



Digital Library for the Implementation of Formative Assessment into Teaching

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Abstract

This paper presents information about the development, implementation, and verification of efficiency of “Digilib” – a digital library of formative assessment (FA) tools. A selection of 10 different types of FA tools (e.g., self-assessment card, prediction card, and Frayer model) was conducted based on a literature search and Internet resources. Subsequently, in accordance with the educational standards and in cooperation with teachers, a total of 36 databases covering 774 FA tools for the selected thematic units and topics in science (biology, physics, chemistry), mathematics, and informatics were created for primary schools. “Digilib” application allows teachers to create and save their own FA tools (forms), which can be assigned to students to collect information about their understanding of the subject matter, i.e., to receive real-time feedback. In the 2022/2023 school year, 8 primary schools, 16 teachers, and 46 classes (grades 5 to 9) with a total of 846 students were registered in the digital library. Semi-structured interviews were conducted to collect teachers’ opinions on the implementation of FA provided by the digital library. This paper presents the results of a semi-structured interview performed at the selected primary school. The respective teacher appreciated the simple user experience, quick feedback about students’ current state of knowledge, automated creation of complex overviews of students’ answers, and archiving. The feedback provided by the self-assessment and prediction cards helps students develop an ability to perform objective self-assessment and address possible misunderstanding in learning.

Keywords: digital formative assessment, formative assessment tools, digital library, implementation, teachers’ opinions

1. Introduction

Formative assessment (FA) is a continuous process of collecting information about students’ learning in terms of the educational goals, based on which teachers decide about changes to teaching; it also provides students with feedback (Tierney et al., 2006). FA helps teachers identify students’ needs and possible learning difficulties, and if necessary, adapt their teaching

accordingly (OECD/CERI, 2008). In terms of FA, students actively participate in the learning process via self-assessment, peer-assessment, and teacher's assessment. If students cooperate with the teacher in the assessment of their learning, they learn how to understand the subject matter, and apply the knowledge and skills in a variety of situations. Students with well-developed assessment skills show higher motivation and ability to acquire, interpret, and apply the information provided by quality assessment, thus improving their own learning and deeper understanding of the subject matter (Hattie, 2012).

The research into FA and computer-aided assessment led to the creation of digital formative assessment (DFA) also referred to as “online formative assessment” or “web-based formative assessment” (McLaughlin & Yan, 2017). DFA can take an exclusively digital form or combine digital and offline tools and activities (Looney, 2019). DFA presents opportunities to support 21st century skills and life-long learning by capturing all forms and outcomes of learning, and by using learner data/information to diagnose and address gaps in learning (Huong & Ki Au, 2020).

Digital communication tools (e.g., Zoom, Google Meet, MS Teams), Learning Management Systems (LMS), and other specialised tools (e.g., Kahoot! Socrative, Plickers, Google Forms, Quizizz, Nearpod and GoFormative) turned formative assessment into an immediate and long-term solution for complex collection of data/information and analysis of students' learning.

Multiple studies (e.g., Bhagat & Spector, 2017; Elmahdi et al., 2018; Faber et al., 2017; Koedinger et al., 2010; McLaughlin & Yan, 2017; Sheard et al., 2012) have confirmed that DFA tools significantly help improve learning outcomes and students' motivation to learn. They allow teachers to receive real-time feedback on students' knowledge levels and determined further learning steps, which facilitates individualisation of teaching (Looney, 2019; Walter et al., 2010). Besides the advantages for students with lower academic performance, DFA tools can also improve the learning outcomes of higher performing students (Faber et al., 2017). DFA tools facilitate students' engagement in the learning process (Wang & Tahir, 2020). Moreover, their efficiency in the improvement of teaching methods and forms has been confirmed (OECD, 2015; Wang & Tahir, 2020). Due to the scope and diversity of the available digital tools, it may be difficult for teachers to select suitable resources and digital formative assessment tools.

In Slovakia, FA has still not been implemented into teaching in a systemic way. In 2020–2023, the implementation of FA in teaching at primary schools was supported by the KEGA No. 004UPJŠ-4/2020 “Creation, Implementation, and Verification of the Effectiveness of Digital Library with the Formative Assessment Tools for the Natural Sciences, Mathematics and Informatics at the Primary School” and KEGA No. 001UPJŠ-4/2023 “Implementation of Formative Assessment in Primary School Teaching with the focus on the Digital Form” research projects. Three Slovak universities cooperated in these KEGA projects: Pavol Jozef Šafárik University in Košice, University of Žilina, and J. Selye University.

