Use of Knowledge Acquisition Surface to Monitor and Assess Students' Success

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Abstract—The aim of the Knowledge Acquisition Monitoring (KAM) approach created is to teach faster and/or more in a particular time frame. The KAM Question Framework that was designed according to the KAM approach ensures the active involvement of the students in the study process and provides them with relevant and updated content in real-time. The obtained data enables understanding the nature of knowledge acquisition - to improve the content, and enhance the efficiency of the learning process. 3-D coordinates were used to design the Knowledge Acquisition Surface (KAS). This surface describes the relevance of the e-course content to the needs of a student or group of students. The course suitability evaluation is performed considering the area in which the obtained knowledge acquisition data point is located. The approach provides the teacher with insight into the specific needs of students, and facilitates e-course improvement.

Keywords—e-learning, learning analytics, learning data, knowledge flow, knowledge management

1 Introduction

To successfully transfer knowledge and achieve learning objectives, it is important to consider the characteristics of knowledge acquisition. Knowledge management is essential to transfer the knowledge included in the course as effectively as possible. We aim to visualize the acquisition of the knowledge included in the course, and to create updated solutions for its more efficient transfer.

Tacit knowledge is closely linked to the individual and is accumulated over several years through education, training, and personal experience. Innovative ICTs will influence knowledge management and its strategy. The provision of structured knowledge, as well as the automated adaptation of processes to changing knowledge, will become increasingly important for the operation of knowledge management systems, especially because of the increasing dissemination of information and knowledge [14].

There are two types of tools designed for knowledge management. One of the types is tools designed to support a certain methodology of knowledge management - knowledge modeling, structuring, or use. The second type is tools designed to support the steps of knowledge engineering (Perry and Bernard, 2019). Knowledge management includes several elements - communication, policy and strategy, knowledge interception, training, and mentoring. The interception of knowledge is related to the identification and acquisition of external information such as Internet resources, scientific publications, knowledge of cooperation partners. In turn, training and mentoring are applied to internal knowledge transfer - formal and informal training, learning from colleagues, further education of employees [18].

In the context of this study, we focus more on in-house training and improving its effectiveness. If we look at this issue with regard to the ability of organizations to learn, then ISO 10015: 2019 requires that an organization should review its current competence levels against required competence needs. That includes considering existing competence levels, compare them with required competence levels, and using risk-based thinking to prioritize actions. The aim is to cover competence gaps [7].

The approach to managing knowledge flows depends on your goals. If the goal to achieve is stickiness in terms of the time spent on screen, then it can be assumed that the time spent exploring the content is infinite. If, on the other hand, the time available for learning content is limited, it is important to think about making the most of it. This may be the case for companies that have limited time to devote to employee training because of the equation "time money", and for educational institutions where the duration of the course is defined by the equation "a certain amount of credit = time". Accordingly, in these cases, it is not the stickiness of the screen content that is to be considered, but the flow of the knowledge.

Given that the content of the course can include both explicit and tacit knowledge, it is important to identify which knowledge corresponds to which type and, consequently, to develop an appropriate knowledge transfer. The created KAM approach aims to use all opportunities to teach faster and/or more in a particular time frame. At the same time, the goal is to provide relevant content with enhanced learner acceptance.

The KAM Question Framework, integrated with short learning content subunits and developed according to the KAM approach, is designed to ensure the active involvement of the student in the study process and to provide teachers with specific information for content updates. The obtained data allow us to understand the type of knowledge flow and to improve the content, thus improving the efficiency of the learning process. The data are visualized; thus, the lecturer has access to graphical information on the compliance of the course content/delivery approach with the student's abilities. User behavior data are analyzed and visualized using statistical methods.

2 Methodology – knowledge acquisition monitoring approach

Content of the course can include both explicit and tacit knowledge, and it is important to identify which knowledge corresponds to which type and, consequently, to develop an appropriate knowledge transfer. It is important to use all opportunities to teach faster and/or more in a particular time frame. At the same time, the goal is to provide relevant content with enhanced learner acceptance. To gain these goals, we will use knowledge analytics and organized knowledge flows.

