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WE-COLLAB

COLLABORATIVE AND TRANSPARENT USE OF LEARNING ANALYTICS IN ONLINE UNIVERSITY COURSES, VALUING THE LEARNER ROLE AND EXPLOITING ADVANCED MONITORING EQUIPMENT

1st edition

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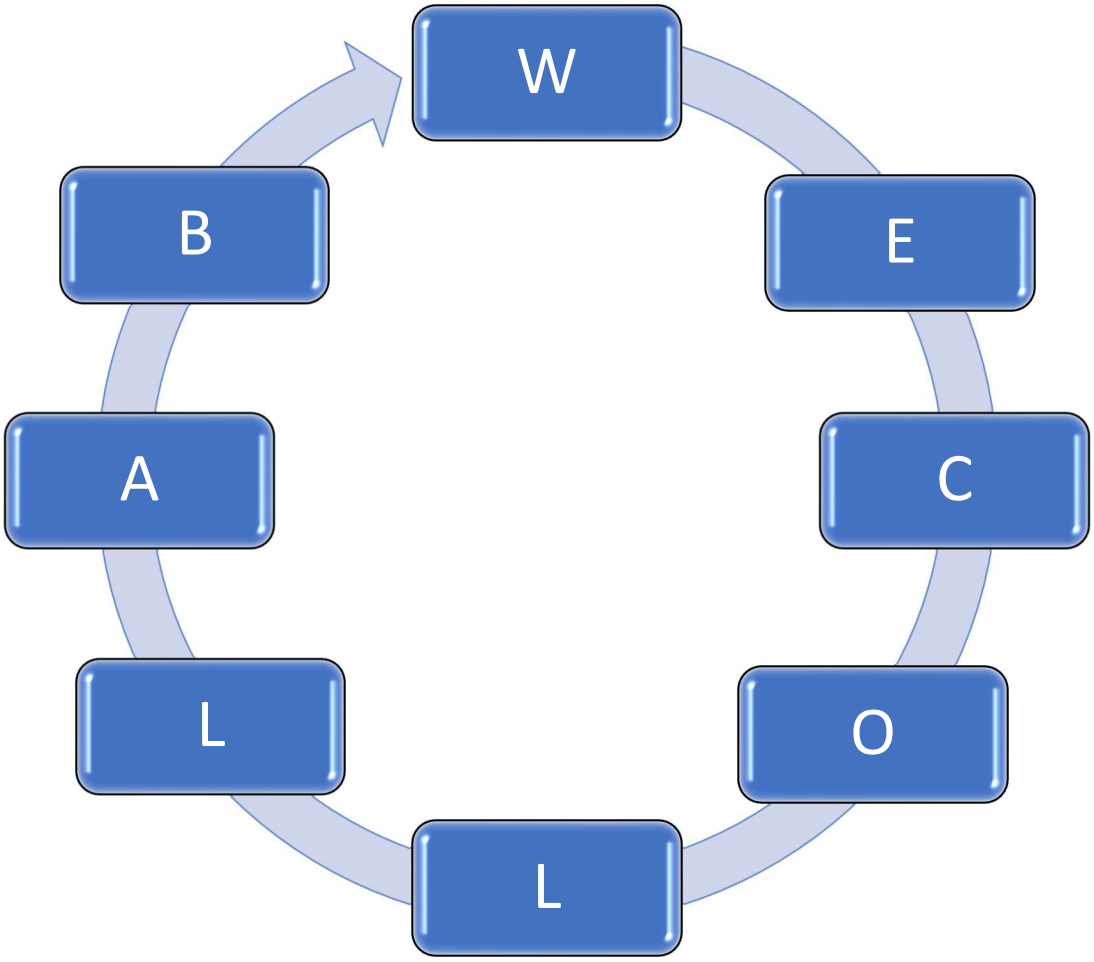
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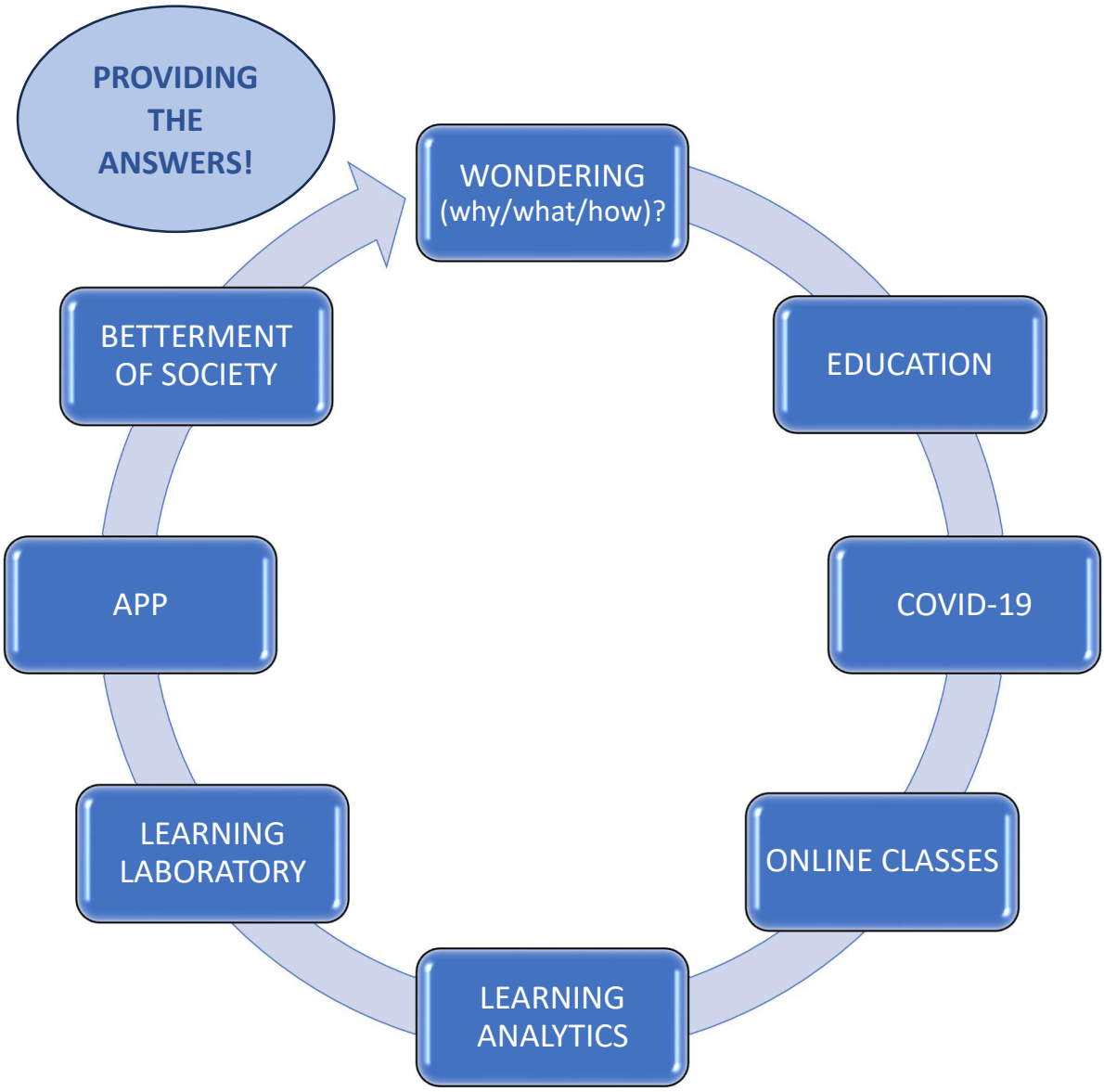
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PREFACE

Going back in 2021, during COVID-19 pandemic instead of students being in front of the teachers at classes, online approach started. Since classrooms stayed empty, new paradigm arose. In education, as in all other areas, there were also many changes during the COVID-19 pandemic. From one moment to the next, teaching was switched from face-to-face to online, which presented teachers with numerous questions regarding the organization of lessons. Teachers were facing "the silence of the black squares", asking themselves do students even listening, are they even there?

Faced with this new situation, teachers wondered how it is possible to capture students' attention and improve communication with them so that students are more engaged in listening and focusing on the lesson. This is how the whole idea behind the project was born and we wanted to give our contribution within the field of education, precisely how to engage our students in online classes. To do this, we collaborated knowledge from various interdisciplinary field in order to understand better our student and provide possible solutions to make them more engaged in that online learning.

Our aim was: bridging the gap of insufficient student engagement in online learning.

Although the situation has returned to normal after the pandemic, in society we are faced with the situation that some changes are here to stay, so now our students prefer to personalize their approach to learning to a much greater extent and combine different learning modalities. This shift in student preference for blended or hybrid learning environments represents a dramatic change in the higher education landscape.

The document in front of you is a result of collaboration within the WE-COLLAB Erasmus+ project and represents the final project result uniting all previous project results. The document summarizes the project results achieved so far, ranging from the establishment of a web platform to the emphasis on the importance of learning analytics and its application. As well, we have emphasized the importance of bio-metric and neuro-metric tools in education to get clearer answers in terms of student responses.

Although together we have completed a cycle that reflects our goals for analysing the learner, the environment and its support, at the same time many new questions have been raised that provide a direction for future analysis waiting to be unveiled, again focusing on the learner and the importance of learning.

Grateful to all the partners involved in contribution to the Project,

Maja Vujičić

1. INTRODUCTION

Ariely (2009, p. 82) emphasized that children are interested in many things (e.g. football) and that we as a society should take up the challenge of igniting their interest in education (e.g. Nobel Prize winners) as much as their knowledge of football players. The same could be applied also for different levels of education.

The WE-COLLAB project and its analysis deals with student centric approach analysing the needs and wants of the learner, putting the learner at the first place, trying to understand which factors have impact on the learner.

Putting the analysis in concrete terms and looking at digital transformation as one of the characteristics of today's world, the question arises of how to motivate and engage students – to achieve their active participation in class and interest in learning. This is the central question of the project. We wanted to help ensure appropriate online teaching and provide high quality educational processes.

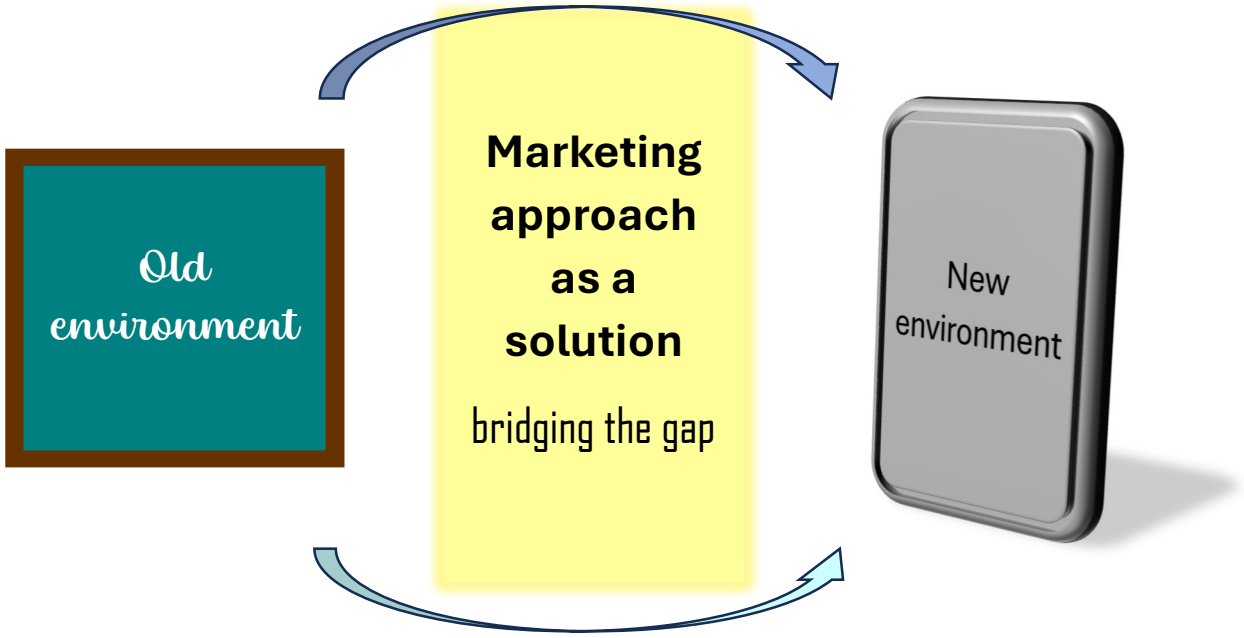
The aim → bridging the gap of insufficient student engagement in online learning.

