i-Learn PAPER 4

Dashboards in EdTech: from analysis to implementation

Reference

i-Learn team. (2022). *i-Learn paper 4: Dashboards in EdTech: from analysis to implementation (4)*. i-Learn. URL

The i-Learn papers have been made possible by the complete i-Learn team, consisting of members of the imec, itec & KU Leuven consortium.
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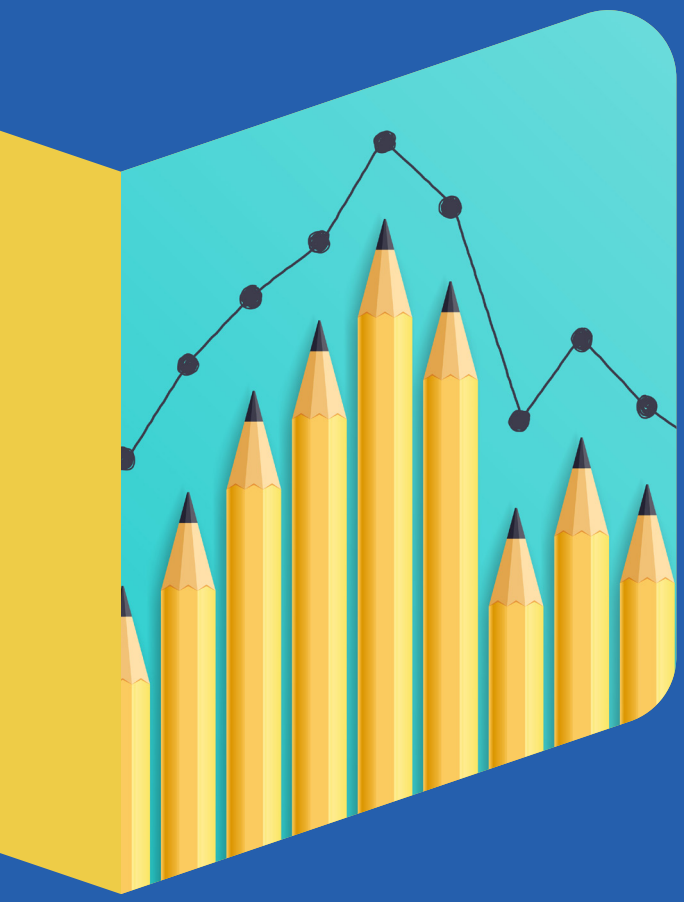
Contents

Introduction and background

The i-Learn project was made possible by the Flemish government, KU Leuven and imec.

The i-Learn papers originated from the eponymous project on digital personalized learning, commissioned by the Flemish government. The project started in September 2019 and ran until June 2023. With the i-Learn project, the Flemish government aims to focus on the responsible and sustainable use of technology and help teachers to implement personalization in Flemish primary and secondary schools.

The i-Learn project facilitates personalized, tailor-made learning for each student using existing digital tools that are made available in an easily accessible manner. The tools can be combined in learning tracks to support daily teaching practice and to offer tailored learning content. This supports the teacher without increasing the burden of planning. Learners also gain more insight into their learning process on the i-Learn portal, along with ways of participating in the process. In addition, there is a focus on the professionalization of teachers and the broadening of the Flemish educational technology (EdTech) sector.



The expertise we acquired during the design, development and evaluation of the i-Learn project is now being recorded and disseminated through the i-Learn papers.

THE PURPOSE OF THIS i-LEARN PAPER

This i-Learn paper explains what **learning analytics dashboards (LA dashboards)** are, what information they present, what they look like, what value they can add for teachers and learners, how teachers and LA dashboards can work together, and the role of teachers in this. These aspects are explained theoretically and illustrated with examples. There is an appendix at the end of this i-Learn paper with an overview of the development of i-Learn's LA dashboard.

The following questions are answered:

- What are LA dashboards?
- What data can be presented on LA dashboards? How can this data be presented?
- What is the added value of an LA dashboard for teachers and for learners?
- How can a teacher use an LA dashboard? How can a teacher work together with an LA dashboard?
- What ethical considerations should be taken into account when using LA dashboards?
- What is an actionable dashboard? What are its advantages and disadvantages?
- Case study: how did i-Learn's LA dashboard come about? How is it used? What does the current i-Learn dashboard look like and what features does it have?

WHO IS THIS FOR?

This document has been compiled with the aim of sharing knowledge and insight with people interested in digital personalized learning and in EdTech in general. The information is especially relevant for people who use personalized learning in practice and want to know more about LA dashboards and how to develop them. The following professional groups can find added value here: developers, web designers, school leaders, IT coordinators, researchers, policy workers, teachers, stakeholders and other interested parties. Each i-Learn paper provides insight into the acquired expertise and evidence-based practices that were collected during the development and implementation of the i-Learn project.

1. What is a learning analytics dashboard?

In today's educational landscape, a wide diversity among learners in terms of existing knowledge, motivation, socio-economic status, languages spoken at home, etc. is creating new challenges. At the same time, thanks to technological progress, there are new opportunities to offer learning content tailored to learners using digital tools. This 'digital personalized learning' is promising because research shows that it can increase the motivation of learners, lead to better learning outcomes and stimulate learners' self-regulating skills (Joos & Meijdam, 2019; Orbán & Woertman, 2011).

Alongside interactive tasks, digital tools increasingly include an LA dashboard. While using these tools, a lot of data is collected about the learners and their interactions with the learning resource. This data often contains more information than the teacher could observe or record in a traditional lesson. Among other things, the data includes what learners are doing at any particular moment, how long they are spending on tasks, what information they have already received, what exercises they have already done and whether their answers were right or wrong, and what they have clicked on. Smart algorithms can perform analyses of this data and generate information that can be used to support the learning process. This collected information is then presented to the teachers and learners (and the developers of the digital tool) on an LA dashboard. For more insight into *Learning Analytics*, see i-Learn paper 3: Learning Analytics

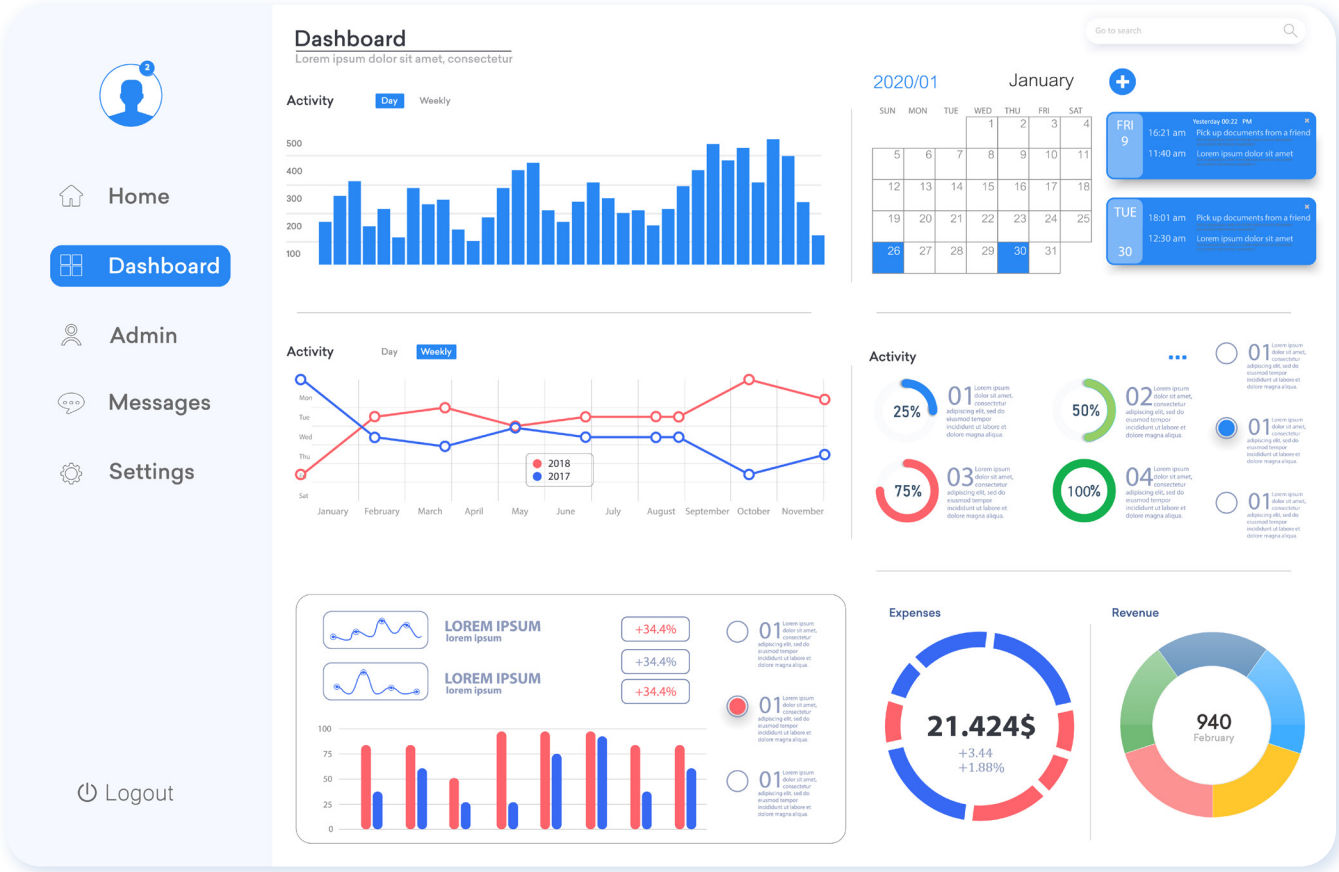
An LA dashboard is

> a single display that brings together different indicators about a learner or learners, learning process(es) and/or learning context(s) in one or more visualizations.