Three crucial attributes of knowledge flow are direction, content, and carrier. A knowledge flow aims to pass knowledge between nodes (team members or roles, knowledge portal, or process) according to certain principles. A knowledge node can generate, learn, process, understand, synthesize, and deliver knowledge. Knowledge usually flows using communication, especially the Internet [21]. Knowledge analytics allows getting insights from knowledge structures, not just tabular data [11].

According to Squier, technology and human-related techniques bring to knowledge management the ability to carry out knowledge management processes more quickly, efficiently, and cost-effectively. The use of technology is most appropriate in situations where explicit knowledge needs to be transferred, and it is more challenging when tacit knowledge occurs [16]. It is important to understand the type of knowledge to manage it properly. By applying knowledge management solutions, it is possible to turn tacit knowledge into explicit knowledge [2].

First, it is necessary to understand and evaluate the fluidity of the knowledge contained in the course, and then to find solutions to reduce this knowledge [17]. We propose 3 knowledge flow strategies, depending on the goals you set (Figure 1).

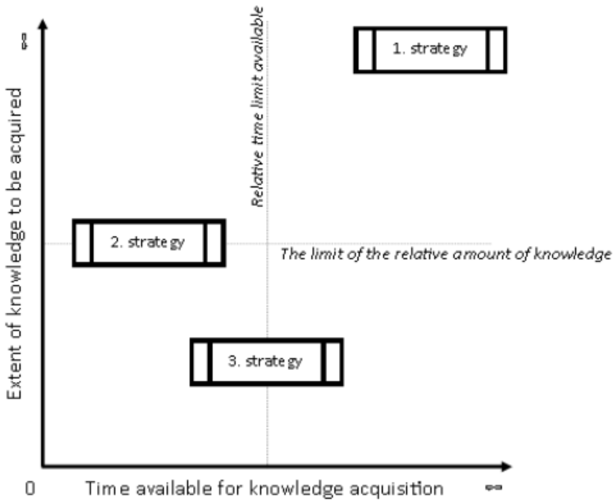

Fig. 1. Knowledge flow strategies

Strategy 1. Neither the time nor the amount of knowledge are limited. The aim is to gain as much knowledge as possible. In the case of Strategy 1, the course content should be designed with the widest possible opportunities to get to the adjacent topics and acquire additional knowledge.

Strategy 2. Time is limited, the amount of knowledge to be gained is undefined (the more you learn at a given time, the better). Accordingly, it should be possible to include additional knowledge in the curriculum if it is evident that the student can acquire it.

Strategy 3. The amount of knowledge to be acquired is clearly defined, time is undefined, there are requirements for the efficient use of time spent in learning (the faster the knowledge is acquired, the better). In this case, the emphasis should be placed on solutions that can reduce the stickiness of the knowledge included in the course to facilitate its acquisition in the shortest possible time.

The approach where courses are designed to include the same amount of knowledge in a reduced amount of time has been used before. The amount of time required to acquire appropriately prepared content can be 3 to 4 times shorter than in a regular academic course [4]. Considering this, the KAM approach also focuses both on strategy 2 and 3.

Successful implementation of these strategies requires the following input data:

- student's initial level of knowledge
- student's final level of knowledge.

These data allow conclusions to be drawn about:

- knowledge transferability in the course
- suitability of the course content to a student or group of students
- technical shortcomings in the course
- content shortcomings in the course.

The proposed mechanism for monitoring and analysing this data is to develop a KAM Question Framework for a specific course. During the previous research, a 3-dimensional KAM was modeled. This surface describes the relevance of the e-course content to the needs of a student or group of students (Kapenieks et al., 2020).

The structure of the e-course was specifically designed to provide monitoring data on the students' initial knowledge and their progress in learning. The course was divided into units and subunits (lessons). The course is technically designed so that the student could only access the study material by answering this "introductory" motivating question. The students are informed that the answers to the questions are mandatory, but their accuracy will not be considered in the final evaluation grade (Figure 2).