The main goal of these research projects was to develop a digital library of formative assessment, implement it, and verify its efficiency.

2. Materials

To achieve the research objectives, the “Digilib” – a digital library of formative assessment tools was developed.

In the preparation phase, the selection of formative assessment tools for the digital version was carried out. Based on literature search and Internet resources, 10 different types of FA tools – supporting the development of conceptual understanding and selected capabilities related to

scientific work (assumptions, reasoning, conclusion, generalisation) as well as motivation, cooperation, and communication – were selected (e.g., Dodge, 2009; Keeley, 2015; Keleey & Tobey, 2017; Walsh, 2013). These FA tools were divided into two categories, i.e., objective (cognitive) and subjective (meta-cognitive). Objective (cognitive) FA tools allow students to evaluate their own level of conceptual understanding and further develop their cognitive processes. Such tools include prediction card, before-and-after card, conclusion drawing card, Frayer model, and concepts-facts-examples. Subjective (meta-cognitive) FA tools are based on students' ability to analyse and manage their own learning. Such tools include the self-assessment card, K-W-L method, learning process mapping card, and various alternatives of exit cards such as the 3-2-1 card, minute card, and short summary.

After selecting the FA tools for the digital version, a digital library was created.

The digital library system consists of the main application Digilib and two sub-applications Digiform and Digimage.

The “Digilib” application was developed as a web application hosted at the faculty web server <https://digilib.fri.uniza.sk/> and equipped with an SSL certificate. It consists of sections such as user, year, class, and topic management, forms and their evaluation, etc. The application employs user roles (administrator, coordinator, teacher, student). The FA tools are referred to as “forms” in it. “Digilib” allows teachers to create and save their own FA tools (forms), which can be assigned to students to collect information about their understanding of the subject matter, i.e., to receive real-time feedback. Moreover, a teacher can provide individual commentary on each student's answers. It also offers a function that allows for inserting mathematical and chemical formulas. This application can also be expanded by adding new types of forms.

The Digiform sub-application allows for the creation of new form templates (FA tools). Two new types of forms were added – a hybrid form and a Digilib survey, which can be created by importing the template exported from Digiform. The hybrid form combines different types of questions including open questions, single and multiple-choice questions.

The Digimage sub-application is an image gallery. Digimage allows for inserting images into questions/answers in Digilib and Digiform.

A user manual was created for the teachers to learn how to use the digital library.

In parallel with the development of the Digilib, the FA tool databases were created. In cooperation among the project research team, experts in subject didactics from the Faculty of Science at Pavol Jozef Šafárik University in Košice, and primary school teachers, FA tool databases were created for the selected thematic units/topics in science (biology, chemistry, physics), mathematics, and informatics as taught at primary schools. Subsequently, they were pilot tested, verified, and optimised. The FA tools were created in accordance with the content and performance standards for specific academic subjects pursuant to the State Educational Programme for the second stage of primary schools (NIE, 2014). A total of 36 databases containing 774 FA tools were created (Table 1).

Table 1: List of the selected thematic units/topics in primary school science, mathematics, and informatics for which the FA tools were designed

Thematic unit/Topic					
Academic subject	5th grade	6th grade	7th grade	8th grade	9th grade
Biology	Nature and Life, Societies of Organisms	Life with Humans and in Their Settlements	Human Body	Basic Life Processes in Organisms, Heredity and Variability in Organisms, The Living Environment of Organisms and Humans	Exploring Inanimate Nature
Chemistry			Substances and their Properties, Substance Transformations	Important Chemical Elements and Compounds	Carbon Compounds
Physics				Bodies in Motion, Work, Power, and Energy, Magnetic and Electrical Phenomena, Electric Circuit	
Mathematics	Plane Symmetry (axial and centric)	Mathematical Operations with Natural Numbers, Triangle, Congruence of Triangles	Fractions, Percentages, Cuboid and Cube, Ratio, Direct and Indirect Proportion, Combinatorics	Positive and Negative Integers, Variable, Expression, Parallelogram, Trapezoid (perimeter and area), Circle, Probability, Statistics, Triangles	Powers and Square Roots, Linear Equations and Inequations, Similarity of Triangles, Graphical Representation of Dependence
Informatics	Software and Hardware (basic concepts); Communication Software and Hardware – Input and Output Devices, Representation and Tools – working with text, presentations, tables, and cooperation – Working with Communication Tools – e-mail, Internet search, Software and Hardware – working with files and folders, computers and additional devices	Software and Hardware – Input and Output Devices, Representation and Tools – working with text, presentations, tables	Software and Hardware – PC memory; Information Society – safety and risks, Viruses and Antivirus Software, Using the Internet Safely, Communication and Cooperation – working with websites	Representation and Tools – working with tables, multimedia, dealing with viruses and spyware; Information Society – safety and risks	Representation and Tools – raster graphic, problem-solving algorithms – Introduction to the Python Programming Language