(SCHWENDIMANN ET AL., 2017, P. 37)

Considerable attention is paid to the design of LA dashboards as components of digital tools. Figure 1 is a fictional example of an LA dashboard. By converting data into **visualizations** and **information,** the teacher can gain insight into the learning process of learners. Commonly used visualizations include pie charts, bar charts, graphs and percentages. Often it is **"real-time" information** that is presented. Developers think carefully about what information should be presented to teachers and learners and how that information can remain clear.

FIGURE 1: Fictional LA dashboard. Purchased on iStock.



LA dashboards can provide information about both the **learning process** (e.g. time spent, number of exercises done) and the **outcome** of the learning (e.g. learner progress, learning goals, test results). This summarized information about the learner(s) can be used for **formative** monitoring and/or **summative** evaluation.

2. Diversity in LA dashboards: information for developers

Today, most digital tools have an LA dashboard. Developing an LA dashboard is complex, given the many choices that have to be made regarding which data is used and how it is converted into information. Furthermore, great differences between teachers can be expected in terms of how they teach, and therefore what information is useful for their classroom practice. Hence there are major variations between LA dashboards in practice. When designing an LA dashboard, decisions must be made regarding the **content (data)** and the **visualization aspect (design)**. This leads to two crucial development questions:

> "**Exactly what data will be presented?**" and
>
> "**How will the data be visualized?**" (Schwendimann et al., 2017)

To answer these two questions, developers (or researchers) must initially explore all possibilities. What do teachers need? What data is logged? What data is useful? How can this data be presented so that teachers can interpret it without much effort? The purpose of the LA dashboard also plays a decisive role in its development: how do the teachers want to use it? What exactly do they want to use it for (Schwendimann et al., 2017)?

In order to create more clarity within this range of possibilities, Schwendimann et al. (2017) and Van Leeuwen and Rummel (2022) have developed a way to classify LA dashboards, summarized in **six categories**: 1) the data sources used, 2) the types of indicators, 3) the target group and purpose of the LA dashboard, 4) the pedagogical approach, 5) the degree of automation, and 6) the data visualizations. The first five categories answer the question "Exactly what data will be presented?" and the last category answers the question "How will the data be presented?"

FIGURE 2: Six ways to classify LA dashboards.

Please note: Figure by Artoos group, based on information from Van Leeuwen and Rummel (2022) and Schwendimann et al. (2017).

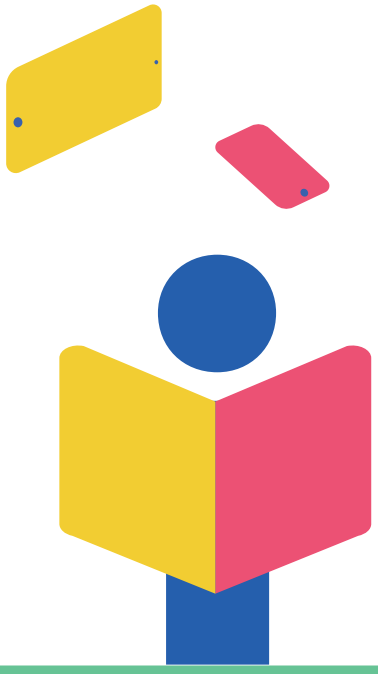
2.1 DATA SOURCES

Different data sources can provide the data for LA dashboards. These are rarely all included in the same LA dashboard, but combinations of data sources are often used to generate more insight into the learning process (see 'in-depth diagnosis' in *4.2 Role and skills of the teacher when using LA dashboards).* The various possible data sources are listed below:

Computer logs: what learners do in the learning environment leaves traces, which can be saved. This can include signing in, clicking buttons, opening videos or exercises, the answers entered, time spent, and so on. These are all actions that are automatically logged by using the digital learning tool. Computer logs are also often used to look at any tools that learners use during their learning process, such as when they make use of intermediate steps in a mathematics exercise or ask for a hint during a task.

Learning objects: these are things that learners make or fill in while learning, e.g. notes, homework, tests, but also data from social interactions such as blog posts, forums, Twitter, answers to questions, requests for help and comments.

Information that is requested from learners, for example by means of questionnaires. Learners may be asked to report what they thought of the learning material they have completed or how they would evaluate their learning progress so far.

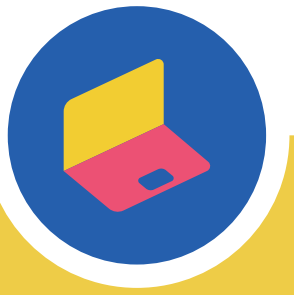


HOW DOES IT WORK IN I-LEARN?

In the LA dashboard of i-Learn MyWay, for example, at the end of a learning track, learners are asked to rate themselves on a scale in relation to the learning objectives set (e.g. 'I can explain the water cycle' is scaled from 'not at all' to 'completely'). The teacher can then combine this information with any results of exercises or tests to see whether the learners have insight into their own abilities.

Sensors: Sensors can measure physical user activity such as body temperature, heart rate and eye movements.

Other data sources include external tool data (APIs), the institution's data files, and data tracking, where data is collected using cameras, microphones, depth sensors, application logs or manual reports (Bodily & Verbert, 2017; Bodily et al., 2018; Schwendimann et al., 2017; Verbert et al., 2014).



The content data most often presented in LA dashboards is:

1. Use of (auxiliary) resources
2. Time spent
3. Assessment data (right or wrong)
4. Data from social interaction

(SCHWENDIMANN ET AL., 2017).

All this data can be brought together in a raw dataset by the data manager. Teachers or learners will never assemble or use this raw dataset themselves. In the LA dashboard, this data is already bundled for them and presented clearly using text, percentages, tables, maps or graphs.

2.2 TYPES OF INDICATORS

A second way to classify LA dashboards is based on the collected data that is presented. Schwendimann et al. (2017) discuss six different 'indicators' that can be used to enable **interpretations and arrive at useful information**:

'Learner-related indicators' provide information about a learner, such as their age.

'Action-related indicators' show exactly what a learner does during learning, such as the number of minutes they spend on an exercise.

'Content-related indicators' are about the content that a learner creates themselves or the content with which they interact during learning.

'Result-related indicators' provide information about the outcomes of a learner's activities, such as the score that they achieved in an exercise.

'Context-related indicators' show the context in which learning takes place, such as how a learner compares to their classmates, but also, for example, how the learner feels during learning. For instance, teachers can present 'feeling samples' to their learners to promote social and emotional learning (SEL).

Finally, **'social-related indicators'** provide information about the interaction *between* learners during learning. This may involve communication in a group forum, for instance (Schwendimann et al., 2017).

2.3 TARGET AUDIENCE AND PURPOSE OF THE LA DASHBOARD

A third way to classify LA dashboards is based on their audience and purpose. In the educational context, the target group often includes teachers, learners, any third parties such as parents, administrative staff, SEN (special educational needs) teaching assistants, researchers, etc. Each profile requires a different LA dashboard with different accents, which often makes LA dashboards very different from each other in terms of interface and content. For example, an LA dashboard **for learners** is likely to contain little information, as its users mainly need to monitor themselves so that they can develop their self-regulatory skills. They will see their progress and overall assessment data, for instance (Schwendimann et al., 2017).

An LA dashboard **for teachers,** on the other hand, aims to allow its users to monitor multiple learners. While it provides information for each individual learner, it will also include an overview with a list of all the learners in the class (with 'general' information, such as their name, the exercises they have done and their scores). The LA dashboard for teachers can also provide summarized information such as

'5 out of 13 learners scored higher than 60% on this test.' Furthermore, it can be useful for teachers to compare different learners who are doing the same exercise at the same time. Comparisons can even be made with learners from previous school years who did the same exercises (Charleer, 2017; Jivet et al., 2018; Schwendimann et al., 2017).

An LA dashboard **for parents** will only show some of the monitored information – just enough to give its users an overview of how their own child is doing in class. An LA dashboard **for administrative staff** is intended for its users to keep track of administrative matters, such as the progress and success rate of all learners in a class or school year (Verbert et al., 2014).

2.4 PEDAGOGICAL APPROACH

Different pedagogical approaches can lead to different LA dashboards. **A first type of approach** has to do with **when** the teacher will use the LA dashboard:

- LA dashboards with **real-time** information are intended to be used **during the lesson** and focus on visualizations that give an overview of the learners' progress at a glance, or that interpret data from sensors and give feedback in various categories to the teacher during teaching (Xhakaj et al., 2017).
- LA dashboards without real-time information are more likely to focus on the analysis **after the lesson**, so that the teacher can look back on the lesson and see what has happened on the platform. The teacher can also use these analyses to prepare future lessons. The visualizations will thus focus on summaries and pattern recognition, and will contain more details that the teacher can study more closely, at their own pace (Garrison & Kanuka, 2004; Graham, 2006; Molenaar & Knoop-van Campen, 2018; Verbert et al., 2014; Xhakaj et al., 2017).

A second pedagogical approach has to do with **the structure of the lesson** in which the teacher plans to use the LA dashboard.

- **When used during instruction and individual exercises in the classroom**, the teacher can get real-time information about how attentive learners are, whether they have a question, how much progress they have made, whether they understand the task, and so on. Data on how attentive learners are can be collected using sensors, for example. This info can help the teacher to take appropriate follow-up pedagogical action, such as providing support to learners who do not understand a task (Verbert et al., 2014).

- **When used during face-to-face group work**, the LA dashboard will focus on classroom orchestration and support the teacher in managing group work. Real-time feedback can be used by a teacher to assess group dynamics or to provide more targeted help to groups. Furthermore, LA dashboards can make suggestions about group composition based on the data collected (Verbert et al., 2014).
- **When used during blended learning**, which is a combination of face-to-face and online learning, the LA dashboard supports the teacher in differentiating and monitoring progress. The teacher can use the LA dashboard afterwards, or to prepare a lesson, but real-time data is also useful during the lesson to see what the learners are doing. The teacher can check which learners have started which exercises, which ones might be working more slowly than the others, and which are making a lot of mistakes or, conversely, hardly any mistakes. Afterwards, the teacher can dig deeper into this data, to try to find out exactly what difficulties certain learners had (Garrison & Kanuka, 2004; Graham, 2006).