The analysis provided gave the answers related to the target groups of teachers and learners but also to all other stakeholders having interest in learning. Thus, the Project contributed to innovativeness in higher education and all involved partners, as well as other stakeholders, willing to learn about these tools.

Hence, the Project supports the priority of implementing innovative practices in the digital age. Furthermore, priority is given to activities promoting innovative methods and tools for learning and teaching as drivers of improving digital transformation → **learning analytics** and **neurosicientific tools** and methods of conducting research.

As mentioned earlier, teachers were faced with the situation of classes going online, especially during the COVID-19 pandemic. In other words, teaching was "moved" from the traditional classrooms to the online, suddenly facing with the situation described as "emergency distance learning" (Digital Learning, 2024). Figure 1 illustrates this change and underlines the role of the marketing approach in student-centred learning, which is explained in the following chapters.

Figure 1: Bridging the gap between old and new environment



In this sense, the central assumptions of our project relate to the following: teachers online tend to repeat their face-to-face (F2F) courses instead of redesigning them to meet the challenges of online learning. Under-resourced IT departments were unable to provide teachers with the expertise they need to rethink their deliver of effective and inclusive instruction to all their students. Teachers need to have the expertise, pedagogical skills, but also technological capabilities to work out which aspects of their own courses are best suited to different ways of delivering lessons. This shift has led to an unprecedented number of teachers being expected to know how to design inclusive learning environments. However, there were higher education institutions struggling to provide teachers with the necessary expertise to rethink their pedagogy and the design of all three teaching methods in a way that enables effective and inclusive teaching for all students. The above statement is presented in Table 1.

Table 1 below shows the situation in which, instead of a systematic and planned organization of online courses, teachers had to be flexible, but at the same time were aware of the existing problem of communication with students and their motivation. The students were no longer in their classrooms with all the necessary tools to support the learning process. They were all confronted with a different environment, as the learning process through e-learning differs from general learning in school. In addition, communication between teachers and students took place via a variety of electronic devices to establish communication on different platforms (Jurs and Špehte, 2021).

Table 1: Differences occurred within education

FORMAL ORGANISATION OF CLASSES – TECHNICAL PART		
Traditional classroom	(post)pandemic new environment → online classroom	e. g. Google Meet/Teams...
Traditional learning approach	Discussions and reading materials – online tasks and web pages	**?**
NEW APPROACH TO TEACHING PROCESS (HOLDING CLASSES)		

Table 1, depicts the situation that occurred at which instead of a systematic and planned organization of online courses, teachers had to be flexible, but at the same time aware of the existing problem of communication with students and their motivation. Students were no longer in their classrooms with all the necessary tools to support the learning process. All of them were faced with a different environment since the learning process through e-learning is different from general learning in school. As well, communication between teachers and students took place through a variety of electronic devices to establish communication on different platforms (Jurs and Špehte, 2021).

Student engagement is a complex, multidimensional concept that goes far beyond simply adding surveys and breakout- rooms. Therefore, the university's priority should be to raise awareness of the impact of digital tools and provide target audiences with better access to digital platforms. The interdisciplinary scope and analysis from different angles added value to the existing knowledge by opening new perspectives and bridging the gap within the defined problems. The WE-COLLAB team was highly interdisciplinary and included experts from the following fields: pedagogy, language, learning analytics, IT, marketing, neuroscience research tools and approaches, all gathered around one theme: increasing engagement in learning and finding a solution to bridge the existing gap. Through the project and its analysis, a contribution is also made to 'teachers', i.e. faculty who teach regular higher education students who need additional support to successfully complete online courses. But in addition to building knowledge about how to approach students, the different types of materials were analysed to gain insights into student preferences. Ultimately, online learning should benefit from more engaging materials for both teachers and students

In the other words, the project united 3 objectives.

Objective 1: Understanding an individual – we have focused on the challenges that often characterize poorly designed online courses. Examples of challenges that we will address in our analysis include the design of inclusive instruction in terms of (1) "Zoom fatigue" due to long, consecutive videoconferencing sessions, (2) higher levels of distractibility and shorter attention spans, and (3) information overload when too much information comes in too quickly. An important element impacting individuals is also a lack of self-regulation and feeling isolated from teachers and peers in the online context.

Objective 2: Exploring environment and engagement – Our second objective is to help teachers build a high level of engagement into the design. To do this, we use innovative research methods, including behavioural data analysis and neurophysiological data analysis to improve the level of interactivity and emotional engagement.

Objective 3: Analysing background processes (use of Learning Analytics) – Because we do not have direct access to students' nonverbal communication, it is extremely difficult to identify online students who are at risk of dropping out if they do not receive additional help. The third objective addresses teachers' ability to use learning environments to recognize who needs extra attention and when, using LA.

At the end of the introductory section and before we proceed, it is important to emphasize that our analysis focuses exclusively on the student engagement in an online context with learning materials. This means that learning is, of course, a much larger and more complex concept that goes beyond the learning approach/material alone.

2. FRAMEWORK

2.1. Service Marketing, Social Marketing and Consumer Neuroscience

Instead of teaching students in front of teachers in the classroom, all teaching was moved entirely online and a new paradigm was introduced during the Covid 19 pandemic. The problem that arose was that students were sitting in front of their PCs without the teachers knowing if they were even there and if they were listening. So the situation highlighted the need to close the gap of insufficient student engagement in online learning. The question is how to motivate students to learn so that they actively participate in class to ensure adequate online teaching and provide quality educational processes.

To find the answers to the questions of the project, we started with a holistic approach to analysing the education segment through the lens of different experts of the interdisciplinary team and one of the directions was focused on the marketing approach. More specifically, on the marketing concept related to service and social marketing. The focus was on analysing teaching through the lens of the marketing concept and analysing how to better address the needs and wishes of the customers – the students. Since we are in the field of education, we based our research in the area of services marketing.

Awareness of the discrepancies in the market and knowledge of the essence of the marketing concept should be at the heart of improving any product/service. At the same time, it should be clear that a product can be perceived as a whole range of options, e.g. as a service or even as an idea. The product that the customer is searching for with the purpose of satisfying needs and wants can therefore be a physical product, a service, an event, an experience, people, places, properties, organizations, information or ideas (Grbac, 2014). In other words, the offer can be very different in the various business areas and consist of values that go beyond the pure utility value of the product. Based on the mentioned above, the product should be analyzed in an holistic view and perceived as a total product – including all tangible and intangible elements (Grbac, 2012, p. 121). As Grbac (2014, p. 9) emphasize: “The marketing concept in business is about identifying and satisfying the needs and wants of consumers on a selected target market and doing so more efficiently than the competition”. Furthermore, as already mentioned, various elements could be considered as a product, which means that both teaching and complete study programs could be considered as a kind of product and approached with the help of the marketing concept.

In other words, the marketing orientation and the marketing approach refer to analyzing teaching and the teaching process as a "product" that can be enhanced, especially in new circumstances and when the environment changes. After defining the framework in which the analysis is carried out, the next step is to better understand the customers – or more precisely, the students. The most important aspect to find out is what exactly constitutes value for customers so that the offering can be improved. The needs and desires of customers should be at the heart of product delivery to ensure long-term success. This is because marketing can be defined as a process of value development and exchange (Grbac, 2012, p. 41),

Education, or more precisely teaching, is a part of services and therefore falls within the scope of service marketing. A service can be defined as any action that one part can offer to another, which is intangible in nature and does not represent a classic ownership (but offers the opportunity to use something) (Kotler and Keller, 2008, p. 402). Service marketing therefore implies a marketing concept adapted to the service sector.

The following remarks, which refer to education and students' perception of its importance for themselves and for society, place this research in the field of **social marketing**. Social marketing is characterized by understanding the target market and getting them to behave in a socially acceptable and suggested manner, promoting positive social values and minimizing negative ones. Social marketing uses marketing principles and techniques to persuade the target market to voluntarily accept, reject, change or abandon a behavior - for their own benefit, for the benefit of the group or society as a whole (Kotler et al., 2002). Its aim is to influence change in society by directing the behavior of the individual towards the good of society (Meler, 2003). Consequently, it is also important to figure out how to optimize social marketing campaigns to influence consumer behavior for the better (Cerf & Garcia, 2017, p. 257). In other words, social marketing is a non-profit segment of marketing that focuses on ideas that help individuals adopt behaviors that are beneficial to themselves and society.

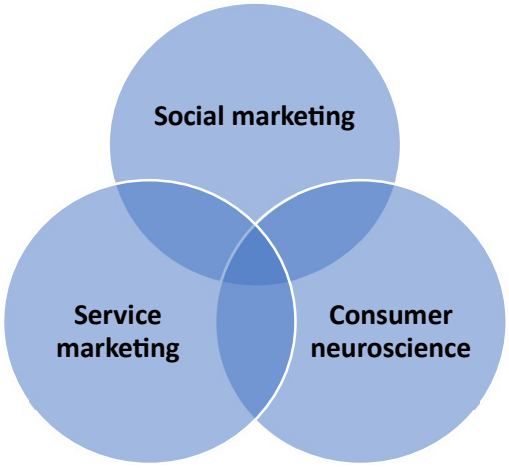
The interested target groups include teachers and students, but also any third party interested in the field of education – from the health sector, sports, policy makers… anyone who is interested in making better decisions that benefit individuals and society as a whole. The focus is on improving individuals and society as a whole, which brings this result into the realm of social marketing.

The third important element relates to consumer neuroscience and the use of bio-metric and neuro-metric research methods. Consumer neuroscience relates to market research based on the methods within which we do not have to ask participant questions like in traditional methods, instead of, we use the neuroscientific methods of the research. In other words: Neuroscience methods can be used to get answers to the questions related to student engagement. Literally described as "ask the brain, not the person" (Camerer, Loewenstein, and Prelec, 2004), techniques based on the use of neuroscience tools are analyzed with the goal of better understanding a student and the process of perceiving learning materials. With the goal of understanding how consumers think and feel, neuroscience is being used to study brain responses and to uncover unconscious processes. Since consumer neuroscience implies the scientific analysis of an individual's neurophysiological responses during the decision-making process in market transactions (Hubert & Kenning, 2008), and it is applied to the higher education segment in this study.

In this process, marketing knowledge and neuroscientific methods are applied to help students on their learning path, where neuroscientific tools can make their contribution. It is about analysing learning materials and how to improve them (and how to analyse them as well). The focus was on analysing reading materials and presentations/video materials) – how engaging are they (or not)?

To give a clearer picture of the idea behind the research and to illustrate the paths of this approach as well as the research framework, Figure 2 shows the overlapping areas of interest of the research focus (service marketing, social marketing and consumer neuroscience).