Source: Own processing

3. Methods

In the 2022/2023 school year, 8 primary schools, 16 teachers, 46 classes (grades 5 to 9), and 846 students were registered in the “Digilib” digital library. All teachers actively participated in the KEGA No. 004UPJŠ-4/2020 and KEGA No. 001UPJŠ-4/2023 research projects and they were interested in the active implementation of FA in teaching. Teachers were allowed to freely choose FA tools from the created databases for science (biology, physics, chemistry), mathematics, and informatics and modify them for the purpose of their own teaching needs. Teachers implemented the FA tools in teaching in the printed and/or digital form using “Digilib”. Regular instruction seminars were organised for the teachers to share their experience with the implementation of FA in the teaching process and consultations were also provided.

The opinions about and attitudes of teachers towards FA and the use of the “Digilib” digital library during lessons were collected by a semi-structured interview. A semi-structured interview is a qualitative research method (DeJonckheere & Vaughn, 2019).

Semi-structured interviews were divided into 4 areas.

1. Introduction (school, academic subjects taught, years, classes).
2. Implementation of the FA tools in teaching (FA tool types, frequency of use, form of implementation).
3. Positive aspects of the “Digilib” digital library implementation in teaching.
4. Negative aspects of the “Digilib” digital library implementation in teaching.

Teachers participated in the semi-structured interviews voluntarily. Ethical principles were strictly adhered to.

4. Results and Discussion

In this part, an evaluation is made of the semi-structured interview performed at a selected primary school in Košice (Slovakia). The respective teacher implemented the FA tools and used the “Digilib” library for teaching chemistry in an 8th grade class attended by 24 students.

4.1 Implementation of the FA Tools in Teaching (FA Tool Types, Frequency of Use, Form of Implementation)

During four months (February – May 2023), students were asked to work with 20 FA tools addressing the “Important Chemical Elements and Their Compounds (hydrogen, oxygen, iron, alkali metals, halogens, noble gases)” and “Chemical Reactions and Formulas (neutralisation, redox reactions)” thematic topics. 10 prediction cards and 10 self-assessment cards were used. Students filled in FA tool forms in the digital form via “Digilib”.

For more details, see Figures 1–3. The prediction (before and after) card activates students’ existing knowledge, raises curiosity and increases their interest in active learning. The teacher formulates true/false statements related to the current subject matter. At the beginning of the lesson, students predict what will or will not be true for the subject matter which they are yet to learn. At the end of the lesson, students assess the statements once more and proceed to check whether their knowledge changed after they have learned the subject matter. All figures are in the language of the application.

Figure 1: My prediction (before and after) card type forms

Top horizontal menu:
 Users – Classrooms – Subjects – My topics – Create a form – My forms (list of FA tools) – Surveys
 Subject management:
 Subject – Grade – Topic; Buttons: Questions – Assign at the beginning of the lesson – Assign at the end of the lesson – Students – Results – Compare

Moje predikčné karty

Predmet: Chémia, Ročník: 8

Predmet ↑↓	Ročník ↑↓	Téma	Otázky	Priradiť na začiatku hodiny	Priradiť na konci hodiny	Žiaci	Výsledky	Porovnať
Chémia	8	Vodík	Otázky	Priradiť na začiatku hodiny	Priradiť na konci hodiny	Žiaci	Výsledky	Porovnať
Chémia	8	Vzácné plyny	Otázky	Priradiť na začiatku hodiny	Priradiť na konci hodiny	Žiaci	Výsledky	Porovnať
Chémia	8	Kyslík	Otázky	Priradiť na začiatku hodiny	Priradiť na konci hodiny	Žiaci	Výsledky	Porovnať