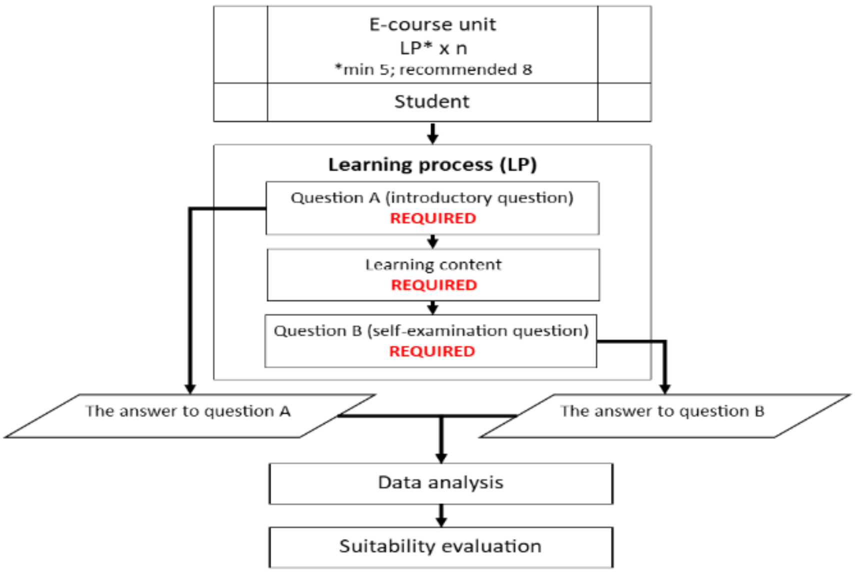

Fig. 2. KAM technology for e-learning delivery

For successful analysis of the results, it was necessary to determine what amount of data collection points (KAM Question Framework) is needed for a reliable analysis. The authors calculated a confidence interval to determine the number of data points (question pairs) required. The confidence interval is calculated using t-values because the sample size is below 30 and, in this case, Student distribution should be used. The sample size is the same as the population size. The confidence interval was calculated for 95%, 90%, and 85% confidence (Figure 3).

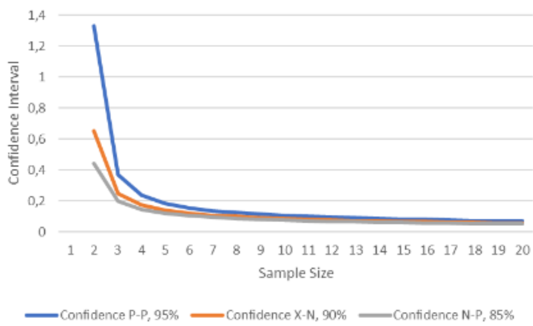

Fig. 3. The confidence intervals on the Knowledge Acquisition Surface depending on the number of questions of sample sizes

We see that by increasing the number of question pairs more statistically reliable results can be obtained. This is especially important in situations where the student's individual success is to be assessed. When it comes to assessing the success of a group of students, the amount of these question pairs may be smaller, because a statistically reliable result is achieved with several answers to the same pair of questions.

A properly selected number of data collection points is important. Excessive content splitting can make the learning process cumbersome. On the other hand, if the amount of data collected is too small, it will not provide a reliable analysis. As a result, it was concluded that the minimum number of data collection points for the obtained data to be usable is 5. Optimally, at least 8 pairs of questions would be needed.

The answer pairs obtained in the data collection process are divided into 4 groups according to the student's success. Depending on how correctly the student has answered the questions before and after learning the subject, conclusions are made about his / her initial and final level of knowledge. This makes it possible to assess the suitability of the course content for the student's needs.

In this process, it is important to understand whether the student has managed to acquire new knowledge during the study in the specific section of the e-course. The number of data collection points obtained is of great importance here, because the obtained results are interpreted considering the probability.