A third pedagogical approach is to consider **the level** at which and **the period of time** over which the teacher wants to monitor the learner. The following questions can then be taken into account:

- **The level**: does the teacher want to follow individual sessions of an individual learner, or see a global overview of all learners?
- **The period of time**: Is it the intention to monitor the learners for one session, during an entire course, over several semesters or even over several years?

HOW DOES IT WORK IN I-LEARN?

In i-Learn MyWay, the teacher can follow the progress of the learners in real time and thus see whether there are learners who are moving too quickly, or conversely too slowly, through a learning track. If the teacher suspects that something is not quite right with a learner's progress, they can check whether the learner has understood the assignment or the teaching material correctly. The i-Learn MyWay LA dashboard also takes into account the need for analysis during lesson preparation, or for post-lesson reviews. Thus, data is also presented that the teacher can use to recognize patterns, monitor learners in the long term, etc. Appendix 1 provides more information about the i-Learn MyWay LA dashboard.

2.5 DIFFERENCES IN AUTOMATION

The amount of **artificial intelligence (AI)** that is incorporated into an online tool will affect that tool's LA dashboard. Various developments in AI have already made it possible to support more of the tasks that the teacher performs (Major & Francis, 2020; Molenaar, 2022).

Van Leeuwen and Rummel (2022) distinguish four types of LA dashboards:

Mirroring LA dashboard: With a low degree of automation, the LA dashboard will perform the task of collecting and processing data about the learners and will show this information to the teacher (in a summative form). Every interpretation of this data and every decision about what action to take is made by the teacher (van Leeuwen and Rummel, 2022).

Alerting LA dashboard: With partial or conditioned automation, the algorithm can check the activities of the learners for deviations from a predefined standard and can then indicate this to the teacher through the LA dashboard (Van Leeuwen and Rummel, 2022).

Advising LA dashboard: This goes one step further and provides additional advice on how the teacher can best interpret the current data/situation. Some LA dashboards have more complex features that give recommendations to teachers or learners, for example. Such recommendations are made using an adaptive algorithm based on learning analytics. For more information on recommendation systems and how they work, see i-Learn paper 3: Learning analytics (Van Leeuwen and Rummel, 2022).

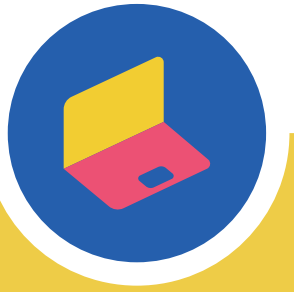
Intervening LA dashboard: With full automation, the algorithm will take over the entire process and will automatically make interventions to support the learners (see also below: 4.1 The six levels of automation). The learning environment will then offer or propose exercises, learning content or methods for each learner, based on the needs that emerge from the data analysis. So the interpretation of the data and the decisions on follow-up actions are made and carried out by the algorithm and the LA dashboard (Van Leeuwen and Rummel, 2022).

2.6 DATA VISUALIZATIONS

A sixth and final category concerns **the visual aspect** of an LA dashboard. There are different ways to present the data visually, depending on the information at hand. The golden rule is that the LA dashboard overview **must be quick and easy to interpret**, both for teachers and for learners. They should be able to understand the relevant data at a glance. LA dashboards with a lot of different visualizations, such as multiple graphs, numbers, percentages, etc., are overwhelming. Deliberately selecting one or a few of these visualizations is therefore better. Using colours, such as green, orange and red, can also be helpful. In general, if too much is going on in the LA dashboard, it is too time-consuming to read everything, and teachers will stop using it. One way to bundle together a lot of information is by incorporating multiple screens into the LA dashboard so that the user can click through to them. Then the teacher has a brief initial overview with the most relevant information and can click through if they want more information (Few, 2006).

FIGURE 3: Different data visualizations. Purchased on iStock.

According to Schwendimann et al. (2016), the most common visualizations consist of bar charts, line graphs, tables, pie charts and network graphs. Within education, overviews of classes are often given, but there are also overviews of individual learners and overviews offering insight into the difficulties surrounding a specific exercise. Then the teacher can, for example, filter by class, specific student or specific exercise to get an overview of just that.



So every LA dashboard developer has to make a whole series of decisions. It is essential for EdTech developers to think carefully about the five categories above before implementing an LA dashboard. What data is available and from what sources? Who are we making this LA dashboard for? What do we want to achieve with this LA dashboard? How do we want teachers/learners to use this LA dashboard? Which visualization do we want to use, and which overviews do we want to present?

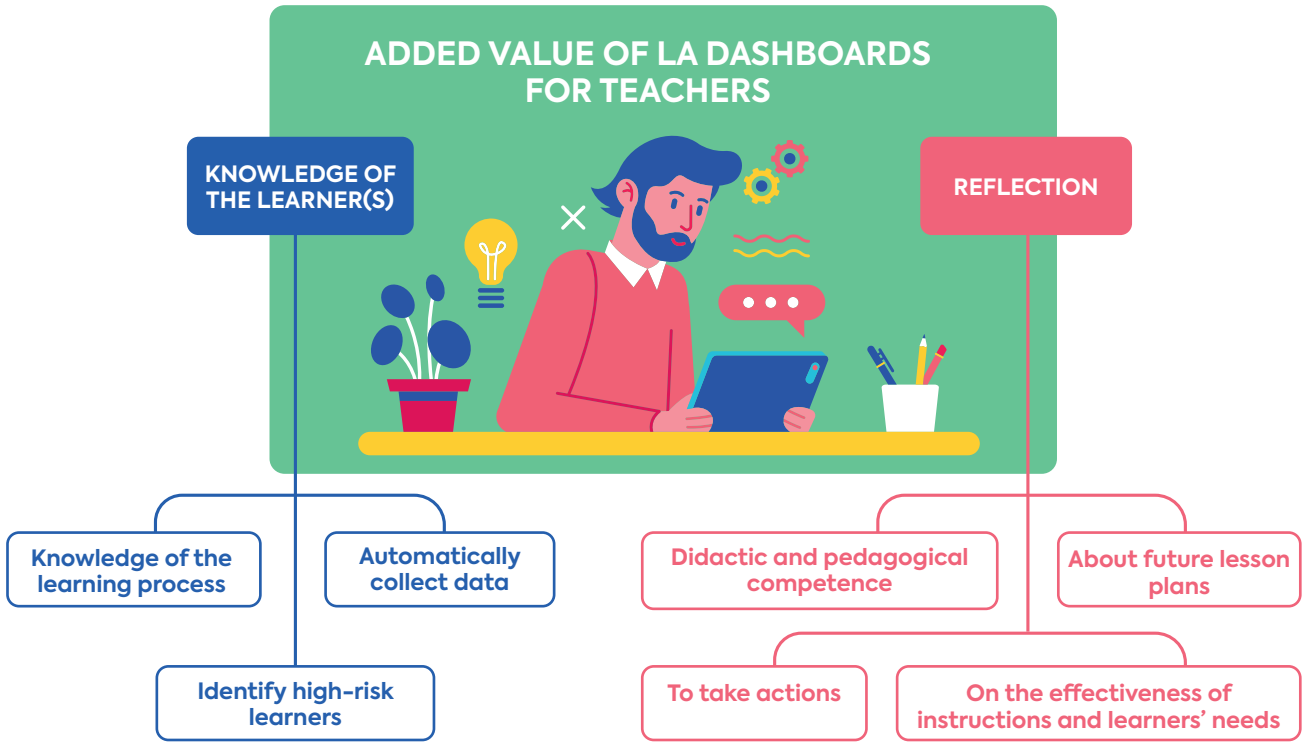
3. The added value of LA dashboards

LA dashboards can deliver high added value to teachers and learners. In the following sections, we delve deeper into the potential benefits of LA dashboards when it comes to supporting teaching and raising educational quality. However, the extent to which their potential is unlocked depends on the quality of the LA dashboard, as well as many characteristics of the school, teacher and learning, such as the level of IT skills among teachers and learners and their attitudes towards data. The presence of an LA dashboard does not guarantee that it will actually be used, or used correctly, or that it will prove worthwhile (Mavrikis et al., 2022; Van Leeuwen and Rummel, 2022).

3.1 THE ADDED VALUE OF LA DASHBOARDS FOR TEACHERS

Within EdTech, two major benefits are associated with the use of LA dashboards for teachers: they increase the knowledge that a teacher has about their learners, and they enable a teacher to carry out different types of reflections on their own classroom practice and teaching.

FIGURE 4: The added value of LA dashboards presented visually.



Please note: Figure by Artoos group, based on information from Molenaar et al. (2017), Ndukwe et al. (2020), Stacey et al. (2018), Wise and Jung (2019) and Xhakaj et al. (2017).

3.1.1 KNOWLEDGE ABOUT LEARNERS

Firstly, thanks to an LA dashboard, a teacher can gather information about what exactly happens when the learner gets started with the digital tool. Without an LA dashboard, the teacher is in the dark about the progress and performance of a learner as long as that learner is busy working and does not interact with them. Due to the amount of data that is collected, saved and analyzed, the teacher can acquire **more knowledge about the learning process and the results** of the learners in a digital tool. The LA dashboard will therefore make it easier to monitor learners individually or in groups, **before, during and after lessons**. It also offers the opportunity to monitor the learners' study progress in the **short or long term**.