Source: Own processing

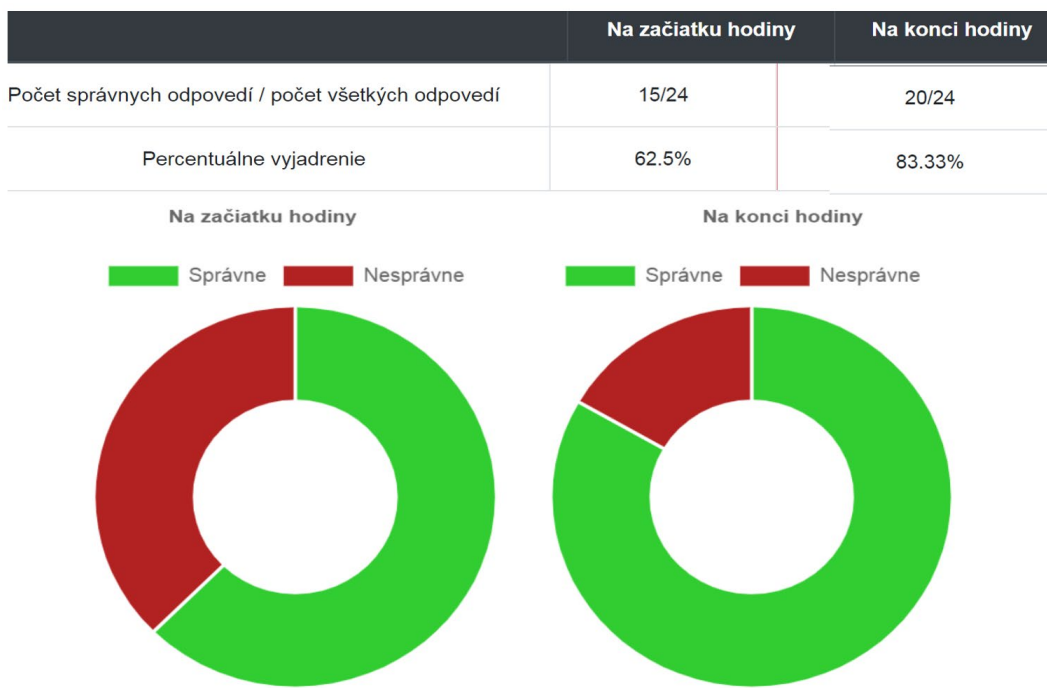
Figure 2: Example of a student's actual attempt to fill in the prediction (before and after) card – Hydrogen and its Properties

Statement: Answer before – Answer after – Is it correct?

Otázka ↑↓	Odpoveď pred hodinou	Odpoveď po hodine	Správna odpoveď
Atóm vodíka obsahuje jeden elektrón.	Áno	Áno	Áno
Vodík je bezfarebný plyn.	Áno	Áno	Áno
Vodík je najrozšírenejší prvok vo vesmíre.	Nie	Áno	Áno
Vodík je umiestnený v periodickej tabuľke prvkov v 1. skupine (IA skupine).	Áno	Áno	Áno

Source: Own processing

Figure 3: The overall class results after completing the prediction card (left – before, right – after; green – correct; red – incorrect)



Source: Own processing

According to the teacher, the students liked the prediction card the most – it allowed them to formulate their own assumptions and consider different statements.

Prediction is a useful FA strategy from multiple points of view (Walsh, 2013). At the beginning of the lesson, the teacher prompts students to formulate an assumption regarding the truthfulness of the statements related to the subject matter which they are about to learn. Students predict which statements will or will not be true about the subject matter which they will be addressing shortly. It is a student activation method aimed at increasing their responsibility for their own learning (Hubbard et al., 2017). It allows the teacher to assess what students know (or think they know) – including their opinions and possible misunderstandings – about the topic, which will be addressed during the lesson. At the end of the lesson, students evaluate whether their knowledge changed after working on the subject matter. This tool activates their previous knowledge and arouses curiosity (Dyer, 2013).

The self-assessment card in Table 2 was filled in by 23 students in terms of the topic “Investigation of acid solutions”. Most students stated they knew examples of acids used in households and/or laboratories and they could also identify a solution pH using a universal indicator paper. Some students were unsure about acid formulas and the equation about hydrochloric acid ionization in the water solution.