Figure 2: Overlapping area of interest in the research focus – learning engagement education through the lens of marketing concept (social, service and consumer neuroscience)



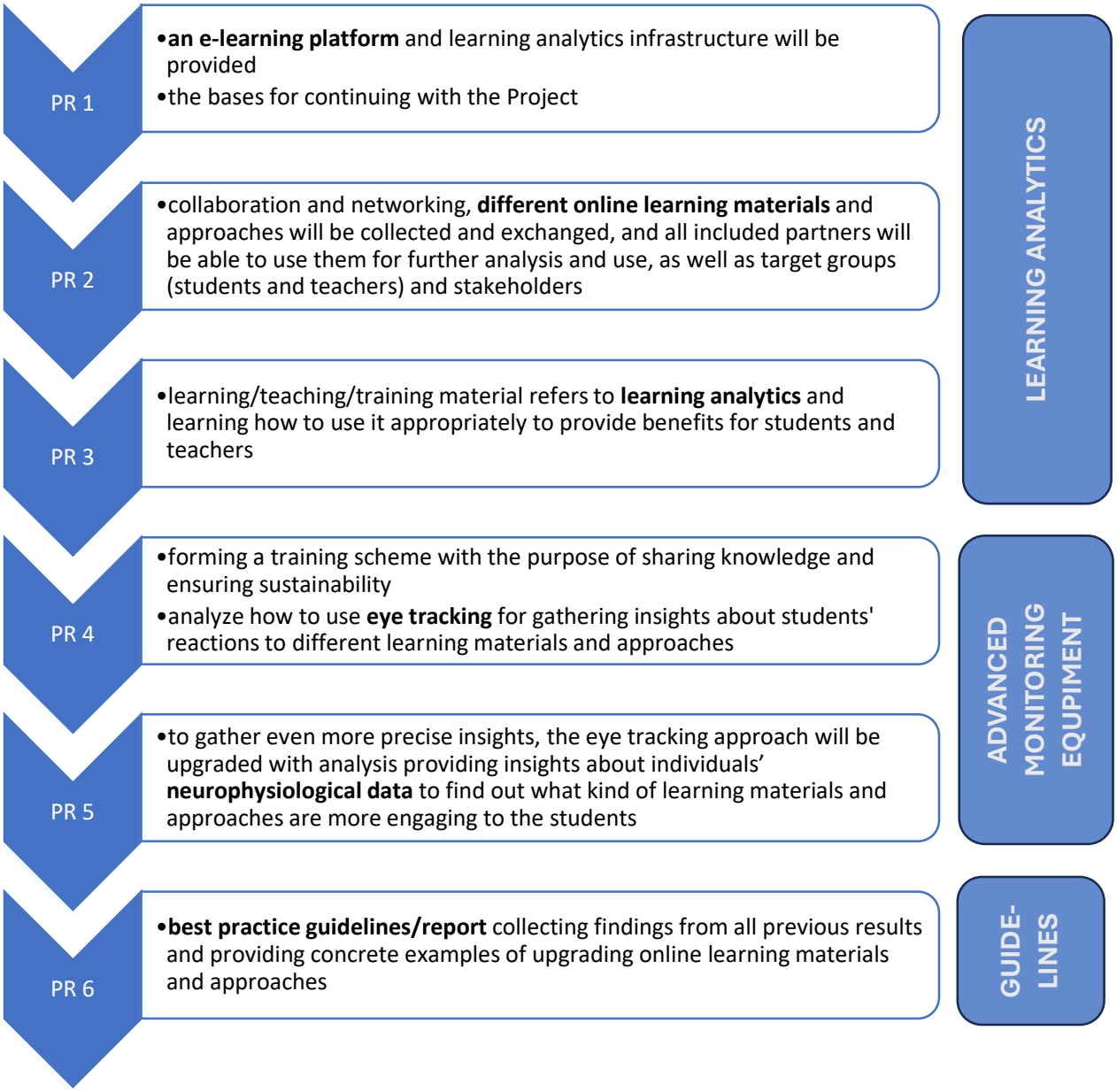
***THE AIM OF THE PROJECT**: bridging the gap of insufficient student engagement in online learning and innovating learning approaches in higher education.*

2.2. Project results

A step-by-step process was prepared with the aim of finding the answers and arriving at a conclusion. The problem described above required an interdisciplinary approach and analysis from different perspectives in order to provide suggestions for a comprehensive solution. First, the platform was set up for uploading and exchanging learning materials. In addition, the most suitable material was discussed, collected and analysed. As an important part of the analysis of the learning process, learning analytics was analysed and presented to underline its importance. To go a step further and analyse an individual (a student) in the learning process, taking into account the importance of the cognitive but also the emotional aspects of learning (Willis, 2026), a further analysis was conducted aiming to use tools such as eye-tracking and the analysis of neurophysiological reactions when students are confronted with different learning materials.

Figure 3 shows the logical and chronological sequence (steps – actual project results) in the search for answers to the questions we posed.

Figure 3: WE-COLLAB project results



PR 6: ***Learning analytics and neurophysiological analysis will enable proposing the best possible ways of understanding students and their needs and wants regarding online learning and ensuring the best possible digital learning materials and approaches.***

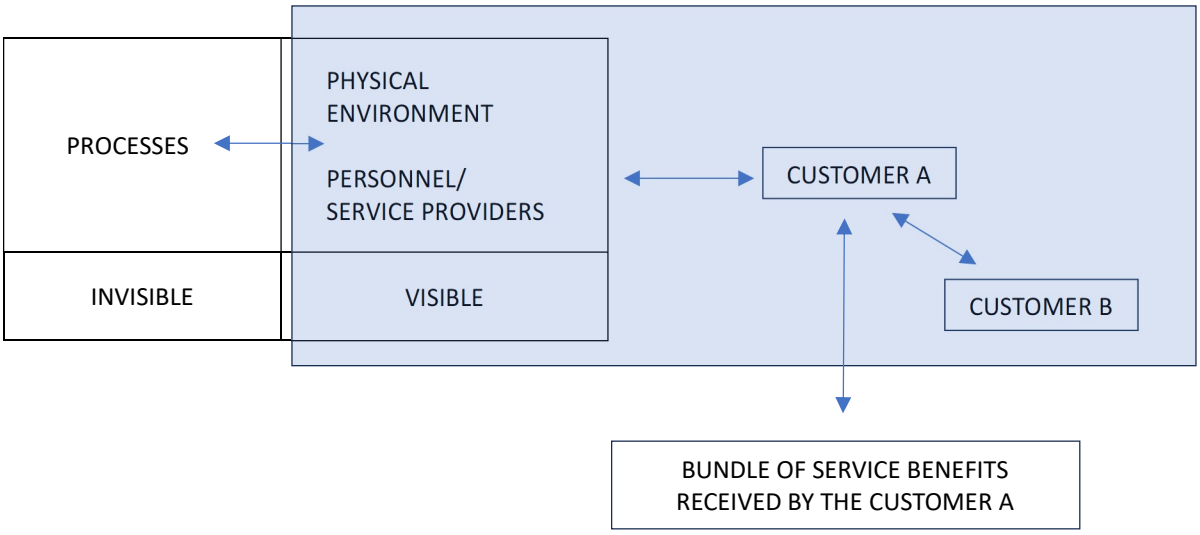
3. ENVIRONMENT AND INDIVIDUAL

As explained in the introduction part, the student can be analysed as a customer within (educational) services. It implies the approach of conducting analysis through the lens of a service marketing concept – servuction system.

3.1. Servuction System and Online Learning

At the Figure 4 it is presented so called servuction system. It refers to the various connections between service customer and service provider on the on side, as well as other services on the other side. Besides, relating to the service provider we can analyse two aspects. The first one is related to those elements that can be seen. On the other, there is an aspect relating to the elements behind the scene, that are going on and which customer can not see but, all those processes behind are relevant for providing flawless service.

Figure 4: Servuction system



Source: Based on Ozretić-Došen (2010)

Herein, based on the service marketing approach, various connection are found:

- customer & personnel
- customer & physical environment
- customer & other customers involved in the process.

As already mentioned, analysing in parallel classes and service and social marketing can also be carried out as part of classroom analysis. Thus, when analysing classroom and online learning, the parallel can be drawn in terms of the following relationships based on Moore's analysis (Pan et al., 2024):

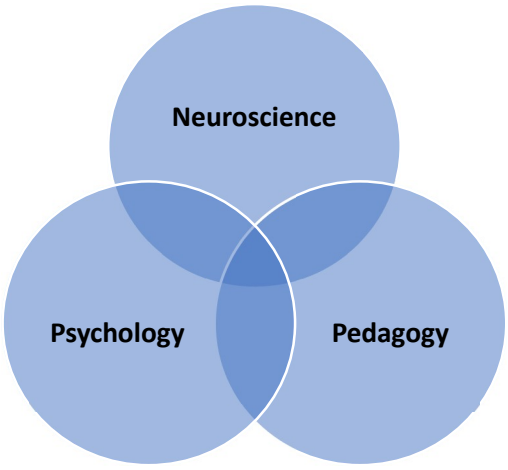
- **Social - Student** – group discussions, small group projects, peer reviews, discussion forums, written-verbal responses, video responses→ education: how can we help our "customers" (students) and make the classes easier for them, encouraging them to be involved and to listen.
- **Student – Content** – assignments, projects, responding to reading materials in forum, reflecting on content in journals, focused notetaking, reciprocal teaching, concept mapping exercise, case studies.
- **Student – Teacher** – assignment submitted & feedback, opportunities for students to ask questions messaging or e-mail, real-time discussions, and discussion forum responses.

In other words, the principle is similar, but here it is about the learning environment and the connections between learners.

3.2. Educational Neuroscience and UDL Guidelines

At the beginning of the year 2000, a new discipline emerged – educational neuroscience (Sousa, 2010, p. 1). As technological developments opened up new research possibilities, new insights were gained thanks to neuroimaging techniques. As in other fields, education also benefited from these new findings.

Figure 5: Overlapping area – the field of educational neuroscience



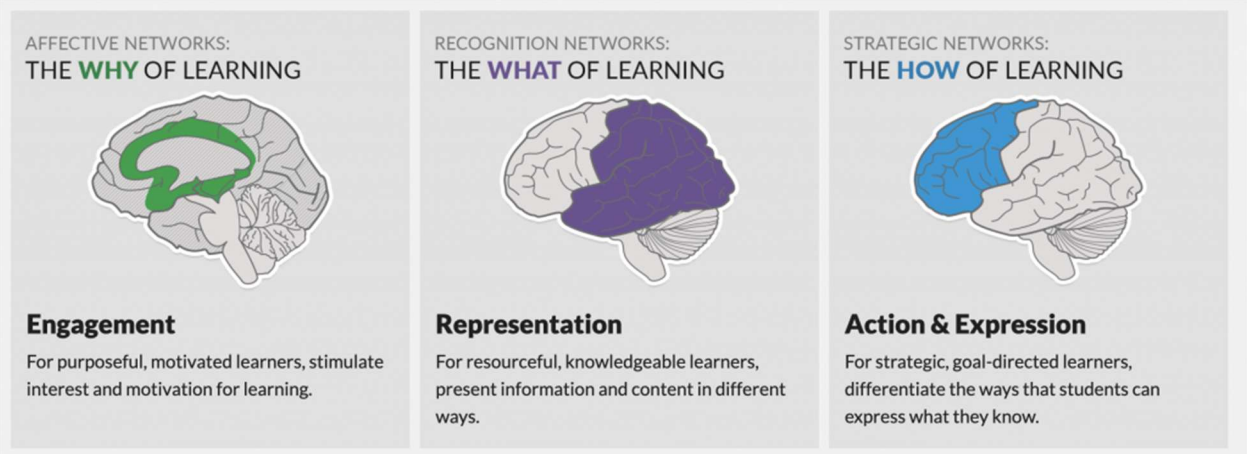
Source: Sousa (2010)

As shown in Figure 5, the fields of psychology, neuroscience and pedagogy intersect to form an area of educational neuroscience that focuses on how neuroimaging contributes to our understanding of how the brain learns and how emotions affect our ability to learn. In addition, researchers in this even broader field are trying to shed light on understanding spoken language acquisition (child), what brain networks are required to learn to read, how the brain represents quantities and numbers, or the ways in which the arts contribute to brain development (Sousa, 2010, p. 3).

So the question is how to help students in this new kind of environment and how to support them in general to learn in this online environment and with most online learning materials. Therefore, research is focused on finding solutions to help teachers create an engaging environment based on the analysis of behavioral and neurophysiological data to improve students' interactivity and emotional engagement.

In terms of focusing to the student and neuroscientific approach inevitable is focus at Universal Design for Learning (UDL) guidelines reflecting on why, what and how of learning, presented at the Figure 6.

