connect people who enjoy making things with others. That has always been the case, but the new-style building blocks described above and the way the Internet connects people and things have given this movement a new impetus and a new dimension. The Maker Movement is a subculture that operates on the principles of openness and sharing. The underlying DIY technology is 'open source'; in other words, the technical specifications and designs are disseminated openly and can be used free of charge. A person who makes something shares the design with the rest of the world. Another person inspired by that idea can copy the design and modify, improve or elaborate on it without having to ask permission. By making their own modifications, people come to understand things at a deeper level and approach technology in more creative ways.

The Internet thus plays an important role in DIY technology. Applications are shared on such websites as [Instructables.com](http://Instructables.com) and [Makezine.com](http://Makezine.com), lowering the threshold to teachers using them in their lessons. Besides collaborating online, makers also like to get together in real life in 'hackerspaces' (community-operated workshops), Fablabs (fabrication laboratories) and during Maker Faires. These spaces and get-togethers often have 3D printers and expensive laser cutters available for everyone to use. The makers attending share their creations and help one another carry out or come up with new projects.

## SWOT ANALYSIS FOR DIY TECHNOLOGY

### STRENGTHS

#### Strengths of the technology

1. DIY technology is low threshold, thanks to the steep fall in the cost of electronics and to modularisation and miniaturisation.
2. DIY technology is open and conducive to sharing, recycling and modification. These qualities facilitate collaboration and provide abundant examples to build on.
3. DIY technology narrows the gap between people and technology, making technology more personal and more appealing to work with.
4. The nature and openness of DIY technology make small-scale applications possible; makers do not immediately need a huge sales market to get their designs produced.

### WEAKNESSES

#### Weaknesses of the technology

1. Not all DIY technology is cheap. Laser cutters are still very expensive, for example. Widespread application and economies of scale are required.
2. 3D printers and other examples of DIY technology still require users to have considerable knowledge and experience. There is a lot of room for improvement in terms of user friendliness.
3. It takes many hours and close supervision to truly learn to make something ourselves. At first, people tend to focus on copying things or on making minor modifications to existing designs.

### OPPORTUNITIES

#### Opportunities for education

1. DIY technology can be used to familiarise pupils with technology and to learn to use technology in an exciting, creative, tangible and context-rich manner. Technical subjects take on a more vivid quality and are closer to everyday experience and application.
2. Not everyone has to become a programmer or learn how to design and make devices. However, the growing impact of technology on our world underscores the importance of knowing how it works and realising that people can and do control it. DIY technology makes it possible for pupils to see this and learn it for themselves.
3. DIY technology offers a natural means to encourage collaboration, creativity, problem-solving ability, and ICT literacy – in short, the 21st-century skills that we in education wish to focus on. We can also collaborate with local FabLabs and maker communities to develop instruction in these skills.
4. DIY technology provides an excellent basis for multi-disciplinary learning. The point is not to 'learn to make something' but to 'learn something by making'.

### THREATS

#### Threats to education

1. Using DIY technology in education requires an approach that is entirely different from teaching pupils subject matter. The process is very open and unpredictable. The barrier to organising education of this kind is therefore relatively large.
2. Learning to program using DIY technology requires schools to invest in physical components, which must furthermore be stored and managed (broken or missing parts must be replaced).
3. DIY projects can be difficult to mark or quantify. It can be hard to fit them into an educational process that focuses on output-based working and efficiency – in other words, making the teaching-learning process more quantifiable.
4. Teachers who wish to make use of DIY technology must move beyond traditional, theoretical teaching methods. They may need to have knowledge and skills that they lack. This is a barrier to using DIY technology, especially at primary schools, which do not have technical teachers.

## Strategic considerations

- The impact of DIY technology and the Maker Movement on educational challenges is more diffuse than that of personalised learning or efficiency strategies. DIY technology has more influence on the core goals of education because it offers other (and more practical) ways of acquiring knowledge and skills, helps people develop into digital citizens, and encourages young children to develop an enquiring attitude and technical proficiency.
- DIY technology and the Maker Movement principles offer primary education options for redesigning 'arts and crafts' lessons and training in manual dexterity. Secondary education can encourage multidisciplinary learning in this way while covering 21st-century skills such as creativity, teamwork and communication that are closely connected to this form of education. When

pupils work together to make something, they must consult, coordinate, manage conflicts and apply all kinds of knowledge that will only result in success if combined. Skills training is already a priority in vocational education, where educational institutions cooperate with businesses. DIY technology can make skills training more affordable and broaden its area of application.