Secondly, using an LA dashboard can **reduce the teacher's workload**. In traditional education, it can be time-consuming to constantly follow up on each learner. Teachers often know their learners well, but when working in a traditional classroom, they miss a lot of factors, needs and indications that can inform them about an individual's learning process. This is not because they are inattentive, but because a lot happens at the same time in a class. A digital tool can help in this regard by **automatically collecting data during the learner's interaction with the tool** that the teacher would miss in traditional interactions (Kasepula et al., 2021).

Thirdly, the LA dashboard can help **identify high-risk learners** or learners who need an additional challenge (Aslan et al., 2019; Molenaar et al., 2017; Xhakaj et al., 2017).

3.1.2 REFLECTION

Firstly, teachers gain insight into the **effectiveness of their instructions** and the different **needs of the learners.** (Do the learners understand what the assignment is? Do the learners need more repetition? Am I giving the learners too much or too little feedback?) (Ndukwe et al., 2020; Xhakaj et al., 2017; Yeh, 2020).

Secondly, teachers gain more insight into their own **didactic and pedagogical skills**. By seeing the effect of the curriculum on their students, teachers may discover significant problems in their educational approach. These new insights can lead to (other) pedagogical actions (by teachers) in daily classroom practice. In the LA dashboard, they can then monitor the (possible) results of their pedagogical actions (Molenaar et al., 2017; Stacey et al., 2018; Wise and Jung, 2019).

Thirdly, teachers can adapt their **curricula more effectively and efficiently**. They can measure whether their curricula and teaching objectives have the desired effect within the desired period. After the lesson or series of lessons, they can decide which pedagogical actions are needed to ensure that the learners understand the learning content well, and they can also think about their lesson plan(s) in the longer term: for example, they can opt to divide the learning content over several lessons because

most learners had difficulty with it (Xhakaj et al., 2017).

Fourthly, the information can encourage teachers to **take action** during the lesson if a learner is at risk of falling behind, but also if they are confused or bored. Even after the lesson, the teacher can use the error analysis on the LA dashboard to adjust instructions in a subsequent lesson or to identify and address issues with those learners who are struggling.

3.2 THE ADDED VALUE OF LA DASHBOARDS FOR LEARNERS

Some tools will provide an LA dashboard for learners in addition to the teacher dashboard. Again, a lot of information **about the learning process** can be presented, but it is important to think about **which information is useful for the target group**. It is possible to investigate which data informs learners, but at the same time also motivates and supports them in their learning process. Not all data will be of benefit. Giving learners insight into their progress by comparing them with fellow learners, for example, can stimulate healthy competitiveness in some and thus increase motivation, but might discourage others. **An LA dashboard with information about a learner's own performance challenges them to develop their self-regulatory skills, train their planning skills and reflect on their own progress and (possibly) that of others** (Charleer et al., 2016; De Laet et al., 2018; Vanbecelaere et al., 2019).

In i-Learn MyWay, for example, learners can view their progress for each learning track, review their completed learning tracks, and see the results of tests in the learning track. The overview of the progress towards the set objectives is intended to motivate learners.

In Prowise's Rekentuin 'Maths Garden'[1] tool, all learners are shown a growth map with their best game, the score on each game, the number of exercises done per game, etc. In the LA dashboard of Linguineo's 'Taalheld²' ('Language Hero'), learners can see their score for each skill. The learners can see which friends they met in the game and which materials they have already collected to complete the assignments. Learners can also click through to an additional overview where they can see how much of what they say is understood by the tool, how complex their sentences are, how many mistakes they make per sentence and even how many words they speak per minute (Depaepe et al., 2023).

4. The collaboration between teacher and LA dashboard within digital personalized learning

Due to the extensive range of (adaptive) digital tools, questions sometimes arise as to the role of teachers is in combination with these tools, and whether teachers are being gradually replaced. Recent research highlights **the important role of the teacher** in using the digital tools intelligently (Depaepe et al., 2023; Holstein et al., 2020; Kolchenko, 2018).

Louis and Major (2020) distinguish three approaches:

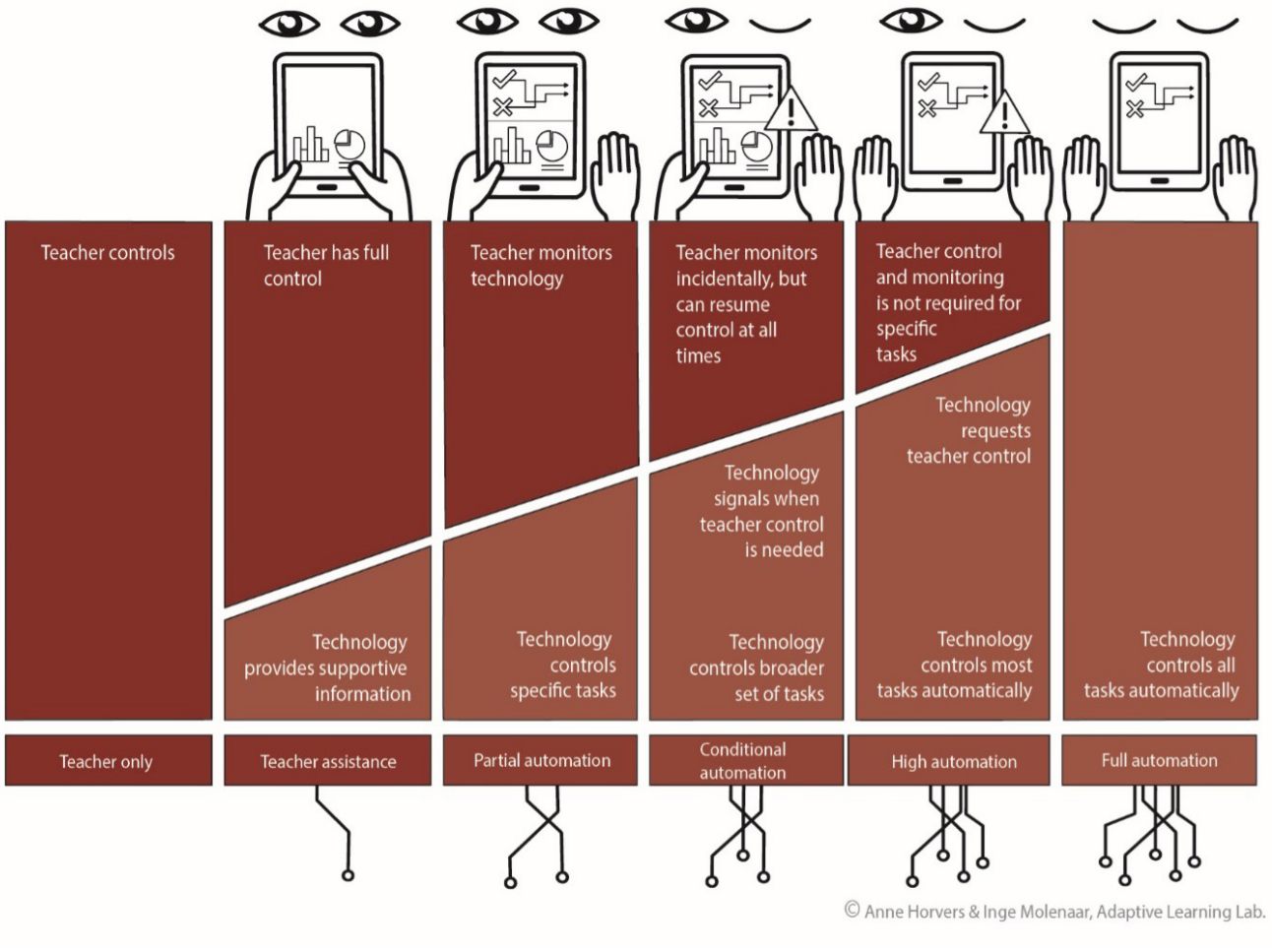
1. **The replacement approach:** the technology replaces the teacher. For example, if a teacher is ill, the learners are given a laptop instead of a substitute teacher to study the planned learning content independently using a digital tool (Louis and Major, 2020).
2. The **additional approach:** the technology offers added value to the teacher but does not replace them. An example might be using the technology to offer additional practice opportunities to learners, either with or without teacher guidance. In this way, teachers can get the learners to work through the content at their own pace, without the learners being dependent on traditional instructional moments in the classroom. For example, learning software is used for corrections. Another example is when a teacher teaches the class about the food cycle, but gives a newly arrived non-native speaker a digital learning path in which they learn vocabulary to do with nature, animals and plants (Louis & Major, 2020).
3. The **integration approach:** there is a **synergy** between the tool, the teacher and the learner. The tools are not designed as complementary or stand-alone systems, but take into account the teacher, the learners and the classroom interactions. For example, the tool can offer instruction, such as a video explaining how to do fractions, while the teacher offers additional instruction or support where necessary. The teacher keeps track of the learners' progress using the LA dashboard. If the teacher sees that some learners are not really making progress, they can get these learners together to provide more explanations and get them to do a group exercise before they go back to working individually (Depaepe et al., 2023; Mutahi et al., 2015; Tabak, 2004).

The form that the **'synergy'** takes in the integration approach is further discussed by Molenaar (2022), who introduced the term hybrid intelligence. Thus AI does not have to replace the teacher; instead it may simply support the teacher's role. The digital tool is developed in such a way that it reinforces human strengths and compensates for human weaknesses. The tool and the teacher share responsibility and there is reciprocal interaction between the two (Holstein et al., 2020, Kolchenko, 2018, Molenaar, 2022).

4.1 THE SIX LEVELS OF AUTOMATION

Molenaar (2022) distinguishes six different levels of automation within the EdTech field. This model visualizes the transition of control between teacher, learner and technology. Because who takes on the most responsibility, the teacher or the tool? Who performs the most tasks? Who performs which tasks? How is the monitoring or personalization of the exercises distributed? Molenaar (2022) divides the broad term 'synergy' between teacher and tool into 6 levels, with control and action increasingly in the hands of the technology, depending on the tool used.