The further processing of the data is based on the following calculation:

$$n_{("P-P")} + n_{("N-P")} + n_{("P-N")} + n_{("N-N")} = N_{(ap)} \quad (1)$$

where:

- $n_{(“P\text{-}P”)}$ is the number of answers for the 1st type pair of questions (correct answers both for question A and question B)
- $n_{(“N\text{-}P”)}$ is the number of answers for the 2nd type pair of questions incorrect answer for question A and correct answer for question B)
- $n_{(“P\text{-}N”)}$ is the number of answers for the 3rd type pair of questions (correct answer for question A and incorrect answer for question B)
- $n_{(“N\text{-}N”)}$ is the number of answers for the 4th type pair of questions (incorrect answers both for question A and question B)
- $N_{(ap)}$ is the number of total pairs of answers.

These numbers are used to calculate value numbers on the KAS. The KAS is modeled in 3 dimensions with P-P values on the x-axis, N-P values on the y-axis, and X-N values on the z-axis. The following formula is used to determine the P-P value:

$$"P-P"_{(value)} = \frac{n_{("P-P")}}{N_{(ap)}} \quad (2)$$

A similar formula is used to determine the N-P value:

$$"N-P"_{(value)} = \frac{n_{("N-P")}}{N_{(ap)}} \quad (3)$$

A slightly more sophisticated formula is used to calculate the X-N value on the z-axis:

$$"X - N"_{(value)} = \frac{\left(n_{("N-N")} + n_{("P-N")}\right)}{N_{(ap)}} \quad (4)$$

The reason for this is the authors' assumption that in the 3rd type answer pair situation, where the answer to question A was correct and the answer to question B was incorrect, the correct answer to question A was accidentally guessed (Kapenieks et al., 2020).

After calculating the values, the obtained data points are placed on the KAS. These data points serve as a reference for assessing the suitability of the e-course for the student or group of students.

3 Knowledge acquisition surface (KAS)

When creating a learning design for online learning, we developed it according to the student-centred learning approach offered by Whitby. To implement this personalized learning approach, it is necessary to find a solution in the online learning environment to understand where the student is in his/her existing knowledge and what he/she still needs to learn. To ensure this, the design of the course should include a solution to include the collection of data required for learning analytics [19].

One of the challenges that teachers face during distance learning is the loss of control over students' motivation. In such a situation, the teacher is forced to choose between lowering the level of requirements or leading the audience strictly along one route without an individual approach [12]. We used the learning events offered by Gagne [5] as a basis for the design of an online course, looking for suitable solutions to make these events meaningful online.

Mo recommends developing self-assessment tests for online courses to motivate students to review what they have learned in the department, or to encourage students to take a diagnostic test at the beginning of the course. In Mo's view, it is valuable to be able to judge a student's performance from different points of view, rather than just one type of task. Also, from a multi-learning strategy perspective, it is better to allow students to demonstrate their knowledge in a variety of ways. The possibility of providing automatic feedback or postponing the test until the student is familiar with the required content is also to be welcomed [10].

An example of this type of learning data processing is the math application developed by Greller's research team that tells the teacher when the student is having difficulties. The teacher can follow the activities of the whole class and intervene when problems are noticed, the most added value is the timeliness of receiving information. The application is designed for learning math, and depending on the answers given by the students, the system predicts whether the next ones will be correct. For example, when answering questions of equal complexity, if one of the answers is correct and the other is incorrect, there is a high chance that the student will not master the topic. On the other hand, a student who has repeatedly answered 2 questions incorrectly will also answer the next two incorrectly with a 30% probability. An application with a "hotspot" schedule allows the teacher to understand which issues are the most difficult [6].

University teachers have cited high student-teacher interaction, instant question and answer opportunity in the classroom, and student check-ups as significant advantages in face-to-face study [13]. In creating our solution, instead of accurately predicting the student's learning success, we focused more on creating an opportunity to find an opportunity to notice the problem, providing the teacher with an opportunity to get involved in time and turn the learning progress in a positive direction. Our approach allows significantly increasing the presence of these factors also during distance learning.

LMS Moodle was chosen to pilot the technology. This is due to considerations that Moodle is an open-access solution, which is widely used in Latvian educational institutions and has the necessary operational stability.

The "lesson" tool included in Moodle allows to create sequentially managed content and contains the necessary elements of student engagement. Given that the active involvement of the student is a very important factor in the acquisition of knowledge, this was an important reason to choose this solution. The second consideration was the relatively easy ability to obtain structured data for further analysis.