- As mentioned earlier, this 'new' technology awareness requires a multidisciplinary approach that meets the wish to work on a project basis in education. Maker Faires and the first schools to apply DIY technology have shown that it is possible to connect disciplines in unconventional ways. Creative disciplines can be combined with mathematics and physics using DIY technology.

- Designing teaching methods that make use of DIY technology requires collaboration within teaching teams and possibly (depending on the nature of the educational programme) with local businesses. It is possible to seek support under the Dutch National Technology Agreement 2020 (see [techniekpact.nl/over](http://techniekpact.nl/over)), which is meant to ensure that the Netherlands has a skilled workforce at its disposal with plenty of trained technicians. Help is also available from local maker communities. Another option is for the educational institution to join forces with sister institutions or other partners in the local community to set up a FabLab. This gives all the partners access to expensive equipment (such as laser cutters) and makes professional supervision affordable. If these efforts involve local residential communities at the same time, then the concept of the 'community education centre' will be even more meaningful.

## Recommended reading

### MaKey MaKey

MaKey MaKey is an example of DIY technology at the interface of technology and creativity. Using a kit of clips and wires, children can create an interface from any objects that conduct electricity; for example, they can turn a bunch of bananas into a piano.

[makeymakey.com](http://makeymakey.com)

### Research on Making

Researcher Paulo Blikstein reviews research on the results of Maker education.

[kn.nu/stanfordblikstein](http://kn.nu/stanfordblikstein)

### Presentation by Gary Stager

In this talk, Gary Stager – a leading proponent of DIY technology and maker activities in education – explains the relevance of these trends for education. He thinks the Maker Movement represents the biggest opportunity for education today and the most important step that education can take.

[kn.nu/stanfordstager](http://kn.nu/stanfordstager)

### FabLabs in the Netherlands joining forces with education

This publication by Vedotech provides a list of all FabLabs that can run workshops or other activities specifically for education.

[kn.nu/rotslab](http://kn.nu/rotslab)

### TeachThought resources

Blog listing examples, resources and other materials for DIY technology in education.

[kn.nu/makerresources](http://kn.nu/makerresources)

### Chris Anderson - Makers: The New Industrial Revolution

Chris Anderson, former editor-in-chief of Wired and now CEO of his own DIY Drone company, talks about DIY technology and the Maker Movement.

[kn.nu/andersonmakers](http://kn.nu/andersonmakers)

### Why five-year-olds need to understand what an algorithm is

This blog post explains why the UK has introduced the 'computing curriculum' (with all pupils being taught to program) and describes the main components.

[kn.nu/computing](http://kn.nu/computing)

## Practical examples

### FABklas

The comprehensive school Christelijk College De Populier in The Hague launched FABklas in 2013 in which pupils develop 21st-century skills by making things to their own design. They also learn the way they used to as little children, by allowing their curiosity to lead them.

[fabklas.nl](http://fabklas.nl)

### ArduSat

ArduSat is a satellite running on open hardware for which anyone can program and conduct experiments. Pupils at three Dutch schools developed their own experiments for the satellite that will actually be conducted in space.

[kn.nu/ardusatproject](http://kn.nu/ardusatproject)

### Raspberry Pi Education

The Raspberry Pi is a credit-card-sized computer with full functionality that was developed just for children. It gives children a basic understanding of how computers work and helps them learn to program. The Raspberry Pi blog gives several examples of how this computer is used in learning.

[kn.nu/raspberrypieducation](http://kn.nu/raspberrypieducation)

### FabLab truck

The FabLab truck is a mobile FabLab for schools and events.

[www.fablabtruck.nl](http://www.fablabtruck.nl)

### FryskLab

FryskLab, run by the Frisian Library Service (BSF), operates from a former mobile library. BSF is using FryskLab to explore how using a mobile FabLab in education can help foster the creative, technical and entrepreneurial skills of children and teenagers.