Table 2: Evaluation of a self-assessment card after teaching the topic Investigation of acid solutions (8th year of primary school)

Student's name:	Form:		Date:
Level of understanding of the subject matter	On my own	With the teacher's assistance	I don't understand it yet
	number	number	number
I can name three examples of acids, which are used in a household and/or a laboratory.	18	3	2
I can write down chemical formulas of three different acids.	12	6	5
I can describe what is the first aid if someone spills an acid on themselves.	19	3	1
I can explain how acids are diluted with water.	18	3	2
I can name the cations, which cause the acids to be acidic.	15	5	3
I can write down the equation of hydrochloric acid ionization in water solution.	12	5	6
I can explain what indicators are.	16	5	2
I can provide some examples of indicators.	20	2	1
I can identify the pH of a solution using a universal indicator paper.	17	4	2

Source: Own processing

The teacher claimed that it was often difficult for the students to evaluate their own performance verbally. However, the self-assessment card helps them determine their level of factual, conceptual, or procedural knowledge. The card formulates the criteria, thus helping the students express their intuitive self-evaluation, which is easier for them than formulating full sentences. The self-assessment card allows the student to evaluate their own level of understanding/ability on a scale “I know/can do this – I need some help – I do not know/cannot do this yet”. Upon evaluation, self-assessment cards show which knowledge students have and where assistance is still needed. Using self-assessment cards in the evaluation phase motivates students to focus and try harder during the following lessons.

These results correspond with the results of previous studies focused on the importance of using student self-assessment. Boston (2002) has explained that when students are able to identify and explain their errors based on self-assessment, it opens an opportunity to close gaps caused by misunderstanding. Hanrahan and Isaacs (2001) have found that self-assessment allows the students to think more critically about their work. Furthermore, the students felt more confident in their work when they were aware of what was going to be assessed. Ozan and Kincal (2018) have found that students' self-regulation skills improved when self-assessment was used as a form of feedback – students take responsibility for their own learning.

4.2 Positive and Negative Aspects of the “Digilib” Digital Library Implementation in Teaching

Table 3 shows the positive and negative aspects of the “Digilib” digital library and its use from the teacher's perspective.

Table 3: Positive and negative aspects of the “Digilib” digital library implementation in teaching according to the teacher

Positive aspects	Negative aspects
Accessibility of various ready-made FA tools.	Too many students in the class.
A wide range of output options – details of student answers, summaries of the individual questions/assignments, assessment by class, etc.	Necessity of Internet connection to fill in the FA tools.
Student performance assessment in the form of tables and charts. The possibility to compare the results achieved by parallel classes.	Missing technical equipment – notebook or tablets for students.
All students’ outputs (filled in FA tools) are in a single database, which allows the teacher to follow their learning progress.	
Development of digital skills in both teachers and students.	
The student can revise their answers and improve their learning.	
The teacher can comment on the answers to provide feedback.	

Source: Own processing

Based on the experience and knowledge gained during the implementation of the “Digilib” in teaching, this teacher plans to continue using the digital library in the formative assessment students and also in other academic subjects besides chemistry. According to this teacher, this digital library creates new opportunities for teachers to perform diagnostics and achieve the educational goals.

Large classes may cause difficulties in providing individualised attention to students (Browne, 2016). Moreover, teachers are more likely to conduct formative assessments if schools and education systems alike encourage them to innovate, for example, through peer support or pilot projects that test new assessment methods (OECD, 2005). If valid, timely, constructive, and specific to the learning needs of the students, formative assessments can be particularly helpful in advancing teaching and learning (UNESCO, 2020). They may also help identify areas for improvement in teacher professional development and may be crucial for teachers in motivating and engaging their students (Muskin, 2017).

5. Conclusion

The “Digilib” digital library of formative assessment tools allows for immediate evaluation of students’ progress and can be used to supplement summative assessment in the long-term run to facilitate constant learning measurements. The ability to use formative assessment is a huge benefit for teachers and digital tools such as “Digilib” provide the opportunity to enhance this ability inside and outside the classroom.

Based on the teachers’ (user) feedback, the “Digilib” functionalities will be further improved and expanded (elaborative feedback from the user/teacher, personalized feedback for the student, reusability, accessibility, interface design, interaction). Further research aims to create more FA tool databases for different languages (Slovak, English, German) and incorporate them in the existing digital library. Subsequently, the influence of Digilib-supported FA tools on the development of cognitive processes, self-reflection competence in students as well as the opinions and attitudes of teachers, students, and their parents to FA will be identified. The findings can be used in the curricular reform of primary education, which is currently being implemented in Slovakia, specifically in educational system digitalisation and student

assessment in the individual education cycles and areas to satisfy the 21st century educational needs.

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