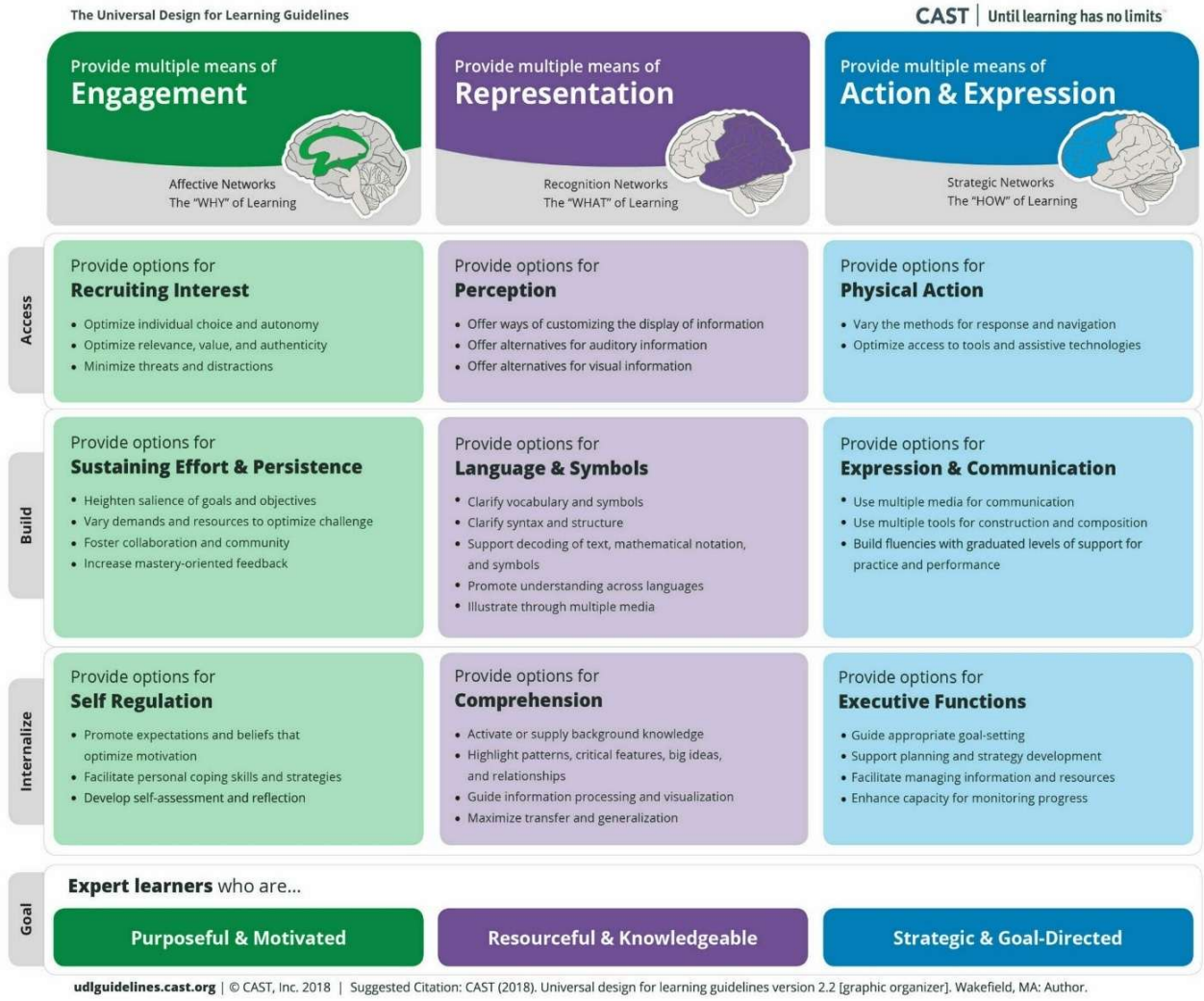
Figure 6: "Why, what and how" – applicated to the learning process



Source: UDL guidelines (2024)

The UDL guidelines reflect a broader picture and approach to learning. More detailed presentation of UDL guidelines is shown also at Figure 7. This argues for an approach that takes into account neuroscientific findings and their implementation in the learning environment. It is important to emphasize once again that the focus of our research is not on the entire learning process, but only on the smaller part related to the (online) learning materials. With the aim of obtaining accurate information about the neurophysiology of the learning process, we compare students' reactions to learning and the differences in their reactions depending on whether they learn online or in the classroom.

Figure 7: UDL approach and guidelines



Source: UDL guidelines (2024)

Although learning implies a much broader framework, our project explicitly focuses on enhancing learning materials to make them more engaging based on neurophysiological findings. In the following part, presented are concrete findings of the WE-COLLAB studies.

4. WE-COLLAB LEARNING ANALYTICS AND SFA

4.1. Learning Analytics

In PR 3, the focus was on Learning Analytics (LA). In the following part, the main directions of the NTUA analysis and a summary in relation to LA are extracted (NTUA, PR3, available at WE-COLLAB we page).

Learning Analytics (LA) can be defined as the measurement, collection, analysis, and reporting of data about learners and their contexts, with the intent of understanding and optimizing learning and the environments in which it occurs. This multidisciplinary field overlaps with data mining in education, statistics, psychology and pedagogy, among others. The scope of learning analytics goes beyond analyzing student performance metrics. It encompasses a broader range of activities: (1) predicting student performance and identifying at-risk students; (2) analyzing student behavior and engagement in online platforms; (3) providing feedback to educators and learners, (4) informing instructional design and curriculum development; and (5) facilitating personalized learning experiences.

The rapid development of technology, particularly the rise of Learning Management Systems (LMS) and online education platforms, has exponentially increased the amount and variety of data available. Over the past two decades, as educational institutions began to realize the potential of this data, there has been a shift from simple reports to more sophisticated analytics.

In today's digital age, where education is increasingly moving online, learning analytics plays a crucial role in improving educational experience. Here are the reasons why it is so important:

- **Data-Driven Decision Making**: Educators can make informed decisions about curriculum design, teaching methodologies, and student interventions based on actual data rather than intuition or anecdotal evidence.
- **Personalized Learning**: With insights from learning analytics, it's possible to tailor educational experiences to individual student needs, ensuring that each learner gets the right content, in the right format, at the right time.
- **Enhanced Student Engagement**: By understanding student behaviors and preferences, educators can design more engaging and interactive learning experiences.
- **Accountability and Transparency**: Institutions can use learning analytics to demonstrate their commitment to student success and to provide stakeholders, including parents and policymakers, with evidence of educational outcomes.
- **Continuous Improvement**: Continuous collection and analysis of data allow for iterative improvements in course content, teaching strategies, and overall educational practices.

In summary, learning analytics is not just about collecting and analyzing data. It's about harnessing the power of data to improve learning experiences, increase educational outcomes and change the way we approach education today.

The following part relates to the data sources, as at the heart of learning analytics is data. The quality, accuracy and relevance of this data play a crucial role in the insights that can be gained from it. Here are the most important data sources in the context of learning analytics:

- Learning Management Systems (LMS): Platforms like Moodle, Blackboard, and Canvas store a wealth of data, including student interactions with course materials, discussion forums, and assessments.
- Online Assessments: Quizzes, tests, and assignments conducted online provide not just scores but also data on time taken, attempts made, and specific areas of struggle or success.
- Student Information Systems (SIS): These systems contain demographic data, enrollment history, and other academic records which can be vital for certain analyses.
- Social Media and Discussion Forums: Interactions on platforms like Facebook groups, Twitter, or course-specific forums can provide insights into student engagement, collaboration, and sentiment.
- Feedback and Surveys: Periodic feedback from students and educators can offer qualitative data that complements the quantitative data from other sources.

It is also important to emphasize that learning analytics does not operate in a vacuum. It serves multiple stakeholders, each with their own needs and perspectives. Stakeholders include students (benefit from personalized feedback, tailored learning pathways, and resources that cater to their specific needs and preferences), educators (can use insights to refine their teaching methods, identify students who might be struggling, and ensure that course materials are effective and engaging), administrators (learning analytics provides a macro view of educational effectiveness, helping in resource allocation, curriculum design, and strategic planning), researchers (can use learning analytics data to study educational trends, test pedagogical theories, and develop new instructional methodologies), and policymakers (with a broader perspective, policymakers can leverage learning analytics to shape educational policies, standards, and practices that align with data-driven insights).

Furthermore, the importance of should be emphasized. Early alert systems, supported by learning analytics, represent a proactive approach to education that ensures students receive timely support and interventions. By identifying and addressing challenges early, these systems improve the academic experience and promote a supportive and nurturing educational environment.

Implementing learning analytics in educational institutions requires a thoughtful and strategic approach. By following best practices, institutions can maximize the benefits of analytics while minimizing potential pitfalls. Implementing learning analytics requires careful planning, collaboration and continuous refinement. By adhering to best practices, institutions can harness the power of analytics to improve education while maintaining ethical standards and prioritizing student well-being. As it is concluded within PR3 of the WE-COLLAB project (NTUA, 2023), as learning analytics continues to evolve, these best practices will serve as a guiding light, ensuring that analytics is used responsibly and effectively.

4.2. WE-COLLAB Student Feedback Application

The partnering institution, LINK srl, has developed the WE-COLLAB Student Feedback Application. The following chapter contains instructions on how to use the app in (online) courses and analyses the advantages as well as the elements that need to be upgraded.

First it is important to explain following. In the framework of the "accelerated HE digitalization" (Nicklin et al., 2022) as a consequence of COVID-19 pandemic environment we were facing the problem of the communication and information exchange. As the motivation behind the project was also the awareness about lack of self-regulation and a sense of being isolated from teachers and peers, which often results in "the silence of the black squares", as explained at the beginning. The WE-COLLAB project thus aims, among other things, to close this gap by enabling lecturers in higher education to "think like an experienced instructional designer" and redesign their online courses to increase their students' satisfaction.

Although tools such as Google Meet and Microsoft Teams or Socrative and Mentimeter (2024) were available to teachers, offering the possibility to give reactions such as emoticons or likes, the problem was also how to collect more specific information and allow students to be more engaged in online lessons. With this goal of enabling better ways of interacting and sharing information online, the Student Feedback Application (SFA) was developed. At the same time, the development of this type of app could contribute to better socialisation of students online, as the loss of socialisation is a negative feature of the online learning approach. In addition, a study comparing perceptions of classes between online and face-to-face students found that the perceived level of socialisation was significantly lower in the online approach (teamwork, peer support, contact with peers) (Vujičić, 2024).

The SFA can give students the opportunity to provide feedback to the professor, knowing that a certain level of engagement is required, and making them the feeling that a response is expected (which indirectly ensures that they can focus better in online courses). Secondly, it helps teachers get information that gives them a sense of the direction of the lesson and where corrections are needed, as teachers have less insight into facial expressions in online courses than in face-to-face courses. AS WELL, SFA offers additional chat opportunities to improve communication among students, where most students have the problem of not being able to socialize.

Relating to the feedback and based on the analysis of previous literature, feedback should be: educative (non-evaluative), clear (unambiguous), empathetic, timely, indicative (the student's performance), representing the ongoing dialogue and not the end result, and proportional (criteria, objectives) (Jurs and Špehte, 2021). In a traditional learning approach, “feedback” is usually perceived as a dialogue or tool for the learner (Jensen et al., 2012). In synchronous online teaching, on the other hand, it is important to give students the opportunity to respond immediately if, for example, something is not clear/difficult to understand or should be repeated. This is because online teaching is a different learning environment to face-to-face teaching and teachers cannot see students' facial expressions that show, for example, their confusion or difficulty with understanding a particular topic.