By choosing the appropriate settings, it is possible to ensure that the student begins learning the content with an introductory question. At the same time, it allows the student to prepare for the acquisition of content, to refresh the previously acquired knowledge in memory, as well as to obtain the data necessary for the assessment of the student's initial knowledge. After answering the question, feedback is provided, informing the student about the correctness of the given answer. For data collection, it is important that the introductory question in the title is identified by a single sample. In the current situation, a single designation A was chosen.

The feed is then created by inserting a "Content" page. The content is created considering the topic to be learned and the principles of e-pedagogy. The content section may include text, images, infographics, videos, links to external learning materials, virtual laboratories, and more. The content must be well related to both introductory and self-evaluation questions, providing the knowledge needed to answer them. A content page can be one or more consecutive pages. The design and content of this section do not have any technological limitations related to the requirements of data analytics, the data from this section are not read and analyzed directly from the researched solution.

After the content page, a self-evaluation question is placed in the lesson. This question allows the student to perform self-evaluation, making sure that the knowledge included in the course has been acquired. After answering the question, feedback is provided, informing the student about the correctness of the given answer. This element allows obtaining the data necessary for the assessment of the student's amount of knowledge at the end of the course. For data collection, the self-evaluation question in the title must be identified by a single sample. In the current situation, a single designation B was chosen.

Both introductory and self-evaluation questions are formed as "multiple-choice" questions with 3 answer options, of which 1 is correct and 2 are incorrect. When you create questions, appropriate feedback is also set up to provide the feedback you need.

When creating a lesson flow, question A is placed first, followed by the content page(s), and at the end of the lesson a self-evaluation question B is asked. Regardless of whether the student has given the correct answer to question A, he/she is directed to the content page. After learning the content, the student is directed to question B. Regardless of whether the student has given the correct answer to question B, he/she is taken to the next lesson until the end of the learning content. This flow mostly includes 5 to 8 consecutive sessions.

At the beginning of each new subunit (lesson), the student is asked an introductory question about the next topic before getting acquainted with the study materials. The purpose of this question is to assess and record the student's initial knowledge.

After that, the student gets the opportunity to access the course content and acquire knowledge. During the study process, the student has access to different types of study materials - in text, infographic, virtual labs, or video format. The type of material chosen depends on the content to be learned.

After mastering the study materials, the student continues the study path and gets to self-evaluation question B. This question is intended to determine the student's level of knowledge after learning the study materials. Question B is equivalent to Question A in terms of complexity.

The student's answers to questions A and B are recorded in the used LMS storage, and from there they are retrieved for further analysis. For successful analysis of the results, it is necessary to determine what amount of data collection points (question pairs) is needed for a reliable analysis. The approach to evaluating data before and after training has been recommended by Zhou. Zhou points to the need to follow the progress made during training as well as the design of the training itself [20].

Crompton points to the need for timely feedback and a personal approach to learning in the digital environment. This is due to the need to design technology in such a way that it notices in good time where students have the greatest effort and delays. The well-designed learning design plays a key role in the success of the learning process while drawing attention to the importance of learning data in the planning and development of digital courses. These data make it easier to identify students in difficulty, as well as enable teachers to engage promptly, motivating students by offering personalized learning goals [3].

The Moodle "lesson" tool used in our case already includes the ability to provide feedback on the correctness of the answer to the question. As part of the pilot, this capability was enhanced with an appropriate color signal. If the answer was correct, the review showed green, and if the answer was incorrect, the review showed red. What needs to be developed in future developments is how a student can be provided with information about his or her location on the KAS, as well as the dynamics of that location over a period.

4 Course content and technical quality assessment

During the piloting of the system prototype, situations were recorded when the data points were outside the calculated knowledge acquisition surface. At the same time, it was observed that in the 3D model, these data points still maintain their position in the same plane as the acquisition surface (Figure 4).