FIGURE 5: The six levels of automation in the EdTech field (Molenaar, 2022)



The six levels of automation that Molenaar (2022) identifies show how the role of the teacher changes as technology takes over more tasks. The higher the level, the less the teacher has to do. However, digital personalized learning tools at levels 5 and 6 are still being developed; some do exist, but they are very rare. The bottom of Figure 5 shows how extensive the incoming data flows are. The more automation is offered, the more data is needed. At the top of the figure, the extent to which the teacher (and learner) must monitor themselves (the eyes) and to what extent they are in control (the hands) can be seen for each level. Levels 2 to 5 are the most interesting to look at, because it is at these levels that the best results with regard to the learning process are expected (Depaepe et al., 2023; Molenaar 2022; Tabak, 2004).

Level two, teacher assistance, refers to a type of teaching where the teacher has complete control over the learning process, but where technology provides them with additional information. **Level three**, partial automation, occurs when technology controls specific tasks, but where the teacher monitors the technology. **Level four**, conditioned automation, indicates a situation where the technology controls a broader set of tasks. It signals when there is a need for help from the teacher. The teacher monitors the technology and can take back control at any time. At **level five,** high automation, technology automatically controls most of the tasks the learner performs and will ask for help from the teacher if needed. Here it is not necessary for the teacher to monitor and check for specific assignments, but they do need to keep a general eye on things.

At levels four and five, it is very important to have good communication between the technology and the human participants. This is because communication is possible in both directions. For example, the teacher's insights can also help to improve the diagnosis made by the technology and optimize the actions. The LA dashboards associated with these different levels of automation will serve other purposes (see 2.5 Differences in automation) (Depaepe et al., 2023; Molenaar 2022, Tabak 2004).

Two important prerequisites for achieving an ideal **synergy** between tool and teacher is the tool having a decent LA dashboard, and the **teacher having the competence** to correctly interpret the data from this dashboard (Depaepe et al., 2023; Molenaar, 2022).

4.2 USING LA DASHBOARDS: A COMPLEX PROCESS

Several studies show that the way teachers use digital tools is more important than the technology itself. Being surrounded by digital tools in the classroom is not sufficient to use them effectively in the learning process. **Whether LA dashboards deliver added value for classroom practice therefore depends on the way in which they are used by the teacher**.

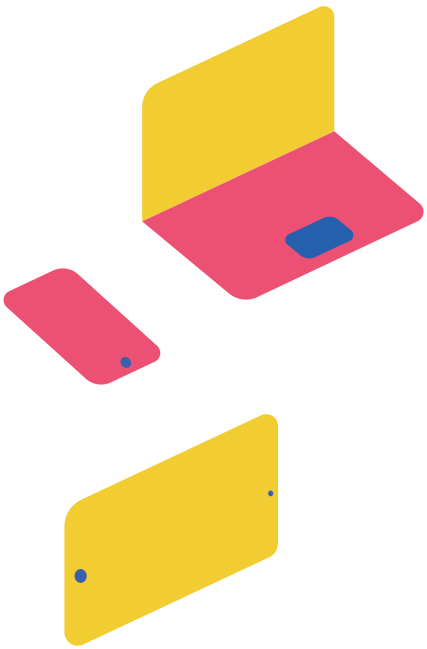
Research shows a **wide variation** in how LA dashboards are used. For example, not all teachers are interested in the same data points, teachers can interpret information in different ways and/or teachers can take different pedagogical actions (Van Leeuwen et al., 2021).

For example, imagine a teacher A who only uses the LA dashboard to transfer the scores for exercises from a digital learning tool to a report, and a teacher B who considers those scores, looks at the error analysis, thinks about possible explanations for weaker scores and combines the results with other observations.

Teacher B uses the information on the LA dashboard to gain more insight into the learning process (Considine et al., 2009; Molenaar et al. 2017; Sailer et al. 2021). **This teacher combines different data points and reflects on their meanings.** Their behaviour is referred to as **'in-depth diagnosis'**. The teacher can formulate hypotheses or preliminary conclusions about the learning process of individual learners, and then compare these to information from other data sources, such as classroom interactions and conversations with parents or third parties. An in-depth diagnosis of this kind gives the teacher a basis to adapt teaching in a meaningful way and to promote learner development. Teachers can carry out the necessary in-depth diagnosis by making **data-driven decisions** with LA dashboards (Klingbeilet al., 2022; Mavrikis et al., 2019; Sailer et al., 2021).

> Making data-driven decisions involves the systematic analysis of data sources by teachers with the aim of studying and adapting their educational practice to optimise learning outcomes.

(PRENGER & SCHILDKAMP, 2018, P. 735)



Wise and Jung (2019) provide more insight into how a teacher can use an LA dashboard. It is a **complex process** that goes from understanding data to taking pedagogical action.

1. **As a first step**, the teacher will review the LA dashboard. Some teachers know exactly what information they are looking for based on questions they have in advance, while others are guided by what they see. Possible questions that the teacher can ask themself are: Are there comparisons between learners? What are the learners' scores for the exercises? And can it be seen whether these are higher or lower than the class average? After the teacher has looked at the data, they will dig further to find more information about any striking data points in the LA dashboard (e.g. a learner suddenly scores much higher or lower on exercises about fractions than the week before) (Depaepe et al., 2023; Wise and Jung, 2019).
2. **A second step**, after collecting the data, is to interpret it. This is quite difficult and requires the teacher to bring together multiple sources and make a plausible assessment. The teacher will supplement information from the LA dashboard with data or observations from outside the LA dashboard, such as classroom interactions, one-on-one discussions, tests, etc. (Depaepe et al., 2023).
3. **In the third step**, the teacher will translate the new insight into an action that can be taken immediately or in the future to help the learner (Depaepe et al., 2023; Wise and Jung, 2019).

For example: the teacher sees in the LA dashboard that learner X is having difficulty with the learning content. The teacher decides to offer 'targeted scaffolding' and let the learner watch a video with more explanation. This involves targeted support for an individually determined learning need. If the teacher had shown the video to the entire class, that would have been 'whole-class scaffolding'. The teacher felt that this was not necessary because they deduced from the LA dashboard and/or the class observations that no other learner made the same mistake as learner X. When planning next year's classes, however, the teacher wants to avoid a similar mistake from the outset. So they decide to include the video as standard in the lesson plan. The next school year, the teacher will keep an eye on whether all learners do immediately work out this learning content correctly (Depaepe et al., 2023).

In this example, the teacher quickly took action. It would have also been possible to wait before intervening. Wise and Jung (2019) call this the 'wait-and-see' approach. Here, the teacher can choose to reflect on their own actions instead of focusing on learner behaviour (Depaepe et al., 2023; Wise & Jung, 2019).

The entire support process is preferably cyclical rather than linear. With the information that the teacher obtains from the LA dashboard, they can continuously monitor the effects of their approach and adjust it where necessary in order to provide the most appropriate educational offer for the personal needs of each learner (Depaepe et al., 2023; Rienties et al., 2018; Wise & Jung, 2019).

4.3 TEACHERS' COMPETENCE IN USING LA DASHBOARDS

In order to successfully deploy LA dashboards in the learning process and to make data-driven decisions, it is necessary for teachers to have certain competencies.

A first important factor that can influence the impact of an LA dashboard on the quality of education is **data literacy**, namely the ability of teachers to convert information into actionable knowledge and practice (Mandinach & Gummer, 2016; Molenaar & Knoop-van Camden, 2018; Wise & Jung, 2019). This involves a combination of being able to 1) read and interpret information, and 2) connect this with relevant pedagogical knowledge, in order to choose an appropriate follow-up action. A second important factor is the affective characteristics of teachers. Research shows that teachers' **attitude** can play an important role: the more confident teachers are in AI education technology, the more likely they are to use it and use it well (Nazaretsky et al., 2021; Van Leeuwen et al, 2021). Other teacher characteristics that can influence the use of LA dashboards are their **domain-specific knowledge**, **professional routines** and **pedagogical knowledge** (Van Leeuwen et al., 2021).

5. Ethical considerations when using LA dashboards

The conclusions that teachers draw when using an LA dashboard can only be as good as 1) the data presented in the dashboard, and 2) their ability to interpret the data correctly (Aerts et al., 2018; Depaepe et al., 2023).

5.1 PITFALL 1: THE DATA PRESENTED

It is important to realize that, despite the many and various items of digital data, not every learning behaviour or relevant action can be captured or presented in digital form. The scope and representativeness of the data is always limited and can, at best, provide a limited view of some aspects of learning behaviour. Digital personalized learning tools are not yet flawless. They contain fragmented or contaminated data and can make erroneous predictions or adjustments. The current algorithms are often still too simplistic or insufficient to recognize rich educational contexts. In addition, the tool developers have already selected the data to be displayed in the LA dashboard. Sometimes the teacher can switch off what they do not find relevant (such as the time learners spent watching a video), but they do not have the option to select what they would rather see instead (such as the order in which learners have done the exercises) (Aerts et al., 2018; Depaepe et al., 2023).

5.2 PITFALL 2: MISINTERPRETATION BY TEACHERS

Teachers must be careful not to over- or under-interpret the captured learning data. When it comes to pedagogical interventions, the safest thing for teachers to do is not only to be guided by what they see in an LA dashboard, but also to check these findings against other observations and data. This may have to do with learning behaviour in the classroom or information from other digital learning applications (Aerts et al., 2018; Depaepe et al., 2023).

Teachers are therefore expected to take responsibility and use their experience and knowledge to critically assess these pitfalls. Additionally, it is important for teachers to provide learners with information about these potential pitfalls of LA dashboards, as many learners get LA dashboards themselves to help them work on their self-regulating skills, for example (Aerts et al., 2018; Depaepe et al., 2023).