To assure technical flowless of the application, following features had to be fulfilled. The SFA was designed to gather voluntary subjective feedback messages from the students during a class ("an event"), based on a set of "reactions" capable of expressing cognitive and emotional states. As explained by partnering organization – Link, within supporting the project and achieving WE-COLLB project results as well as depicted at ALTA 24 publication (Penas Ibanez et al., 2024): the SFA is a slim application with a user interface consisting of a few basic screens. The core screen of the app is a virtual keyboard, including six buttons associated with specific reaction types, revealing student reactions. The reaction messages are visualized in an Event Dashboard, which combines three panels: (1) a word cloud (at which size and colour of the names of the reaction buttons evolve according to students' feedback), (2) an analytical view, which lists the reaction messages as they arrive, together with timestamps and sender identifiers; and (3) a chat area. The data generated by the attendees through the virtual keyboard of the SFA, besides feeding the Event Dashboard, are saved to a local store and optionally sent to a Learning Record Store (LRS) in the form of xAPI statements; thus, the data can be retrieved and analyzed at any time. Events must be defined in terms of time and entitled participants (LMS already includes a Calendar were starting time and duration of each Event can be defined). Furthermore, the SFA adds a mechanism that, under the control of the organizer of the event, allows participants to join the same event with different levels of anonymity.

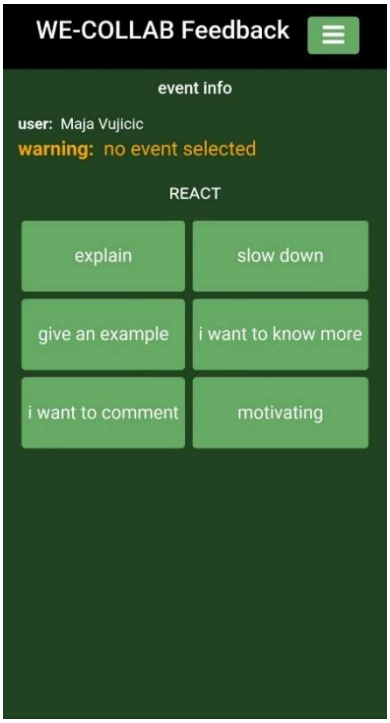
In order to be implemented within classes, a preliminary research for adapting SFA was conducted. The aim was to provide an app that could be adapted to the exact needs of the specific class/students. In order to achieve this, first it was decided on the number of the reactions provided. It was decided that six reactions will be included not including too much of them in order not to cause a distraction. Hence, fllowing part is depicted at ALTA 24 conference proceedings and it relates to defining the student reactions. In order to select the most appropriate reaction buttons, a survey of students (2nd year students at the University of Rijeka - Croatia, Faculty of Economics and Business) was conducted, followed by an interview with an expert in the field of pedagogy. The research was conducted in March 2024 via Google Forms. A total of 165 participants took part in the survey. Participants indicated which reactions they would find most useful in the context of the application described. In addition, based on previous results (Pan et al., 2024), participants provided their responses on the Likert scale (from 1-strength disagree to 5-strength agree) regarding perceived usefulness as well as the possibility of SFA being a distraction.

From the results, the following 6 options emerged as the most important ones that students would like to have in the application (in the brackets is the number of times specific reaction was mentioned in the survey and similar expressions were grouped in the same response): explain (113), interesting (74), clear (73), too fast (59), educative (36), repeat (32). Responses such as clear, interesting and educative were eliminated and changed after consultation with an expert in the field of pedagogy. Clear offers no additional benefit, interesting and educative are reformulated into motivating. This decision was also based on other responses collected (but which took less time), such as: impressive, inspiring, intriguing – all of which led to the solution to include motivating as one of the reaction buttons. Repeat was covered with explain, but also with the introduction of an example as a reaction with the aim of achieving an even deeper understanding of the educational material presented. In addition, reactions I want to know more (more) and I want to comment (comment) were added based on the students' summary of the following

suggestions: I want to comment, I want to give an example from the practice, I want to know more, I want to give a counterargument.

Finally, the following responses were included in the SFA: explain (you need a more detailed explanation of the topic presented), slower (slow down (you need to present the lesson more slowly), example (you need an example to understand the explanation), (I want to know more) (you are interested in knowing more about the topic), (I want to) comment (you want to give a comment), motivating (you find the topic interesting and motivating). The example of SFA interface is shown at Figure 8. In addition, the perceived usefulness of the SFA students described was rated with an average of 4.00 and the perception of possible distraction with an average of 2.35. With the goal of facilitating better communication among students and bridging the gap of lack of socialization, chat was also established at SFA.

Figure 8: The example of SFA interface



SFA was tested in courses at the Faculty of Economics and Business (UNIRI) in the Marketing course at undergraduate level among full-time and part-time students in the 2023/2024 academic year. SFA was experimentally introduced in the courses at UAM in 2024, as well as Sapienza with the aim of conducting the study related to PR5.

Based on the BrainSigns analysis (related to the PR5, available in chapter 5.2.) there are also comments from the students. The conclusion refers to the following main limitations in the use of SFA. First, students are used to employ tablet/laptop for taking notes and following the lesson, and the use of an additional device (mobile phone) is demanding. Second, students have their mobile phones there, but for

"emergencies" (e.g. calls, messages, WhatsApp) and if they have an application open, they cannot use their phone anymore. On the other hand, if they use the application through using the Webapp directly on the laptop, then is difficult to take notes. Finally, they prefer to intervene during the lessons instead of using the app, which again opens new questions and gives directions that the use of the SFA is not seamless so far and the cost is higher than the benefits.

It is important to emphasize the sustainability of the student feedback application as one of the outcomes of the WE-COLLAB Erasmus+ project. SFA has been developed and adapted in relation to the specific responses, but it is important to emphasize that it has the potential to be further improved. The possibilities include the input of precise terms/responses, which can be flexibly modified according to the wishes of the students and teachers – i.e. it can be determined how many and which responses the app should contain. In addition, a few further steps can be taken to focus the app more on its use as a tool for answering some specific questions from teachers. In the context of the above, the application could be personalized and adapted to the academic level. This means that the application could be further upgraded by adding other interactive possibilities that give even more precise feedback - i.e. the application could be upgraded to allow even deeper interactions, e.g. by displaying the criteria that need to be met as a kind of checklist to control certain learning materials (Rodway, 2017). Further analysis should focus on enhancing the application to provide even more detailed responses from both sides – students and teachers - and analyzing its use in other domains (Rodway, 2017; Carless and Boud, 2018), as suggested in previous research.

SFA is therefore aimed at improving interactivity and should enable students to send an immediate response during (online) lessons.

5. WE-COLLAB ANALSLSIS AND FINDINGS

5.1. Individual – learner and learning materials

5.1.1. Comparison of Contents

One of the main project goals was to compare different learning materials and student engagement. What is more important, we wanted to analyse student reactions that can not be spoken and explained in words, so we use neuroscientific tools to gather deeper understanding of an individual reactions to the different learning materials. Aim of this study was to identify differences in attention and engagement across different educational material types, reflected in neurophysiological responses.

With this purpose, study compared following learning materials on the same topic:

- Task A: an educational video
- Task B: a traditional training video with PowerPoint slides and narration
- Task C: a text-only format.

For the purpose of this study conducted by BrainSigns, 10 participants from Sapienza University were involved. The focus was aimed at evaluating participants' cognitive responses to three different educational materials stated explained above. Participants engaged with each format of educational materials, and neurophysiological signals were consistently recorded.

Used neuroscientific tools included:

- electrooculography (EOG), - ocular parameters (eye blink rate and duration)
- photoplethysmography (PPG) and HR (LF/HF HRV)*
- electrodermal activity (EDA)

by means of which measured were eye blinking, cardiac activity, and skin sweating.

As well, participants completed content-focused questionnaires and qualitative inquiries on learning material quality.

Table 2 summarizes conclusions and guidelines – directions for implementation in practice.

Table 2: Conclusions and guidelines – directions for the implementation in practice

			Task A = video	**Task B = PowerPoint + narration**	**Task C = text**
NEUROSCIENTIFIC TOOLS	**Attention** (biomarker = ocular parameters)	inverse Eye Blink Rate	(2^{nd} place)	(3^{rd} place)	highest values (1^{st} place)
		Eye Blink Duration	reduced blink durations		higher values
	Mental engagement and effort (physiological responses: HR (LF/HF HRV))*				the highest values
	Physiological arousal (electrodermal activity)		no significant effects		
TRADITIONAL APPROACH	Questionnaire data – error rate		22%	28%	44%
	Qualitative Assessments - comprehension ease - memorization - attention - interest - engagement		 70% 68% 74% 81% 84%	 59% 53%	 38% 36%

*Heart Rete – Low Frequency/High Frequency Heart Rate Variability

Source: Study made by BrainSigns (WE-COLLAB PR5)

***MAJOR FINDINGS**:*

The comprehensive findings unequivocally endorse Task A's pedagogical superiority in multiple dimensions, emphasizing its significance in cognitive performance and learning experiences. In conclusion, participants exhibited greater difficulty with the textual material, as evidenced by lower scores in both performance and experiential quality. This difficulty indicates a heightened cognitive effort required for engaging with textual content.

Based on the BrainSigns study following can be concluded (BrainSigns, 2024):

1) Related to the **ocular parameters,** Eye Blink Rate (EBR) in particular is considered one of the most powerful biomarkers of attention, with an inverse correlation with it. Significant effects have been measured in terms of both Eye Blink Rate and Duration. The Task C (text) exhibits the highest values of inverse EBR, i.e. Attention, followed by the educational Task A (video) and the Task B (PowerPoint presentation). The following indicator, Eye Blink Duration (EBD) revealed that Task C (text) appears to be associated with higher EBD values. The analysis of EBD for Task A and Task B (both video formats) indicated reduced blink durations, particularly in the highly dynamic and information-rich Task A (video). This pattern aligns with the findings of studies proposing blink waveform parameters, including blink duration and prolonged closure durations, as indicators for predicting drowsiness and diminished performance.

2) Related to the **physiological responses** (Heart Rate (HR) and the Low Frequency/High Frequency Heart Rate Variability (LF/HF HRV)), HR showed significantly ($p < 0.05$) highest values in correspondence of the text (Task C). In the other words, task C (text) can be correlated to the highest mental engagement and effort

3) In terms of **electrodermal activity** (EDA) (related to biomarker of physiological arousal) no significant effects have been found.

4) Related to the traditional approach and use of **questionnaires**, participants' responses revealed notable disparities. Error rate was the highest in the Task C (text) with a 44% error rate, notably surpassing Task B (ppt + narration) with 28% error rate and Task A (video) with 22% error rate. Furthermore, Task A was favoured through all aspects of qualitative assessments including comprehension ease (received positive responses from 70%, memorization (68%), attention (74%), interest (81%), and engagement (84%). Task B and Task C scored 59% and 38% for interest and Task B and Task C scored 53% and 36% for engagement. Assessments and performance-based questionnaires showed that participants found the text material the most challenging.

5.1.2. Learning material analysis

5.1.2.1. Testing pre-recorded learning materials

The motivation for the WE-COLLAB project can be described by the problems defined in the project proposal, which result from the following challenges:

- "Zoom fatigue" due to long, consecutive video conference sessions,
- increased distractibility and shorter attention spans as well as
- information overload when too much information arrives too quickly.

The study made by SenseLab (CBS) give the answers in line with those directions addressed at the beginning. The study findings aimed to provide guidelines for designing optimal online learning materials.

The aim of pilot study conducted at CBS was to understand students' learning processes when they are faced with pre-recorded online learning materials. The analysis is conducted based on data gathered from eye-movements and response to the teacher's voice (measured based on bio-metrics) and data related to the test persons' learning outcome (measured in "traditional" approach – level of correctness in a multiple-choice test).

The study utilized following approaches:

- **eye-tracking** provides data on visual **attention** and search patterns with the purpose to reveal how visual elements in online material are able to grab attention as well as reveal precisely where and when a viewer of an online learning material loses attention and risks missing core objectives
- **voice analysis** and **face recording** provide data on **emotional engagement**
- **surveys** providing data on level of memory of the learning material.

Within the study, learning materials based on four videos were prepared. The study tested those four videos individually exposed in a randomized order to 50 test persons. After each video the test person answered multiple-choice questions about specific content in the video described as the learning objectives for the material. The main conclusions are depicted within Table 3.