[frysklab.nl](http://frysklab.nl)

These and other examples  
can also be found at  
[kn.nu/voorbeeldendiy](http://kn.nu/voorbeeldendiy).

7

## SMART SENSORS





**Computers still work in much the same way as when they were invented. A processing unit receives instructions (a program) for analysing input and producing output. All computers work this way, no matter how tiny they are or unrecognisable this process may be.**

The three main components of ICT contain microchips:

- processors (of a certain processing speed)
- working memory and data storage
- connections for transferring data

In 1965, Gordon E. Moore, co-founder of Intel Corporation, predicted (in what later became known as Moore's Law) that chip performance would double every two years while costs remained the same. Moore's prediction has proved remarkably accurate since 1965, with the cost of ICT components falling sharply in price as a result. This has led to the rapid development of ICT products and services, for example more powerful, cheaper hardware and 'free' cloud services. The sharp fall in prices has also meant that computers can

be used everywhere, increasingly in less recognisable forms and often invisible to users. Automobiles, household appliances and everyday utensils are becoming 'smarter'. The input for these invisible computers is provided by sensors that can track movement, noise, temperature, and the concentration of certain gases or chemicals etc. We are surrounded by a growing number of computers with sensors; some of them are integrated into devices (smartphones, tablets, laptops and desktops), while others can be found in utensils, clothing and jewellery, and other accessories. The spaces in which we live and work also have sensors, some more obvious than others, that record data.

#### **The Internet of Things**

Virtually all these devices are connected to

the Internet and to one another. A growing number of 'intelligent' devices share their observations, data and analyses with one another across the Internet and perform actions as instructed. This phenomenon is sometimes referred to as the 'Internet of Things'. Examples from everyday life include: automobiles whose windscreen wipers start automatically when it rains, and lights that switch on as soon as it is dusk or when someone passes by. Less common (but perhaps convenient) are smart sensors integrated into elegant armbands that tell wearers when they have been sitting too long at their desk or if their blood pressure is too high, their pulse too fast, their blood sugar level too low, their stress levels too high, or their sleep patterns too irregular. There are also bands that can be combined with smartphones to contact

a physician automatically if certain critical values have been exceeded. And what about a living and learning environment that alerts you to high temperatures, poor air quality, too much noise or insufficient lighting? Or that adapts to your (pre-programmed) wishes or to generally applicable criteria, and that immediately tracks the effects in order to analyse the effectiveness of the environment?

In our analysis of recent and emerging technologies, we focus on two forms that are already expanding rapidly and that we believe offer long-term prospects for education:

**1. Quantified Self:** intelligent sensors collecting data on people's wellbeing and behaviour

**2. Smart Buildings:** intelligent sensors collecting data on the conditions and usage of a building and environment

What advances in personal and environmental smart sensors have in common is that they can take an enormous number of readings of a rapidly growing number of factors and thus record huge quantities of data over the course of a process, event, condition or experience. In the same way as in data-driven education, the collecting of huge quantities of data on human behaviour and performance – and in this case, their environment as well – raises all sorts of questions. On the one hand, we can do wonderful things with that data in terms of detecting problems early on and taking proactive action. For example, we can design an automobile that drives, steers and parks itself. On the other hand, living in a world that keeps constant track of us and intervenes without our asking is a frightening prospect. After all, we human beings treasure our independence and self-determination. In this report, we

have chosen to look at the developments as impartially as possible, without losing sight of the risks. There is good reason for the distant location of the 'smart sensors' technology trend along the ICT route in education: use of this technology is only just beginning, and there are still many questions and uncertainties about it. Initial ideas for potentially interesting uses of this technology in education are discussed in the analyses below.

## 7.1 Quantified Self

Analysts have predicted that the coming year will see the breakthrough of clothing and accessories (for example armbands and wrist watches) that track our daily behaviour and performance and monitor our bodily functions without our noticing or even being aware of it. This is certainly a very interesting development. It can be very motivating to measure performance. We are fascinated by record-breaking athletes, but we're also very proud when we can show we've improved our own performance, whether on a cycling track or in a video game.