6. A detailed example: actionable LA dashboards

6.1 WHAT IS AN ACTIONABLE LA DASHBOARD?

To conclude this i-Learn paper on LA dashboards, we will take a closer look at actionable LA dashboards. As mentioned earlier, LA dashboards can have different levels of automation. With mirroring LA dashboards, the data collected is displayed as accurately as possible for the teachers, but its interpretation is entirely up to them. Learning analytics with a higher degree of automation, such as alerting, advising and intervening dashboards, will help the teacher interpret the data and offer advice. These examine how the learning process happens and analyze aspects of this process that the learner has not yet mastered. This can involve misconceptions, errors in strategy and incorrect reasoning methods. Predictive algorithms inform the design and help guide the decisions (Davies et al., 2017; Van Leeuwen and Rummel, 2022). A mirroring LA dashboard can also be actionable when it helps the teacher to interpret the presented data.

An actionable LA dashboard helps the teacher interpret the data and encourages the teacher or learner to take action. This type of LA dashboard works with categories that immediately give the teacher an idea of where the learners are in their learning process or, in the case of an LA dashboard for learners, give the learners an immediate idea of how they are doing, and also offer advice. The teacher does not have to view and analyze all the visualizations to interpret them, as the dashboard does this work for them (Depaepe et al., 2023; Tempelaar, 2021).

For example, there are actionable LA dashboards that deduce, from the results of learners, who belongs to a 'risk group'. It is also possible for dashboards to show which learners are in danger of dropping out with categories such as 'learners who try, but are finding it hard', 'learners with little motivation or who make little effort, who are finding it hard', and 'learners who are inactive in all subjects'. In addition, advice can be formulated for the teacher, such as 'get this learner to redo the exercise', 'get this learner to repeat the theory', and 'give more exercises about this piece of learning content', as well as checklists with calls to action such as 'contact' and 'tick as completed'. Actionable LA dashboards for learners can formulate advice such as 'review theory', 'ask for a hint', 'ask for help', 'redo the exercise', etc. (Davies et al., 2017; Depaepe et al., 2023; Tempelaar, 2021).

6.2 ADVANTAGES AND DISADVANTAGES OF AN ACTIONABLE LA DASHBOARD

Working with such categories has many advantages, but also disadvantages. Van Leeuwen and Rummel (2022) have found, for example, that teachers who are under time pressure benefit more from an actionable LA dashboard than from a mirroring LA dashboard. An actionable LA dashboard provides a useful, immediately applicable overview and gives advice. However, as discussed earlier, the data is not always reliable and is subject to incorrect interpretations. The developers must anticipate the needs of the teachers, interpret the data where possible and make recommendations for actions. Given that the predictions build on the developers' pedagogical insights, which will always be limited in scope, such LA dashboards need to be extensively tested and adjusted. The group of teachers and learners who use the digital tool and the LA dashboard(s) associated with it are usually very diverse. It is therefore extremely difficult to make recommendations and recognize patterns for a diverse group of learners, across ages, subjects, interests, etc. (Davies et al., 2017; Van Leeuwen & Rummel, 2022).

For example: the learning materials are often tailored to the age of the learners, expressed in the grade or school year they are in, such as 'fractions for the 4th grade'. If an LA dashboard then indicates that a learner scores below the average, it is useful to know where that average comes from. Is this the average of the learners in the same class or school, or of all learners on the learning app who are doing exercises for the 4th grade? How does the dashboard determine whether learners are motivated or inactive? The time that a learner spends on an exercise can very often be misleading, for example, because they may go the toilet halfway through, or become distracted at some point and spend time on something else. Furthermore, it may not be clear how teachers should interpret findings such as 'makes a lot of mistakes' versus 'makes few mistakes'. How is the percentage of mistakes considered to be 'many mistakes' determined? 30% wrong? 50% wrong?

Because the actionable LA dashboard mainly works with categories, when in doubt, the teacher will have to dive into the raw data and be sufficiently data-literate and analytically skilled to discover any reasoning errors made by the algorithm (Depaepe et al., 2023; Tempelaar, 2021).

6.3 HOW TO DEVELOP AN ACTIONABLE LA DASHBOARD

Tempelaar (2019) indicates that a combination of data streams must be analyzed in order to better predict learning outcomes. The following data points are listed for this purpose:

- **Process data** (e.g. how long a learner works on the learning tool, how many tasks are completed, which learning tracks or learning activities are completed)
- **Product data** (e.g. cognitive test results or a learner's self-assessment)
- **Disposition data** (e.g. results of metacognitive decision moments, motivation of the learner, learning objectives, self-reported commitment to learning, attitudes towards certain learning content)

Process data, product data and disposition data (about the 'mindset' of learners) all lead to better predictions of learning outcomes. The LA dashboard, if it has advanced learning analytics, will be able to provide insight into patterns it finds in the learners' data. For example: the algorithm of the action dashboard detects that a learner has difficulty with certain spelling rules (e.g. the -dt rules in Dutch) based on the language exercises that they have done. Or the algorithm discovers that a learner regularly misspells certain difficult words. That is to say the LA dashboard provides the teacher with information about common mistakes (Klingbeilet et al., 2022; Mavrikis et al., 2019; Tempelaar, 2019).

Developers of action dashboards must ask themselves the following questions:

- What should the teacher/learner be able to see in all this data?
- What skills are needed to move from the LA dashboard to an action?
- How can the teacher/learner know what to focus on among all this data?
- Where can the teacher/learner find the calls to action?

It is recommended to not give too much information, but to stick to relevant, real-time information. If graphs are used, there must be an explanation right next to them of what information can be extracted from them, so that teachers do not have to work this out for themselves.

For example: The LA dashboard of app X shows the progress of the entire class in a series of exercises that lead to a learning objective. When a learning objective has a blue check mark, it means that the entire class is at the target level. When there is a blue check mark with a number in yellow, the entire class has achieved the learning objective, except for this number of learners.

Each learner's status for each learning objective may also be indicated by coloured dots. A dark blue dot means that the learner has achieved the objective. A light blue dot means that the learner has almost achieved it or is clearly working on it. A yellow dot means that the learner is stuck on this learning objective and the associated exercises. A white dot indicates that the learner has not yet done sufficient work on it.

Within the scope of the i-Learn project, an LA dashboard was developed as part of the learning platform for digital personalized learning called 'i-Learn MyWay'. The data that is collected about the learners as they go through learning tracks is recorded in a database and then translated into overviews for teachers and learners. To develop these, insights into actionable dashboards were taken into account. Appendix 1 of this i-Learn paper briefly explains how this LA dashboard was developed.

7. Conclusion

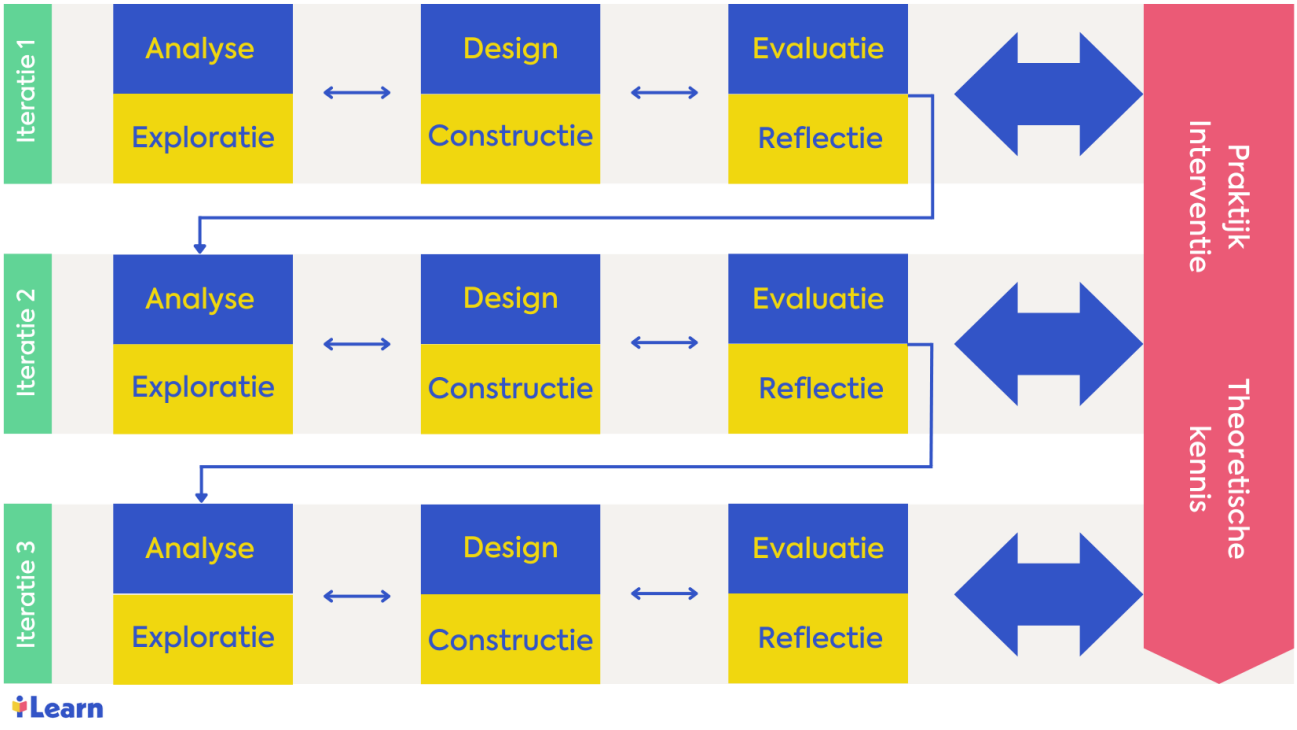
A lot of online learning environments within the EdTech sector today contain LA dashboards that present collected data about learners and their learning processes. Developing such an LA dashboard is a complex task. Many different circumstances, data sources, indicators, profiles, etc. must be considered. Despite the fact that developing LA dashboards takes a lot of work, it is definitely worth the effort. Both teachers and learners can benefit from them. For teachers, an LA dashboard provides insight into the learners, the learning process and their own role and skills as teachers. For learners, the LA dashboard can strengthen their self-regulatory skills.