Table 3: SenseLab (CBS) study – the main findings

Approach/ kind of material	Findings
AUDIO	Intonation refers to rise and fall of the voice - is the speech monotone or lively. → **SWITCHING TONE WILL LEAD TO HIGHER MEMORY RETENTION FOR ONLINE STUDENTS.**
	Speaking rate refers to the rate with which a person speaks, it is measured in numbers of syllables per second; variations in speaking rate might indicate some important utterance. → **CHANGING SPEAKING RATE WILL LEAD TO HIGHER MEMORY RETENTION FOR ONLINE STUDENTS.**
	One simple way to make the variation is by making pauses in the speech and especially after the core learning objectives. → **MAKING PAUSES IN YOUR SPEECH WILL LEAD TO HIGHER MEMORY RETENTION FOR ONLINE STUDENTS**
VISUAL	Clear layout → **A CLEAR LAYOUT HELPS IN MEMORIZING THE CONTENT AND PREVENTS STUENTS FROM MIXING THE LEARNING OBJECTIVES.**
	Visual attention data revealed that looking at the learning objective several times increases the memory. → **LESS REMEMBERING IF THE LEARNING MATERIAL DOESN'T BECOME REVISITED**

Source: SenseLab – CBS, 2024 (WE-COLLAB PR4)

MAJOR FINDINGS: Conclusion related to the conducted pilot study emphasize that memorization of the content provided in the learning video can be increased by: switching tone, change in speaking rate and variation in teacher's voice, leading to higher memory retention for online students → and in the end higher learning outcome. The study revealed understanding of how visual elements in online material grab attention and revealed where and when a viewer of an online learning material loses attention and founds in risks missing core objectives.

The findings can also provide guidelines for designing online learning material and be combined with the guidelines from the Department for Teaching & Learning, CBS.

5.1.2.2. Testing storytelling video example

The following part relates to the evaluation of a lesson presented within a video. First of all, it is important to explain following important concepts for this analysis and what they refer to:

- **Mental workload** – the amount of cognitive resources „allocated" on the main task
- **Approach – Withdrawal** – the balance between the behavioural inhibition and approach system, implies a measure of the positive and negative user's motivation
- **Visual attention** – a measure of sustained focus
- **Emotion** – combines the information about the valance, i.e., the quality, and the arousal, i.e., the intensity, of the user's emotional state into a synthetic indicator (BrainSigns, 2024).

The experiment was conducted during a "Learning laboratory" organized in May 2024 at Copenhagen Business School – SenseLab (CBS) the purpose of which was to demonstrate how neuroscientific tools can assess learners' reactions to varying learning materials. Five examinees participate in the pilot study (3 males, 2 females). The aim of the study was to evaluate students' cognitive and emotional experiences while watching two learning videos of the same content ("Politeness and Communication") but of different lengths. Following are descriptions of videos watched:

- LONG: Duration 11 minutes and 30 seconds, including 27 slides with more text and
- SHORT: Duration 5 minutes and 20 seconds, including 15 slides with fewer details.

The neuroscientific tools used were EEG (Mindtooth Touch) for brain activity, PPG and EDA (Shimmer3) for heart and skin responses. As well, at the end of watching the videos, participants answered to the questionnaire consisting of 10 questions. The results of this study are shown in Table 4, which refers to the comparison between the reactions to the longer and the short video.

MAJOR FINDINGS: Final conclusion from this pilot study is that the LONG video resulted in greater appreciation and better performance. Although this video requiring more mental effort, effective narrative and a balance between duration and information density were crucial for maintaining participants engagement.

These findings underline the potential of neuroscientific approaches to better understand students and based on that tailoring lessons to their cognitive and emotional abilities. In this way, their engagement and learning outcomes can be optimized. All of this suggests that neuroscientific tools can provide valuable insights for adapting educational content to improve student learning and provide a strong basis for the development of student-centred educational models.

Table 4: Comparison of the short and long video

<table>
<tr><th colspan="2"></th><th>SHORT video</th><th>LONG video</th></tr>
<tr><td rowspan="5">NEUROMETRICS (synthetic measures of a specific mental/emotional state)</td><td>Mental workload
the amount of cognitive resources „allocated” on the main task</td><td>Workload levels above baseline.</td><td>Workload levels above baseline.
The LONG video demanded more mental resources after the initial 3 minutes.</td></tr>
<tr><td>Approach – Withdrawal / Motivation
the balance between the behavioral inhibition and approach system, measure of the positive and negative user’s motivation</td><td></td><td>The LONG video increased motivation and interest toward the end, attributed to more dynamic content and new slides.</td></tr>
<tr><td rowspan="2">Attention
a measure of sustained focus</td><td></td><td>LONG video captured higher attention initially (likely due to the greater number of slides and textual content).</td></tr>
<tr><td colspan="2">In both videos tables required more attention regardless of the video length.</td></tr>
<tr><td rowspan="2">Emotion
synthetic indicator of the users emotional states; combines:
• information about the valance (quality)
• arousal (intensity)</td><td></td><td>The final participatory example in the LONG video boosted emotional engagement again.</td></tr>
<tr><td colspan="2">In both videos emotional engagement was highest at the beginning (reflecting curiosity) but decreased over time due to relaxation.</td></tr>
<tr><td>TRADITIONAL APPROACH</td><td>Learning Performance – Questionnaire</td><td></td><td>Participants answered more questions correctly after watching the LONG video, suggesting better learning outcomes.</td></tr>
</table>

Source: Study made by BrainSigns (PR5)

5.2. Environment – comparison of remote and in-presence classroom

This study aimed at comparison of students' reactions during in-person and remote lessons. Students' cognitive and emotional experiences during two different approaches were analysed.

The study was conducted at Sapienza in 2024 at the courses "Lingua Spagnola" and "Bioingegneria" using the same teacher and content to eliminate bias. Participants included 6 students attended 4 lessons within the "Lingua Spagnola" course; 3 students attended 1 lesson within the "Bioingegneria" course. Lessons were 30 minutes in length, delivered by the same teacher in both in-person and remote formats.

The goal was to assess the impact of these modalities on: **mental workload**, **attention**, and **emotional engagement**. It was organized and based on the equipment as described below:

- **mental workload, attention, and stress** – measured by EEG (Mindtooth Touch) for analysis of brain activity
- **emotional arousal and engagement** – measured by HR and EDA (Shimmer3) for analysis of heart and skin responses
- **WE-COLLAB Student Feedback App (SFA)** for collecting students' real-time feedback.

Special remarks refer to the SFA usage. Explicit feedback from students collected through the SFA (included comments like "slower" and "explain") reflected difficulties in following the teacher. Also, the app was not seamlessly integrated into the learning process since students prioritized using laptops or phones for other tasks. In addition, the sparse and inconsistent feedback limited the correlation with neurophysiological measures. The SFA needs to be further improved (as explained in chapter 4.2. of this report).

MAJOR FINDINGS: Based on the BrainSigns findings within PR5 of the WE-COLLSB project, it can be concluded that neurotechnologies provide objective insights into students' learning experiences:

- ***In-person lessons may induce higher stress but enable lower distraction compared to remote settings.***
- ***Remote lessons, while cognitively demanding, may need better engagement strategies.***

Comparison of the in-presence and remote approach is shown in Table 5.

Table 5: Comparison of the in-presence and remote approach

	IN-PRESENCE LESSONS	REMOTE LESSONS
WORKLOAD		Significantly higher workload, suggesting greater difficulty in learning and memorizing the provided information.
DISTRACTION		Higher distraction levels were observed, **indicating that increased workload did not equate to better engagement.**
STRESS	Higher stress, particularly at the beginning, possibly due to social or environmental factors.	
EMOTIONAL AROUSAL	At the same time, emotional arousal was similar across both modalities, with minor differences in Skin Conductance Level (SCL). The emotional arousal (a combination of SCL and Heart Rate) showed no substantial variation between in-person and remote formats.	

Source: Study made by BrainSigns (PR5)

Overall, the following conclusion can be drawn. The studies conducted highlight the importance of tailoring educational strategies to each modality and using neurotechnologies to optimize lesson design and improve student engagement in both face-to-face and remote environments. In particular following conclusions are derived (BrainSigns, 2024):

- Neurotechnologies are a powerful tool to get objective information about the students' experience
- The advantage of this information is to be available online and eventually synchronous with specific events
- They can be translated into relevant KPIs, i.e. learning analytics, to be applied at different levels of education: evaluation of materials and contents, of education modalities, of lessons design, etc.
- It is still difficult to integrate them with other analytics (e.g. Feedback App), to understand how to integrate them in a different way.

6. ADDITIONAL

6.1. SenseLab (CBS) – setting directions for the further research

As part of PR 4, the Learning, Teaching and Training Activity named "Learning Laboratory" was organized at the Copenhagen Business School, Department of Marketing, in their SenseLab. The aim of the workshop was to develop ideas to outline the value of using bio-metric and neuro-metric data in the process of planning and improving online learning materials. The workshop combined theoretical and practical elements, including lectures by experts in online learning (Department for Teaching & Learning, CBS) and experts in bio-metric and neuro-metric testing (iMotions).

Within part led by experts from the CBS Department of Teaching and Learning were analyzed and commented participants' courses and methods and shared our experiences of teaching and supporting teaching. Following, presented topics included: state of the art in higher education pedagogy, accessibility and inclusion, online engagement fatigue, AI in online assessment. Accessibility is seen as a valuable enabler for online students and the focus is on course design, such as using higher contrast, color coding, and less text on slides, which makes it easier to visually interpret the content. A short guide to creating accessible online teaching materials has been presented and can be found online (https://teach.cbs.dk/resources/accessibility/).

One of the most important parts of the Learning Laboratory and the main focus was to understand the value of biometric research in learning. To give us a complete picture of data analysis and an overview of the possibilities based on many examples, we were visited by the provider of software for bio-metric and neuro-metric data acquisition (iMotions). The main points they explained insights about: what is feasible and what cannot be measured, advice on how to conduct a biometric study, do's and don'ts, examples from previous research that could be useful for our research.

The information about the software and its use provided a direction for the further development of our research questions. Particular attention was paid to defining parameters that are important for eye-tracking research: what should be tested (stimuli, models, videos, PowerPoint…), how should be tested (use of equipment and need for data), who should be tested (optimal subjects), what should be presented as a result, what conclusions should be drawn. To proceed with our experiments at Learning Laboratory, we discuss the proposed research questions and discuss their further development, possible analysis, implications and perspectives. Based on this discussion, we determine the most promising research questions to proceed with in the field research. This was followed by data collection, including setting up a study and conducting the experiments with the subjects. Then we analyzed the data and learned how to do that. Finally, the preliminary results and reflections were presented and, based on this, the next possible steps for the research were determined.

Hence, a lot issues were discussed and many answers were given, but at the same time new questions were raised on the basis of the discussions, which are summarized in Table 6.

Most of the topics are focused on bio-metrics and neuro-metrics and one relates to the Student Feedback Application, which is why it is discussed separately here. It is about the research question "How can feedback be optimized and what is the value of feedback in online learning materials?" – This could be applied to the invented app.