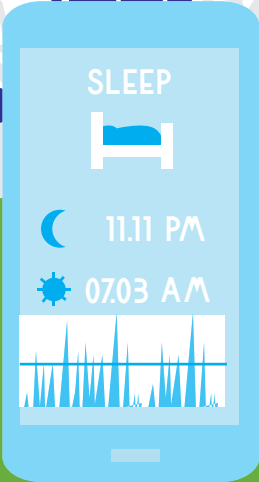
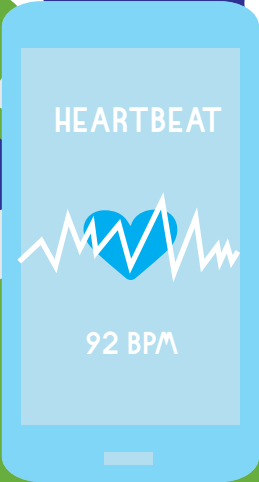
The advantage of Quantified Self applications is that performance tracking takes no effort, requires no separate action, and produces feedback on the spot. We have known for some time that immediate feedback

motivates us to work towards achieving goals that we have set for ourselves. The applications that we have on our phones often collect, categorise and analyse data on our performance the very same day (several times). Such direct feedback influences our conscious behaviour and our ability to stick to our resolutions. Nowadays, we can wear stylish armbands that register our daily pattern of physical activity or sport, or rest or sleep and combine the readings with the numbers on our bathroom scale. If we like, we can receive feedback throughout the day and see the relationship between our behaviour and the consequences. The information is transmitted wirelessly to an app on our smartphone and accumulated over a number of days, weeks or months in the cloud, from where it can be shown on a dashboard on the web or our phone.

Graphics help us visualise our behavioural patterns, physical activity and sleep patterns. In terms of optimising learning, this is very interesting; it allows us to keep track of when we are focused and whether conditions are conducive to concentration. Based on these insights, we can modify our behaviour or the conditions in order to reach a pre-determined goal more easily or quickly, for example exercising enough to keep our bodies fit, resting enough at the right times, or taking the right dose of medication at the

right moment. Quantified Self (QS) generates personal data, but because applications on our smartphone record and process this data, it can easily be shared with others in a closed community or on social media. RunKeeper and Endomondo are applications that make it possible for people to share their running or cycling speed and distance on Facebook. Activity trackers such as Fitbit and UP also have a group function that allows people to compete with their friends, offering support in achieving their weight loss, exercise or sleep goals.

The GOALS study (see [kn.nu/goalsstudie](https://kn.nu/goalsstudie)), which is being carried out by the Open Universiteit of the Netherlands, focuses on the relationship between school performance and how much exercise pupils get. Initial results indicate that girls in particular benefit from physical activity before the school day begins. Girls who cycled to school scored significantly better than girls who were driven to school. There was no difference for boys. These results show that there are many unexpected ways to improve pupil performance.



QUANTIFIED  
SELF



## SWOT ANALYSIS FOR QUANTIFIED SELF

### STRENGTHS

#### Strengths of the technology

1. Sensors are growing smaller, cheaper and more accurate all the time, and can track a growing list of functions.
2. Smartphones already have many sensors that can be combined with a rapidly growing number of applications for QS purposes; the connections between sensors and smartphones are also improving, with lower power consumption and easier synchronisation.
3. Devices that have sensors and their QS applications are getting much easier to connect and combine, for example an activity tracker connected to a bathroom scale. This helps users build a more complete picture of their habits and patterns, reflect on these and modify their behaviour accordingly.

### WEAKNESSES

#### Weaknesses of the technology

1. We now need multiple devices with different sensors to be able to acquire a complete picture.
2. Data collected by different sensors is not always easy to transfer or combine.
3. QS collects sensitive personal data that gets stored in the cloud. Is it safe there, and protected against misuse or unwanted distribution?
4. Sensor readings used to be analysed and interpreted by experts. App programmers and users are not always skilled enough to do this well.