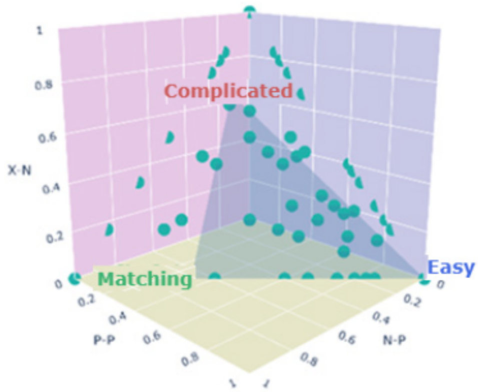

Fig. 4. KAS piloting results – data points placement

Considering this circumstance, the extended knowledge acquisition surface was modeled to get a clear idea of the possible location of such points (Figure 5).

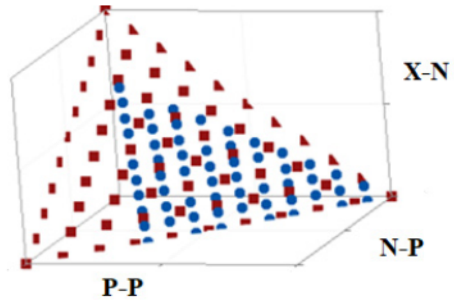

Fig. 5. KAS and extended knowledge acquisition surface

Figure 5 shows both surfaces modeled from artificial data: the knowledge acquisition surface (blue dots) and the extended surface (red dots). The knowledge acquisition surface is modeled from the extended surface data, considering the probability.

The calculated probability includes situations for which the correct answer is guessed, as well as the possibility of other random decisions. Accordingly, situations, where students' answers to questions are out of probability, remain outside the surface of knowledge acquisition. In this case, there is reason to believe that their location has some other explanation and that it is necessary to understand the causes thereof.

During the pilot, we noticed that the location of the points on the KAS indicates two significantly different situations. The initial goal was to make sure that the points show the students' behavior and the success of the course. During the pilotage, we communicated that they also should indicate the content quality and technical quality of the course.

Evaluating the data displayed on KAS and noticing any deviations from the intended, the algorithm we offer to find the causes is as follows (Figure 6):

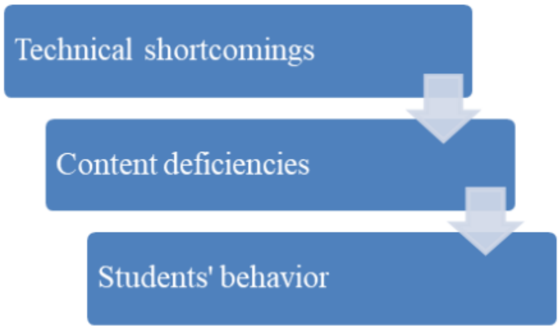

Fig. 6. Algorithm for finding the causes of non-compliance

The most significant technical shortcoming is the insufficient amount of input data. Our calculations show that data from at least 5 question pairs are required to obtain correct results, while the optimal amount is 8 question pairs or more. This type of discrepancy can occur if the unit has too few lessons or students in the course (less than 5). A typical situation is when students answer a question of introductory, get acquainted with the content, but avoid answering the question of self-examination (this can be avoided with various technical restrictions if the content of the course and the planned course allow). This may also be due to low student activity, but let's look at this separately in the next section of this article.

In order not to confuse the user of KAS with data that does not meet the analytics requirements, it would be necessary to automatically exclude it, preventing it from reaching the KAS.

Technical shortcomings may be incorrect or misplaced correct answers in any of the multiple-choice questions. This may be a situation in which none of the answers is listed as correct, the correct answer is replaced by an incorrect one, or vice versa, or all the answers are listed as correct.

There may also be technical errors elsewhere in the course content. Care should be taken to ensure that any lessons in the flow are included in the stream. In the case of content that includes video, make sure that it can be played and that there is no loss of sound, and that there are no other defects. If you've included a link in your content, make sure it's up-to-date and working.

After checking the technical shortcomings, the next step is to check the quality of the content. This step is much more challenging, as the quality of the content and compliance with the objectives of the course is substantially more difficult to assess. According to the authors, this area requires in-depth research, but there are situations where they may affect the analytical results.