Table 6: Potential research questions and designs for the future studies

Potential research question	Description	Research Design
Text vs. illustration – what works best?	- When to use text and when to use illustrations for explaining content of theory? - The question can be related to textbooks, PowerPoints, and videos. - For the videos the speech could be an independent variable related to rhythm, prosody, pauses, …	A pilot study was made (five test persons) in SenseLab at CBS – eye-tracking and emotional response (face recording)
Domain of text – will a summary increase motivation for learning?	- When will a short text (summary/abstract) in a learning situation increase motivation for learning and which kind of glossaries and keywords can support the learning? - Will highlighting of these words increase the value of summary/abstracts. - The study could differentiate between actors, such as students (academic learning) and employees (organizational learning).	Short and long study could be relevant - eye-tracking supplemented with questionnaire
Subtitles in videos – are subtitles good for learning?	- When will subtitles support the learning and when will it take away attention from the video content? - Where do people look and how will they divide the attention? - Which variables (sound/illustration/graphs/…) could influence the ration between subtitles and video content? - Can personality be variable that explain the value of using subtitles?	Relevant for eye-tracking

Does AI support learning?	- Will AI be noticed by the viewer? Does it influence the learning outcome? - Can AI help individuals and personalize the learning material? - Will personality explain the willingness to accept? - Will an avatar be accepted in a learning situation?	Relevant for EEG + GSR and also qualitative research
Can voice increase learning in online videos?	- What is the impact of the teacher's voice in a video (memory/liking/acceptance/…)? - Testing "talking heads" vs. "full body" appearance. Fluency and mother tongue could be added as variables.	Voice analysis in combination with eye-tracking. Some of these were tested in the pilot study in SenseLab at CBS
What is the optimal duration of an online learning material?	- Testing time for optimal learning material. - How long can/will be best for learning? - Time of day could be a relevant variable. - Memory test could/should be added.	A pilot study was made with test persons in SenseLab at CBS – EEG + GSR
When is enough enough?	- This could be an add on to the RQ about duration, as measuring fatigue is central. - When does it happen and how to plan a learning material based on this insight. - Is fatigue related to personality (big five), age, gender, stress, time, …?	Suitable for EEG + GSR + HVR (heart rate variability)

Source: Based on PR4, SenseLab CBS Learning Laboratory – Jesper Clement (2024)

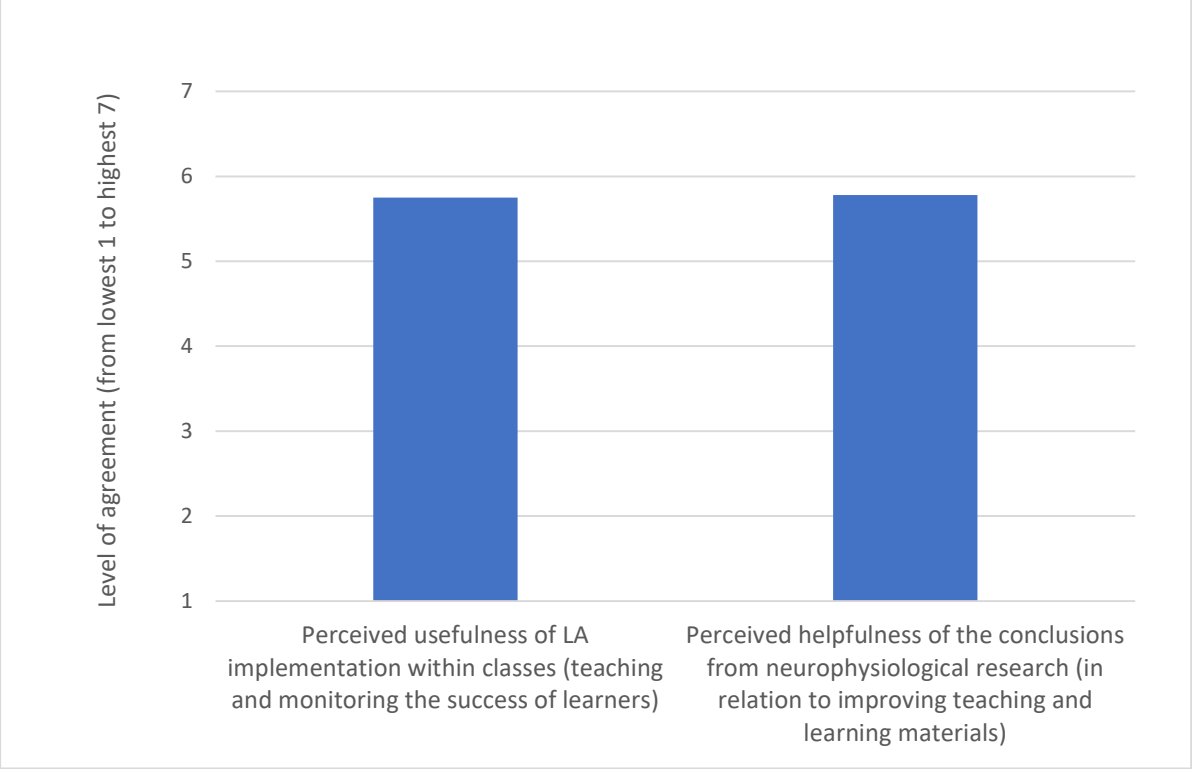
6.2. Survey Results (UNIRI)

In line with the social marketing approach and with the aim of determining the level of experience and awareness of the possibilities of learning analytics and neuroscientific research tools, the surveys was conducted. In addition, the perceptions of the target group in different countries with regard to the project topics were to be analyzed.

The survey was conducted in January 2025 at the partner institutions (UNIRI, UAM, KTU) and involved a total of 67 participants. The survey questions can be found in the Appendix at the end of this document. Participants included teachers from all levels of education (primary, secondary, tertiary level), with the average experience of 18 years working as a teacher, and from various fields.

Based on the results (Figure 9), it can be concluded that the perception of the implementation of learning analytics is rated as very useful for teaching and monitoring the success of learners (on average 5.7; on a scale from the lowest 1 to the highest 7).

Figure 9: Perceived usefulness of LA and helpfulness of neuro-metrics within learning process and materials



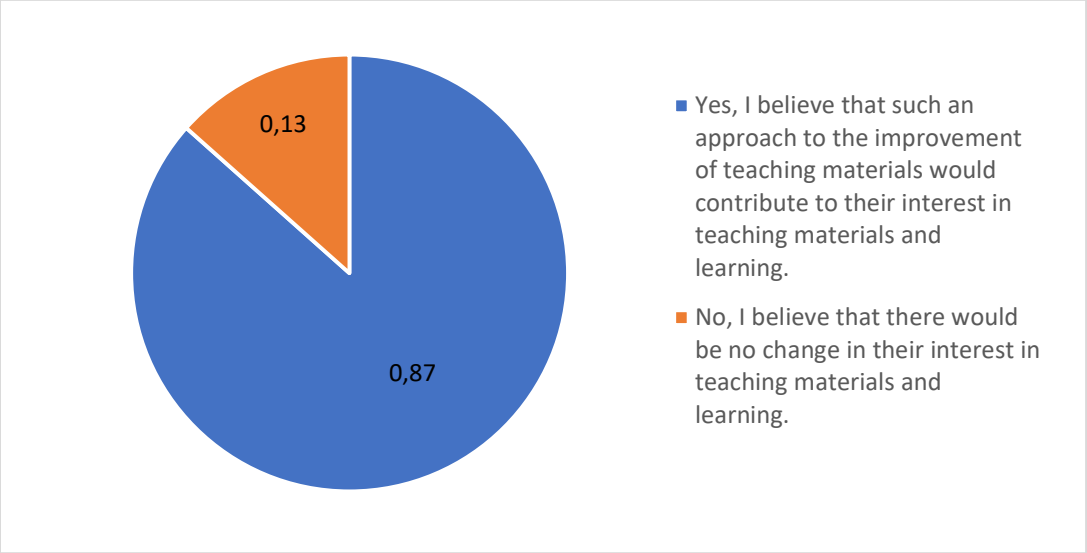
Source: Results of the survey conducted within PR6 (UNIRI)

Furthermore, the participants estimated that the knowledge gained from neurophysiological research could be helpful for improving teaching and learning materials in their teaching practice (average rating of 5.8; on a scale from lowest 1 to highest 7). Related to the LA usage it can be stressed that majority of participants from elementary schools do not use Moodle.

Teachers assume (93% of the respondents) that most of their students are still not familiar with the possibilities of implementing neurophysiological research and the findings based on it in learning practice.

Important finding that supports our continued efforts and commitment in this area is the result of the survey, which showed that 87% of respondents (teachers) expressed their opinion that their students would benefit from teaching materials adapted on the basis of knowledge obtained from neurophysiological research (Figure 10).

Figure 10: Opinion about students having benefit from teaching materials based on knowledge from neurophysiological research



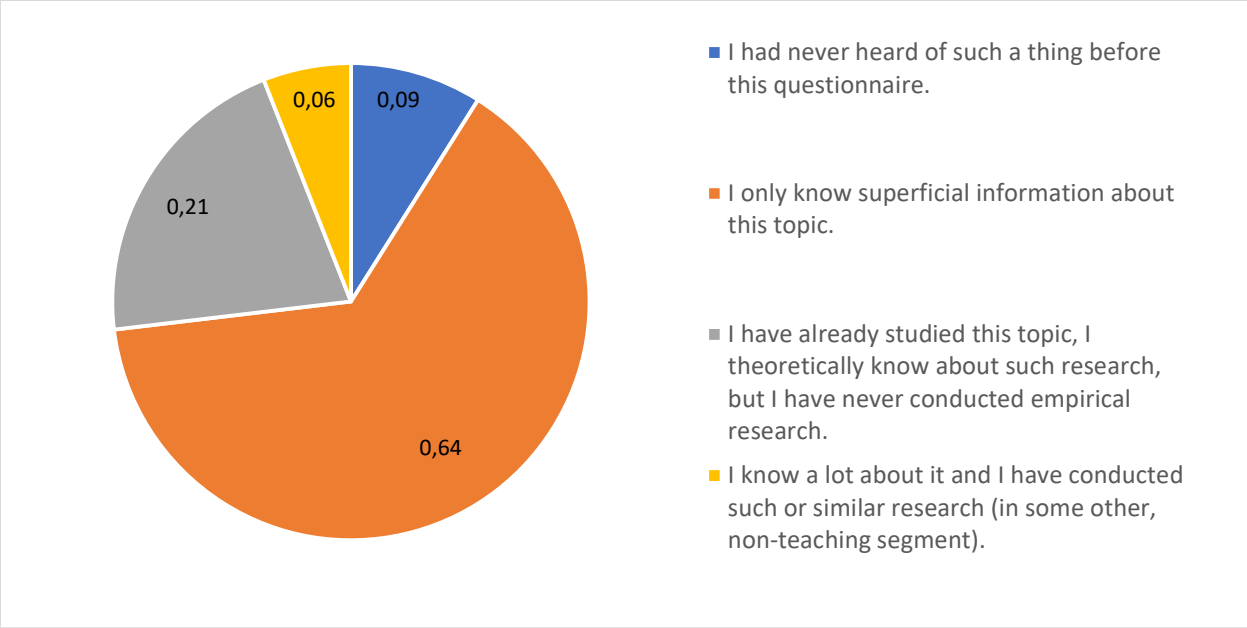
Source: Results of the survey conducted within PR6 (UNIRI)

Below are the answers related to the teachers' self-assessment. Answers about the level at which teachers would evaluate their knowledge about the implementation of neurophysiological research insights (with the purpose of improvement of learning materials) are shown in Figure 11.

Related to the participants engagement with this topic, it was interesting to analyse their involvement during last years. What is found is shown at Figure 12.