### OPPORTUNITIES

#### Opportunities for education

1. QS technology offers detailed information on a pupil's wellbeing and behaviour. This can be used to optimise and personalise the learning process.
2. QS technology can help pupils and teachers identify the most productive conditions for pupil learning. It also offers pupils an appealing way of examining their eating patterns and exercise habits – obesity being a growing problem in modern societies.
3. QS technology can add a motivational element of competition to behaviour and skills learning.

### THREATS


#### Threats to education

1. QS data are highly personal. Pupils and teachers will have to exercise extreme caution when it comes to sharing such data in the context of education.
2. The technology is still in the experimental stage. There are few real examples of applications, and very little research has been conducted so far.
3. Collecting QS data can be addictive. The point of collecting such data should always be to support effective learning and to optimise pupil performance, not simply to generate data for other purposes or for its own sake.

## Strategic considerations

■ Quantified Self technology is clearly at the start of the hype cycle and will continue to evolve. The applications are experimental and there is, as yet, no evidence that they produce results or benefits. It is too early to think of applying QS technology on a large scale. Most applications appear to be related to fitness and health. Nevertheless, there is a growing awareness of the influence of physiology and mental state on learning. Inclusive and special education may be particularly productive areas in which to track behaviour and mental state in subtle ways. QS technology may allow more children to continue successfully in mainstream education, or perhaps reduce their dependence on special tools and materials. Dedicated experiments are needed to explore the usefulness of the technology and to investigate and identify applications.

■ Even when used on a small scale, QS technology requires us to pay close attention to how we deal with and share data. Measures to protect pupil and teacher privacy must be put into place. Parents must also be made to understand why the technology is being used. If the benefits for their child are clear, they will generally be more likely to cooperate.



These and other examples  
can also be found at  
[kn.nu/voorbeeldenqs](http://kn.nu/voorbeeldenqs).

## Recommended reading

### Keuzes voor de e-coach - Maatschappelijke vragen bij de automatisering van de coachingspraktijk (April 2013)

A technology assessment by the Rathenau Institute concerning the social, ethical and legal impact of using computer technology to teach people healthy lifestyle habits (the 'e-coach').

[kn.nu/keuzesecoach](http://kn.nu/keuzesecoach)

### Effect of exercise and sleep on pupil performance

This study by the Open Universiteit of the Netherlands involves the use of sensors to collect data on the exercise habits and sleep patterns of secondary school pupils and the effect of these on learning.

[kn.nu/celsteceffectbewegen](http://kn.nu/celsteceffectbewegen)

### Quantified Self and education

Presentation by Hans de Zwart, Director of Bits of Freedom, on the relationship between Quantified Self and education.

[kn.nu/dezwartqsvooronderwijs](http://kn.nu/dezwartqsvooronderwijs)

### Quantified Self in clothing

The firm Omsignal is developing a shirt that measures perspiration, heart rate and respiration; the readings can also be shared with others.

[omsignal.com](http://omsignal.com)

### Smartphones and Quantified Self

Smartphones are evolving in a way that makes them increasingly suitable for QS applications. They are being fitted with

special features, i.e. low-energy co-processors designed to read sensors.

[kn.nu/smartphoneqs](http://kn.nu/smartphoneqs)

### Data strategist

Data strategist Joost Plattel discusses self-tracking and what he does with all the data he collects on himself.

[kn.nu/joostplattel](http://kn.nu/joostplattel)

### Learn better with your body as interface

In what way can embodied learning help pupils acquire 21st-century skills such as collaboration and creativity?

Waag Society (Dutch institute for art, science and technology) and Kennisnet have developed an 'embodied learning' system to explore this question.

[kn.nu/waagembodiedlearning](http://kn.nu/waagembodiedlearning)

### Turning mobile phones ON in the classroom to turn them OFF

Can you use mobile phones to get pupils to learn more while having fun? This blog post about Quantified Self explores applications that can make young people aware of their own smartphone behaviour.

[kn.nu/mobieltjesaan](http://kn.nu/mobieltjesaan)

## Practical examples

### How does direct feedback impact pupils?

Ingelotte de Bont (a student of Communication and Digital Media at Rotterdam University of Applied Sciences) explores the impact of step counters/sleep trackers on pupil behaviour at Ashram Comprehensive in Alphen aan den Rijn.