It is necessary to make sure that both introductory and self-examination questions correspond to the content of the course between them. To obtain appropriate results, both questions must be equal in terms of content and of equal complexity. At the same time, they should not be identical.

The proposed answers are also important. There may be situations where the correct answer can be assessed visually rather than in terms of content, for example, one of the answers is broader and more data-based than the others.

Content shortcomings also include a situation where there is misleading content in the course content that causes students to misunderstand. In this case, irresponsibility is created because there is an error in the lesson content section, while both questions and their answers are written correctly. Accordingly, students deliberately choose the wrong answer, thinking it is correct.

5 Students' behavioral data analytics

Once we are sure that the placement of points has not been affected by technical or content deficiencies, the evaluation of student data can begin. The KAS technology has been piloted at the primary, secondary, and higher education levels and the results show that it is applicable at all these levels.

The analytics tool was designed to give an idea of each unit and lesson, as well as the success of an individual student throughout the course.

The obtained points on the KAS enable drawing conclusions about the suitability of the course or course unit for a specific group of students or individual students. The suitability evaluation is performed considering the area in which the obtained data point is located. These areas are shown in Figure 7.

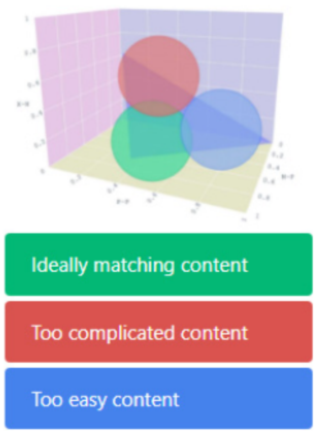

Fig. 7. Learning content suitability areas

The colored zones are based on the identification of opportunities and directions for the improvement of the study materials. They indicate that the content of the course is too easy or, conversely, that it too complicated. There are 3 zones: A zone (green); B zone (blue) and C zone (red).

The preferred situation is where as many points as possible are in the green area (A zone). The green area marks a situation where the content of the course or the course unit is ideal for a group of students or an individual student. Every opportunity has been taken to teach the maximum possible amount of knowledge. The student has not encountered any significant difficulties in acquiring them, at the same time has managed to improve his/her knowledge.

The blue area (B zone) indicates a situation where there are untapped opportunities in the learning process. Although the student did not have any difficulties in learning the subject, the teacher had the opportunity to teach more within the current timeframe. The content of the course or the course unit has been too easy, the student has used a lot of previously acquired knowledge in the performance of tasks, thus losing the opportunity to learn something new. Also, there is a possibility that the blue area indicates easily flowing knowledge, as no special effort is required for teaching. This could allow increasing the amount of knowledge included in the specific stream to achieve a better final knowledge of the student, or to reduce the time planned for the acquisition of this learning material.

The red area (zone C) describes a situation when the offered study material is too complicated for the student and therefore has not been mastered. Wanting to teach more than the student can master or excessively complicated explanations have the opposite effect to what is expected - the student has not learned anything. In such a situation, the teacher must either review the amount of material or the way it is presented to achieve the desired goal - the acquisition of knowledge.

The obtained results show that by applying KAS, it is possible to notice and evaluate the student's actual involvement in the course. KAS gives an idea of the content of the course and its suitability for the student or group of students. This is important in situations where the content is too light - the teacher notices it and can decide to include additional challenges in the course, both in terms of tasks and wider content. Doing so allows the student or group of students to achieve better learning outcomes within the existing time frame.

Even more important is the fact that KAS allows to identify and assess situations where students have learning difficulties. The surface shows when one of the students has difficulties and when the whole group has them. Depending on these outcomes, the teacher may decide to change the course content or teaching approach to improve the flow of knowledge and promote learning objectives.

There is a lot of diversity in the group of students. Each of the students embarks on their studies, bringing their own individual knowledge and experience. Although not all students can be expected to have the same initial knowledge of the topic of the course, the objectives set out the level of knowledge to be achieved. Therefore, the teacher needs to notice which students differ in their abilities and prior knowledge from others. Figure 8 shows one of the situations obtained during piloting.