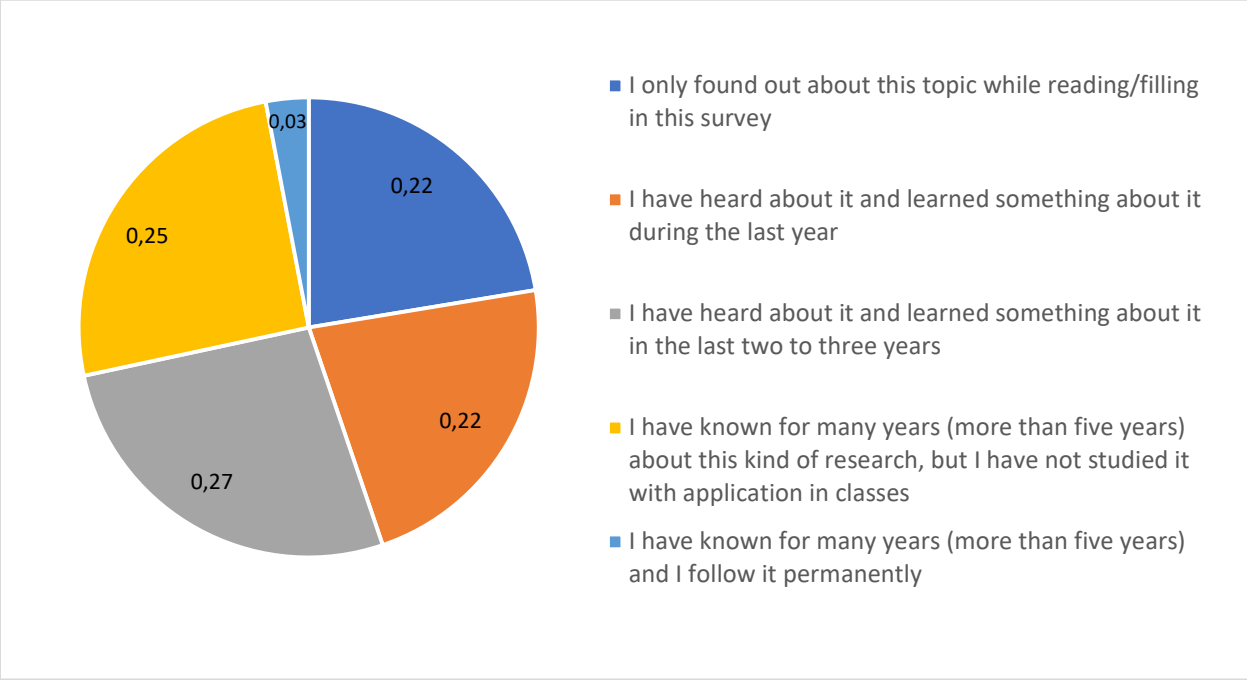
In summary, the positive comments, the interest shown and the awareness of the importance of this interdisciplinary field showed that this topic will soon become even more prevalent in the field of education.

Figure 11: Teachers' evaluation of their knowledge about the implementation of neurophysiological research insights (with the purpose of improvement of learning materials):



Source: Results of the survey conducted within PR6 (UNIRI)

Chart 12: Teachers' level of knowledge about the topic of the application of neurophysiological research insights with the purpose of improving teaching and learning materials



Source: Results of the survey conducted within PR6 (UNIRI)

7. CONCLUSION

At the beginning of the COVID-19 crisis, higher education institutions (HEIs) rushed to introduce online teaching on an unprecedented scale. The digital transformation has irreversibly changed the (higher) education landscape. Today, after leaving the pandemic scenario behind, we are facing a situation where many students no longer want the rigidity of a single teaching method and prefer more flexible blends of asynchronous, synchronous and face-to-face (F2F) courses.

The WE-COLLAB project focused on two main directions:

- learning analytics and
- use of neurophysiological research methods

with the purpose to improve teaching and better understand learners.

The field of education and learning is of great importance and can now be explored with new possibilities. The most important part of the project was therefore to raise awareness of this type of approach and its necessity.

The project has provided answers and at the same time raised many new questions that can be analysed on the basis of an interdisciplinary approach. The application of the methods explained also ensured the sustainability of the project through important shared knowledge within the partners.

Defining discrepancies and bridging learning gaps based on insights derived from learning analytics and the neuroscientific approach is the expected future focus of teachers at all levels of education (and all stakeholders interested in education) with the aim of ensuring learner engagement in (online) learning. As emphasized in the EU Digital Education Action Plan (2021-2027), the current situation in education entails significant changes related to the habits that are different after the Covid pandemic and the fact that new technologies are driving the adoption of new types of digital educational content.

Our obligation as teachers is to find out how to make digital educational content more engaging and interactive. With this purpose, even after the end of the project, we will continue our studies and our collaboration to achieve sustainability through the future goals that are already set.

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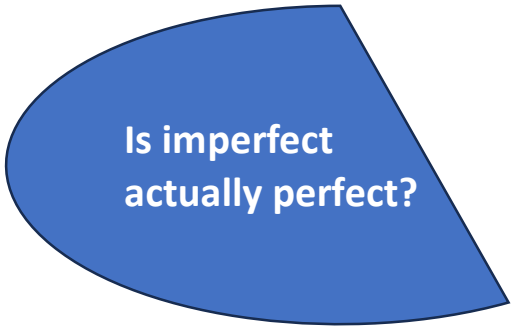
APPPENDIX

Takeaways



Perfectly fluent speech did not result in better memorization of the lesson watched and listened.

Simplicity in visualisation of the presentations provides better memorization of lesson.

**The less -
is MORE.**

The longer video boosted emotional engagement and…

… participants answered more questions correctly after watching the long video, suggesting better learning outcomes.

Questionnaire (PR6)

Dear Sirs,
Following is an online survey prepared within Erasmus+ project WE-COLLAB (Collaborative and transparent use of Learning Analytics in online university courses, valuing the learner role and exploiting advanced monitoring equipment). The project brings together research on how learning analytics and inferences based on neurophysiological analysis can help to improve online teaching and learning materials. The survey is very brief, placed within this page and your answers will give us important guidelines for further work. Anyone interested in the results of the project can leave their e-mail addresses at the end of this survey (at the end of this page).
Thank you in advance!
WE-COLAB team (www.we-collab.eu)

At which educational level you hold classes: elementary school, high school, university, something else.
How many years of experience with holding classes do you have: _____
In which city do you work – hold classes: _____
What is the field of your work/research:

Within your classes, do you use Moodle? yes/no

Learning analytics *implies measurement, collection, analysis and reporting of data about learners and their contexts, with the purposes of understanding and optimizing learning and the environments in which it occurs (monitoring the engagement and progress of students and alarming and "taking actions" in case of noticing problems within the process of listening and passing the courses).*

Do you find the implementation of learning analytics useful in teaching and monitoring the success of learners?
strongly disagree – strongly agree (1 – 7)

By applying research methods such as eye tracking, facial expressions, measuring heart rate, galvanic skin response, EEG (electroencephalography) the insights into neurophysiological reactions of individuals about their perceiving, reacting and memorizing certain teaching materials were obtained. *Findings about segments in which their attention was higher or lower were gathered. Based on learners' perception of different teaching materials, it is determined, e.g. the cognitive engagement of students (focus or distraction) and their emotional engagement (interest or boredom). The collected conclusions may be used to improve (online) teaching and learning materials. The above does not refer to changing the learning outcomes and key elements that learners have to master, but to the design of teaching materials in order to adjust them to the knowledge obtained by neurophysiological findings (what is "easier to follow" for the brain, and when it "loses focus").*

Do you think that the conclusions obtained from neurophysiological research in connection with the improvement of teaching and learning materials could be helpful in your teaching practice?
strongly disagree – strongly agree (1 – 7)

According to your assessment, do you think that your students follow this information/ trends and are acquainted with these possibilities of neurophysiological research:
- no, I think most of them are not familiar with this kind of research
- yes, I believe most of them are familiar with such research

Do you think that your students would benefit from teaching materials adapted on the basis of knowledge obtained from neurophysiological research?
- no, I believe that there would be no change in their interest in teaching materials and learning
- yes, I believe that such an approach to the improvement of teaching materials would contribute to their interest in teaching materials and learning

At which level would you evaluate your knowledge about the implementation of neurophysiological research insights (with the purpose of improvement of learning materials):
- I know a lot about it and I have conducted such or similar research (in some other, non-teaching segment)
- I have already studied this topic, I theoretically know about such research, but I have never conducted empirical research
- I only know superficial information about this topic
- I had never heard of such a thing before this questionnaire

On the topic of the application of neurophysiological research insights with the purpose of improving teaching and learning materials:
- I have known for many years (more than five years) and I follow it permanently
- I have known for many years (more than five years) about this kind of research, but I have not studied it with application in classes
- I have heard about it and learned something about it in the last two to three years
- I have heard about it and learned something about it during the last year
- I only found out about this topic while reading/filling in this survey

If you prefer, you can leave an additional comment:

If you are interested in the results of the survey and the insights obtained within this topic, in the framework of the WE-COLLAB project, you can leave your e-mail here:

WE-COLLAB
IN A NUTSHELL

- **6** PROJECT RESSULTS
- **5** TRANSNATIONAL MEETINGS
- **4** MULTIPLIER EVENTS
- **3** NEURO-METRIC STUDIES
- **2** LEARNING ANALYTICS TRAINING GUIDELINESS
- **1** LEARNING LABORATORY

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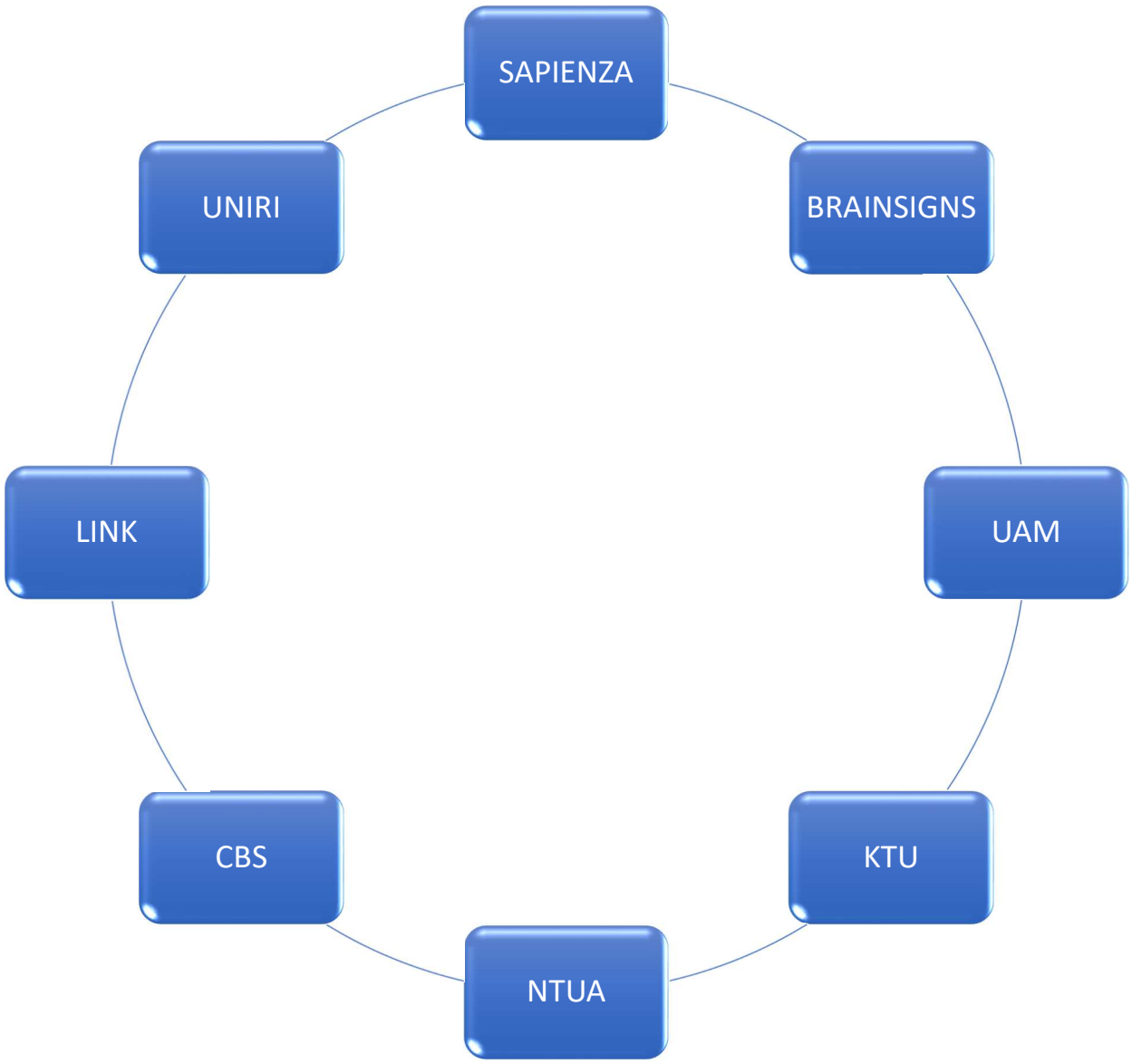
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