[kn.nu/directefeedback](http://kn.nu/directefeedback) (in Dutch)



consisting of a physical building accounts for a major share of an educational institution's fixed expenses. Smart sensors can assist in more effective capacity planning and utilisation, and in controlling maintenance and operational costs; they can also create conditions in the learning environment that contribute optimally to pupil performance, for example good air quality, lower noise levels and good lighting.

Smart sensors in the physical learning environment can be used to monitor that environment continuously (conditions and usage), analyse the resulting data and make recommendations for adjustments based on that analysis. The adjustments can often be made by computers, within predefined criteria. This process goes one step further than the 'smart meters' that have become popular among consumers anxious to improve the quality of their lives and homes. Such meters may well analyse energy consumption,

for example, but they do not make automatic adjustments.

Smart Building technology can be used in the learning environment to:

- gain a detailed picture of a building's energy consumption, automatically take action by switching lights on or off according to room use and available schedule, and recommend improvements in capacity utilisation and other optimisations
- adjust room heating automatically based on weather forecasts or scheduled room usage
- continuously monitor a room's air quality and take action automatically if it falls below a certain standard (there are various studies showing a relationship between air quality and concentration; opening a window at the right moment can already make a difference)
- provide long-range data on the actual use of a building's rooms versus the schedule and on the effective utilisation of a particular

type of room (number of people present, type of activity, use of facilities).

Smart Building technology can be easily integrated into new school buildings, but it can also be installed in existing ones. Smart Building technology often works on a low-energy wireless network that operates independently of the existing wireless Wi-Fi. Low-energy wireless networks are designed to work optimally with such systems, which are part of the Internet of Things.

One interesting way to combine behaviour and room utilisation tracking is to use smart sensors to measure processes and interactions at work and come up with interventions in the room that promote collaboration. For example, Sociometric Solutions has developed a device that measures interaction between people in a room. The sensor tracks the number of interactions, physical and vocal social signals,

and the physical space between persons in the room. Using this data, interviews with the people wearing the sensors, and a general picture of the daily work patterns, the company can advise on how to position the occupants' desks or other workspaces in order to increase productivity or

collaboration. A better understanding of group behaviour and how it can be improved would also be very interesting in educational contexts.

## SWOT ANALYSIS FOR SMART BUILDINGS

### STRENGTHS

#### Strengths of the technology

1. Smart Building technology allows for the systematic analysis of environmental conditions (indoor climate) and building utilisation so that proactive measures can be taken automatically, for example in the case of wasted energy or poor air quality.
2. It analyses actual capacity utilisation of rooms and facilities and compares this to planned utilisation.
3. It monitors the status of machinery used in the learning process and detects problems at an early stage before they escalate or malfunctions occur.

### WEAKNESSES

#### Weaknesses of the technology

1. Smart Building technology requires complex investment choices that need to be closely coordinated with the school's long-term accommodation policy.
2. The technology must be at the service of people; automatically controlled facilities can make a building feel cold and impersonal.
3. The danger is that people will come to rely too much on the system. When it comes to deciding how best to use a building, the most important factor is the people and not the technology.

### OPPORTUNITIES

#### Opportunities for education

1. Smart Building technology saves on maintenance and utilisation costs by promoting more efficient capacity and facilities utilisation.
2. It improves the learning climate by monitoring conditions proactively.
3. It can provide personal feedback on how a learner uses machinery without the instructor needing to be physically present.
4. Smart sensors help analyse group processes and the effectiveness of a physical space for learning by tracking social interaction.

### THREATS

#### Threats to education

1. Smart Building technology requires an investment in advance that will only produce dividends in the longer term. It is difficult to estimate what the long-term return on investment will be.
2. By coming to rely more on systems, their measurements and automatic adjustments, schools may find their independence undermined and relinquish some of the flexibility that they need in everyday practice.
3. If data tracking is faulty, system integration (for example between roster systems and heating and lighting) can lead to irritation and put unwanted strain on people.
4. The use of sensors in the primary teaching-learning process is still in its infancy. There has been little practical evidence of the impact of technology on learning and organisational processes.