In order to effectively deploy LA dashboards, a synergy must be established between the teacher and the tool. If they work together and complement each other, the dashboards will increase the teacher's capacities and better support the learning process. Where LA dashboards present the collected information about learners to teachers clearly – as many dashboards do – and the teachers subsequently interpret this information, there are opportunities to reduce teachers' workloads. Actionable LA dashboards will interpret the data and formulate any advice to teachers. In the currently understaffed education sector, this can save teachers valuable time. However, it is important for teachers to develop a certain level of data literacy so they can correct the digital tool where it might make an error.

Appendix 1: Developing the i-Learn LA dashboard

This appendix provides a brief insight into the development of the LA dashboard in i-Learn. This behind-the-scenes information might prove valuable for didactic experts, researchers and developers who are engaged in a similar project. The i-Learn project follows the model of Educational Design Research (EDR) in its development[3]. In the i-Learn research project, three major phases or iterations are distinguished, in accordance with the EDR model: scientific analysis, technical development and an evaluation of the results by means of research (see Figure 6). The LA dashboard for teachers and the LA dashboard for learners were developed through these three iterations (McKenny & Reeves, 2014).

FIGURE 6: Visualization of the three iterations involved in the development of i-Learn MyWay and the i-Learn Academy.



ITERATION 1: THE I-LEARN PROTOTYPE

In the first iteration, scientific research was carried out into the needs of digital personalized learning in Flemish education (needs determination). Based on the information collected, a first version of the i-Learn portal was developed with first versions of the LA dashboards for teachers and learners. In this prototype (i-Learn 1.0), it was possible to offer tailored learning content to learners by dividing them into **groups according to their level**. For example, learning tracks with lots of new information were assigned to a group of learners who were able to get to grips with the content very quickly, while learning tracks with more repetition were assigned to a group who absorb learning content less quickly. In the prototype, the learners were **asked at the end of a learning track about how much they liked it,** how hard they found it and how well they thought they had done. The teacher was able to view all of this in the LA dashboard and provide feedback. Several **categories**, such as 'these learners go significantly *slower* than their fellow group members', were presented to give the teacher direct insight into the situation. The learners were also divided into two categories **within each learning track**: 'learners with a completed learning track' and 'learners with an outstanding issue'. The teacher could then send feedback to the learners via the LA dashboard. This was a ***mirroring, and partly alerting, LA dashboard*** because it checked the activities of the learners for deviations from a predefined standard and then indicated this to the teacher via the dashboard categories (Van Leeuwen and Rummel, 2022).

Several issues emerged from the evaluation of the prototype that were addressed in the second iteration. Firstly, there was a need to achieve adaptivity/differentiation in a more efficient way than by creating groups. A new concept was developed that focused on differentiation built into the learning tracks. Rather than working with groups, the new concept was based on **key moments**. This new way of working also made it possible to display the **results** of key moments in the LA dashboard. Second, more opportunities were offered to teachers to adapt or make their own learning tracks. There was also some thought about categories that were designed to make interpretations of learner data easier and clearer.

The following items were not included in the second iteration:

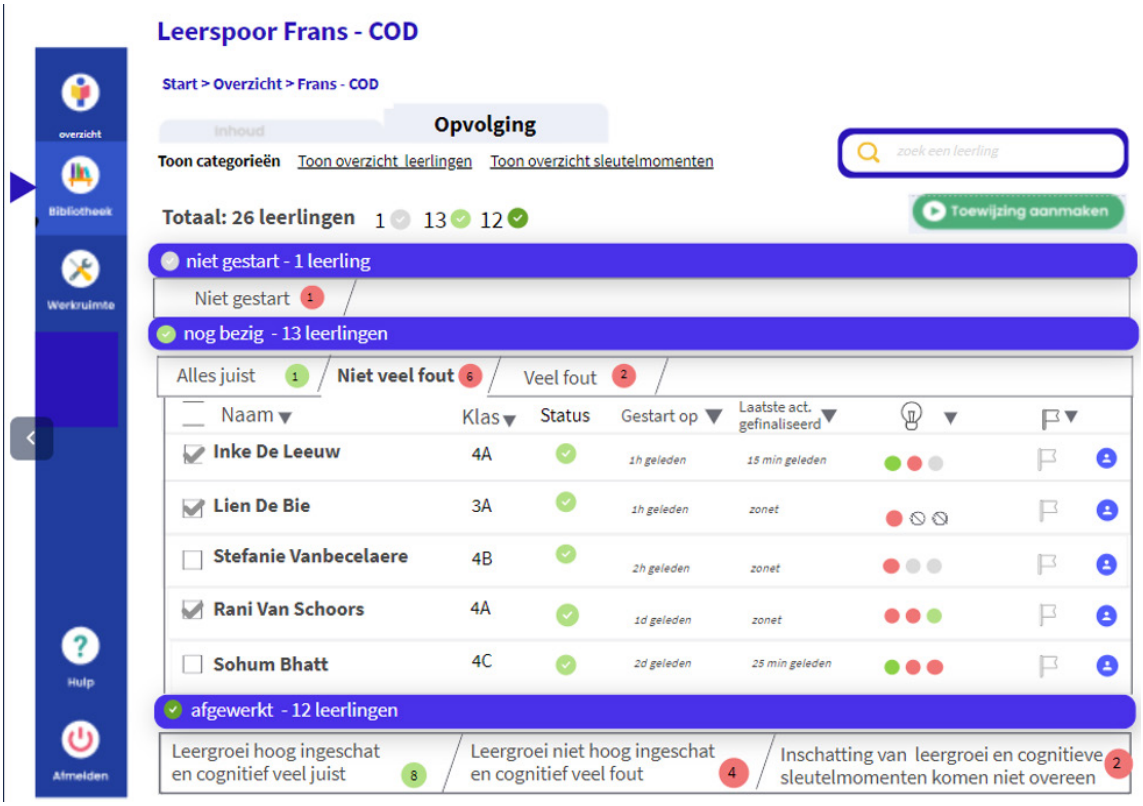
1. How long a learner worked on a learning track. This proved impossible to determine due to technological limitations, as the timestamps stored on the portal could not show the actual working time.
2. The categories of moving 'faster' or 'slower' through a learning track were omitted. Both teachers and researchers argued that these were not objective and therefore not useful.

ITERATION 2: THE 'IDEAL' LA DASHBOARD FOR I-LEARN

In the second iteration, the focus was on the centralized and visually clear display of relevant process data, product data and disposition data, because this leads to better predictions about learning outcomes. The LA dashboard was designed according to the design idea of **action dashboards** (Tempelaar, 2019). Several questions were answered to move from an actionable LA dashboard to an action dashboard:

1. **What should teachers and learners be able to see in the data?** They need to see who requires extra support, what mistakes are made systematically, and how far each learner is along the learning track.
2. **What skills do teachers and learners need to take action from the LA dashboard?** Ideally, an action dashboard will already interpret certain information and present it to the teacher or learner in such a way that they understand what is going on without having to be data-literate. However, there must also be a possibility for teachers to check for themselves where these interpretations come from and whether they are correct. Teachers are always encouraged to think critically about the data presented. For the i-Learn LA dashboard, teachers need to possess a certain degree of data literacy to be able to analyze which of the learners scores better than or not as well as average and to understand the variation between learners. In addition, they must be able to understand visualizations, have the time and inclination to look at data and be able to evaluate the data accurately.
3. **How do teachers know what to focus on among all the data?** Teachers will focus on the categories, the green check marks, and the green and red dots. The flags they allocate to learners will also stand out. We therefore worked with colour and shape to make the information clear at a glance. In another overview, the self-assessment of learners is presented using a growing tree. There are many different overviews available in which multiple aspects can be filtered if the teacher wants to dig deeper into the data.
4. **Where are the 'calls to action' located?** The teacher can intervene on a learning track while learning is taking place and can also provide appropriate follow-up actions afterwards (such as assigning a new learning track). Actions can take place in i-Learn or live, in the classroom. The teacher can flag up individual learners or groups of learners and, if necessary, assign them to categories. It is easy to give feedback and to assign a learner to another category or new learning track. The actions are quickly offered by the LA dashboard itself without needing to click through too much. The teacher can filter by flags.

FIGURE 7: LA dashboard for teachers of the learning track for the direct object in French. Second iteration, the 'ideal LA dashboard'.



As can be seen in Figure 7, an overview with a lot of information was chosen in the second iteration. This LA dashboard met many of the teachers' needs, but it had to compromise on clarity. The following was shown for each learner: their name, class, when they started the learning track, when they finished the last activity, and how many cognitive key moments they got right and wrong. There was also a possibility for teachers to monitor a learner.

Categories were used to make the information more actionable.

- Categories: 'not started', 'still in progress', and 'finished'.
- Subcategory: 'many mistakes.'
- Subcategory: 'learning growth not assessed as high, lots of cognitive mistakes', 'assessment of learning growth and cognitive key moments do not match.'
- A pie chart with an overview for each key moment showed what percentage of the group chose a certain answer.

The researchers considered what the best option was: **interpreted categories** (e.g. it's going well, it's tough) or **objective categories** (e.g. everything right, everything wrong). With interpreted categories, it is easier for the teacher to take quick action, since the results of the learner have already been interpreted. However, it is a challenge to interpret the results in such a way that they are useful and valuable for every teacher. Therefore, it was decided to start with the objective categories and evaluate them throughout the iteration. Furthermore, it was decided to include only cognitive and metacognitive data in the categories, and not the learners' progress. The reasoning behind this was that learners' progress could result in a distorted picture in certain situations, for example when learners were allowed to carry out a learning track at their own pace over a longer period of time.