## Strategic considerations

■ Smart Building technology makes it possible to adapt a building (an important and expensive condition for a safe learning and working environment) to support the learning process. It can do this by tracking and improving the building's efficiency systematically and by monitoring its compatibility with the learning processes taking place there every day. For example, touch screens next to the door allow users to confirm that they have reserved a room or – if the room is available – to reserve it on the spot. In that way, rooms that have been reserved but are not in use become available and reservations can be made at the last minute without putting an extra burden on administrative staff.

■ The trend towards personalised learning often leads to educational institutions looking at their buildings and premises through new eyes and considering how to adapt them to this new approach. Smart Building technology can track whether existing buildings suffice so that a set of specifications can be drawn up for a new building. It can also help determine how a new, flexible building can best facilitate the teaching-learning process, for example not only how rooms are utilised but also how pupils, instructors and facilities can be accommodated to encourage collaboration and communication.

■ A more direct form of application in education is the use of smart sensors to track and record the learning process in order to provide feedback and evaluation later. This is particularly interesting in practical training; instructors do not need to be present at all times to observe how pupils adjust and use machinery. By tracking this with room or machinery sensors, pupils and instructors can 'replay' what the pupil did later and evaluate how effective his or her actions were and where they can be improved.

## Recommended reading

### ICT energy efficiency in higher education, continuous measurement and monitoring (November 2011)

This SURFnet publication, produced by Novay, recommends strategies for real-time and continuous measurement of the energy consumption of ICT systems.  
[kn.nu/ictenergyefficiency](http://kn.nu/ictenergyefficiency)

### Schools not exploiting opportunities to save on ICT

A quick scan conducted by SME at the request of Kennisnet shows that there are many ways for schools to cut costs by being smart about energy consumption. Smart meter technology is given as an example.  
[kn.nu/besparingskansict](http://kn.nu/besparingskansict)

### Sociometric Solutions

Cases in which sensors are used to increase interaction between colleagues and optimise rooms for that purpose.  
[sociometricsolutions.com/cases](http://sociometricsolutions.com/cases)

### The Impact of School Buildings on Student Health and Performance

Summary dating from 2012 of what we know about school building climate and the impact on pupils' health and performance.  
[kn.nu/impactschoolbuildings](http://kn.nu/impactschoolbuildings)

## Crowdfunding and Smart Building technology

Crowdfunding sites are full of Smart Building technology projects. This blog features a small selection.  
[kn.nu/crowdfundingsmartbuildings](http://kn.nu/crowdfundingsmartbuildings)

### Smart Citizen Kit

DIY technology tools can use open hardware to monitor the indoor climate. The data can be shared online. This kit monitors temperature, humidity, carbon monoxide, carbon dioxide, light and noise levels.  
[smartcitizen.me](http://smartcitizen.me)

## Practical examples

### SchoolVision

Information on a dynamic lighting system that can be adjusted to suit pupil activity, targeted behaviour and work attitude. Includes the case study of a primary school that makes use of this system.  
[kn.nu/schoolvisionenglish](http://kn.nu/schoolvisionenglish)

These and other examples  
can also be found at  
[kn.nu/voorbeeldsb](http://kn.nu/voorbeeldsb).

# Afterword

I can't count the number of times I've heard people proclaim 'ICT is only a tool'. I must admit that I find this quite tiresome at times. Learning is obviously the main priority in education; pupils and their teacher are obviously the most important factors, and not buildings or other tools - whether we're talking about pen and paper, or fingers and tablets.

But what people who proclaim that ICT 'is only a tool' don't seem to realise is that ICT is the driving force behind many of the important changes taking place in our society. Its impact is similar to that of the steam engine, which launched the industrial revolution. ICT is changing both how we deal with information and how we communicate with one another beyond recognition.

Learning involves making information meaningful; learning involves conversation and mutual communication; above all, learning also involves learning how to learn. In my view, information and communication technology will therefore bring about radical changes in the way we approach learning, and thus in the way we design education. That calls for more commitment than using it as 'only a tool'.