The 'ideal' LA dashboard for **learners** included the following features:

- Learning tracks recently worked on, with an *estimated* duration, on the home screen (the duration was estimated by the creator of the learning track, not by the learner).
- Unread feedback on home screen
- Results of cognitive key moments
- Learning track record of learners themselves
- Self-assessment visually depicted with growing plant
- Unread feedback icon

ITERATION 3: THE FINAL LA DASHBOARD OF I-LEARN MYWAY

Several elements that were developed in the second iteration were included in the new version, but a lot of functionalities were **not** consolidated in i-Learn MyWay.

The final i-Learn LA dashboard is only accessible for one learning track at a time. So there is no overview of learners with all the learning tracks that they followed individually. Three different overviews are available in the LA dashboard for teachers. When a teacher goes to their assigned learning tracks in the library, they can see which assignments have been done for each track on **an initial overview**. There is also the code for the learners and three statuses with numbers: 'status retrieved', 'status started' and 'status completed'. Figure 8 depicts a situation in which two learners have completed this learning track.

FIGURE 8: Assignment 006J2 of Computational thinking learning track – press event.

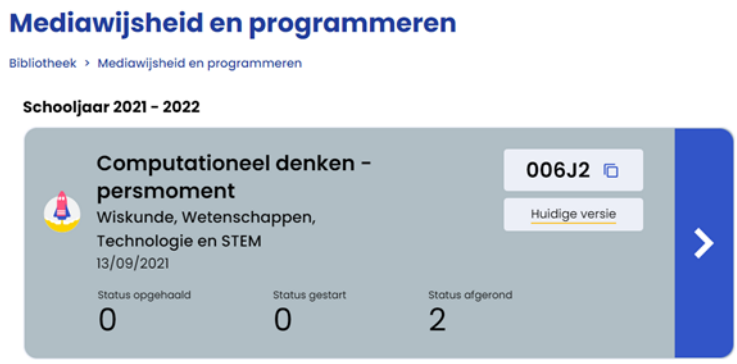
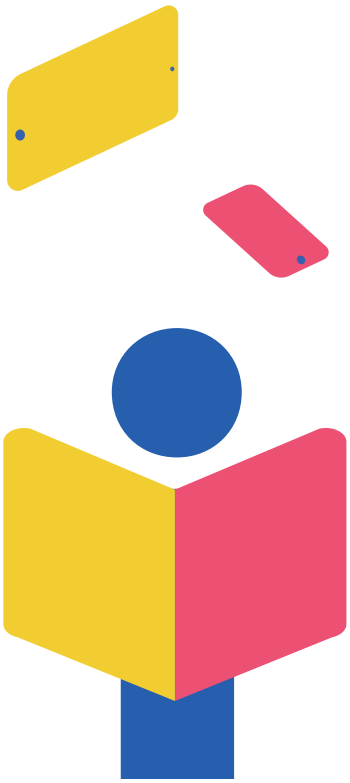


FIGURE 9: Second overview of the LA dashboard for Media Literary and Programming learning track, assignment 006J2.

In **the second overview**, in Figure 9, the status is repeated and the green dot shows that the learners have started on the learning track. A green dot with a check mark shows that the learners have also completed it. Whether a student has completed the learning track can also be seen by looking at the self-assessment score. At the end of the learning track, the students are asked to assess themselves in relation to the learning objectives stated at the beginning. If a percentage can be seen here, it means that the student has reached the end of the learning track. There is one cognitive key moment in the learning track. How the learners scored on it is shown by a red or green dot. In the i-Learn LA dashboard, only the answers to the cognitive key moments are visible – so the answers to the motivational key moments, metacognitive key moments and learning activities in the tools cannot be seen. Depending on the answers to the key moment questions, the learners are guided to the follow-up track that best suits their updated learning needs.

A third overview can be seen when the teacher clicks on 'view progress'. There it is possible to follow the entire learning track for each learner and to see what choices the learner made.

By combining these three overviews for each learning track, the teacher has access to process data, product data and disposition data. The following **data sources** are used in i-Learn's LA dashboard: 1) computer logs: clicking on buttons, including logging in, opening learning activities, timestamps when clicked, answers to key moments (assessment data), etc.; 2) information that is obtained directly from the learner: their self-assessment; and 3) data of the learners obtained from the school. With regard to the **types of indicators**, learner-related indicators are shown (learner name, class, learning objectives), as well as action-related indicators (clicked learning activities, progress of learning tracks), content-related indicators (learning activities in tools with which learners interact during learning, results at motivational or metacognitive key moments) and result-related indicators (results at cognitive key moments). The **target audiences** for this project are teachers and learners, so there are two LA dashboards. The LA dashboard for learners is much more limited than the one for teachers. Learners can see which learning tracks they have started and which they have completed (and revisit them). They can also see their results at cognitive key moments, and their progress in each learning track. The LA dashboard for teachers is intended for real-time use and for analysis and preparation outside of class. It can be used for face-to-face group work and blended learning. The teacher can follow individual sessions, and also follow the learners over semesters and school years, but only in the assigned learning tracks.



The final LA dashboard is a **mirroring LA dashboard**: it has a low degree of automation and mainly collects, processes and presents data about learners to the teacher. The teacher then interprets how the learning process is unfolding and takes appropriate pedagogical actions.

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End notes

1 https://www.rekentuin.nl/

2 https://www.languagehero.app/home

3 EDR is a way of conducting research in which the setting is stimulated and supported by an iterative development of solutions to complex, practical educational problems. There are many variants of EDR, but most have the following characteristics: 1) EDR uses scientific knowledge to substantiate the design work; 2) EDR produces scientific knowledge; 3) Although the terminology and content vary, three phases can be distinguished: an analysis/orientation phase, a design/development phase, and an evaluation/reflection phase. These are often repeated throughout the duration of a project; and 4) EDR seeks to develop both practical interventions and reusable information (McKenny & Reeves, 2014).

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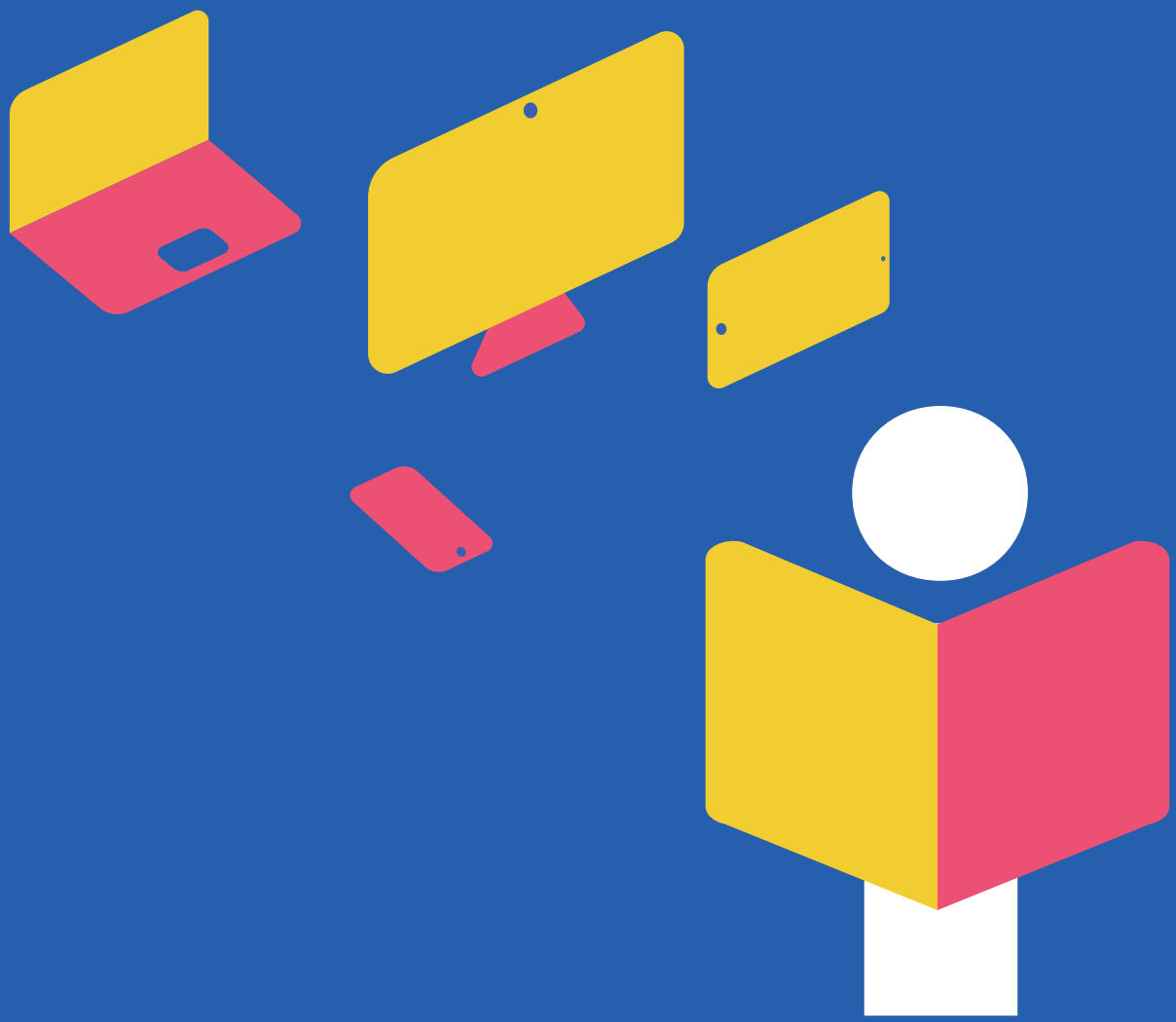

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