Will pupils be entering school buildings en masse carrying their own tablets and permanently connected to the Internet? Will pupils do much of their learning outside the school, using rich

online learning environments that feature the international stars of the teaching profession? Will pupil data (whether formal or informal) on behaviour and wellbeing provide the basis for more personalised learning, with individual learning requirements as the starting point? Will that cause pupils, parents, teachers and schools to cooperate in very different ways? The answer to these questions is 'Yes, beyond a doubt!'.

But that does not explain how we can incorporate these trends into innovative education, and how we can get to that point safely, departing from the current situation. On top of all this, there is often a general resistance to change - and it is precisely in education that we should be careful about launching major changes too quickly. After all, it is our children who will be affected.

But let's not confuse challenges when discussing responsible change. The current debate about tablets in education reminds me of a quote from a 'Teachers Conference' dating from 1703: 'Students today can't prepare bark to calculate their problems. They depend upon their slates which are more expensive. What will they do when their slate is dropped and it breaks? They will be unable to write.' Similar statements from subsequent centuries bemoan the fact that pupils are unable to mix ink themselves anymore because they can buy it ready-made, or lament the wastefulness of throw-away ballpoint pens.



Things are no different in the ICT industry. I am reminded of what IBM CEO Thomas Watson allegedly said in 1943 (when computers still took up entire floors): 'I think there is a world market for maybe five computers'. He would have scoffed at the idea of a computer in every home. And not long ago, people said 'Banking on the unreliable Internet? That's irresponsible!' Such opinions make us realise how difficult it is to forecast what the future will bring and whether something will eventually turn to be a trend – or a hype.

The demands being made of good education – by parents, children, government and the labour market – are changing rapidly. Technology, and specifically ICT, is evolving at lightning speed.

The aim of this trend report is to support educators in giving shape to innovative education by reviewing developments in ICT and identifying priorities based on research. The SWOTs and recommendations accompanying our description of each technology trend are meant to help readers size up the possibilities and impossibilities of information technology, which is expected to play a major role in the next five years and that may help us tackle key challenges in education.

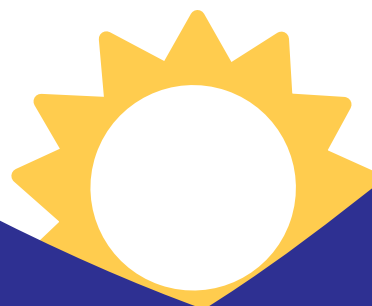
This report is intended to spark discussion within educational institutions and among school administrators regarding a long-range policy on ICT. It should offer them a framework for informed decision-making about the contribution that ICT will make to achieving their own vision of education, their ambitions and their aims. Kennisnet would like to be part of that discussion and welcomes good practical examples that it can publish online and share with others in education.

I would like to end this afterword by expressing my sincere thanks to the many administrators, school boards, teachers and pupils, and to the Ministry of Education, sector organisations and our think tank, #4T2. They have all provided important input, ideas and advice.

I hope your work in education brings you much wisdom, insight and enjoyment!



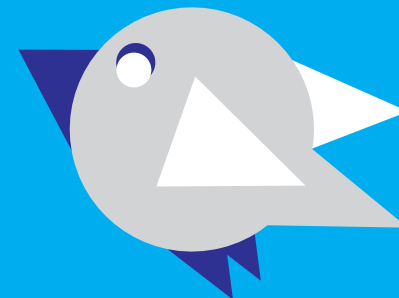
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Comments are welcome on Twitter  
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Or e-mail us at **[innovatie@kennisnet.nl](mailto:innovatie@kennisnet.nl)**.



# About this publication

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*Kennisnet is the public educational organization which supports and inspires Dutch primary, secondary and vocational institutions in the effective use of ICT.*

*Kennisnet ensures that educational institutions are aware and take advantage of the opportunities offered by ict. Research has shown that, for the use of ICT for educational purposes, a balanced and coherent use of four building blocks is essential. These blocks are: vision, expertise, digital learning materials and ict infrastructure. Kennisnet facilitates the schools to achieve this. Barriers are removed and the strengths of the educational sector are bundled together.*



**Kennisnet. Let ICT work for education**

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