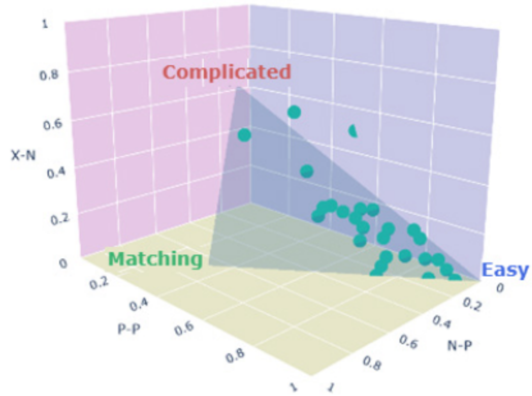

Fig. 8. A group of students in which most students have equal knowledge (course "Total Quality Management")

In this group of students, the content of the course is easy for most students and knowledge flows quickly, however, some students face difficulties. Their points are in the upper area of KAS.

In another course with another group of students, the situation is different. In this group, the diversity of the students' initial and acquired knowledge is wider. There is no dense group of points on the KAS, they are located on 2/3 of the surface, with a small concentration in the middle of the right edge of the KAS (Figure 9).

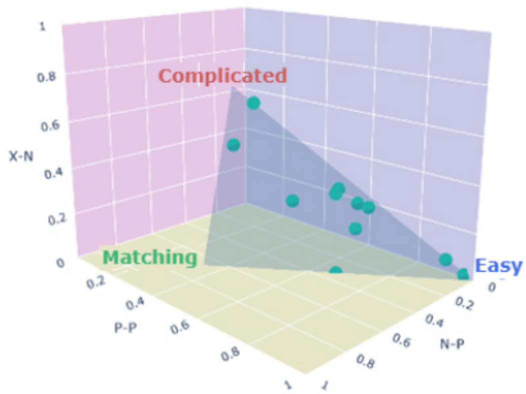

Fig. 9. A group of students in which students have a varying level of knowledge (course "Enterprise Modeling with the 4EM Method")

In this situation, the teacher needs a solution both for those students for whom the course is too complicated and for those for whom it does not pose any challenges.

The method allows to assess the suitability of the course content for a group of students and an individual student, as well as provides the teacher with insight into the need for the specific content update.

6 Conclusions

One of the benefits of learning analytics is the ability to gain insight into those aspects of learning that would otherwise remain hidden. This can reduce generalized assumptions about student behavior and, on a larger scale, lead to changes in the learning process and pedagogical practices. When using learning analytics, it is not only the amount of data obtained that is important, but also its interpretation. It is important that these data are not obtained anonymously, in groups, but are available to the teacher for each student. Although economic efficiency is important, from the student's point of view, personal pedagogical approach and individual support in matters related to psychological, mental, and physical development are very important [6].

The KAS approach enables monitoring the students' knowledge acquisition, as well as assessing learning content suitability for the student or group of students.

The method allows assessing the suitability of the course content for a group of students and an individual student, and provides the teacher with insight into the specific needs of course improvement.

At least 5 data collection points are necessary for the obtained data to be reliable. Optimally, at least 8 pairs of questions would be needed, as KAS does not require a large amount of data collected from a large group of students. The results are available in real-time and allow the teacher to immediately make the necessary changes to both the course content and the teaching approach.

Knowledge acquisition data allow conclusions to be drawn about knowledge transferability of the course. Our proposed plan is to develop and apply the KAM Question Framework, ensuring the availability of data for each course and group of students.

Our results confirm Sclater's indication that learning analytics can bring significant benefits in the areas of quality assurance and assessment, drop-out reduction, assessment and action in low-achieving situations, and the development of adapted learning. Learning analytics can provide the teacher with more information about the quality of the course content and provide direction for improvement. The teacher also could notice in time which students have difficulties and react to them on time, promoting student motivation and reducing dropout. Learning analytics allows students to control their own learning [15]. Students' involvement and cooperation with the teacher are of great importance when learning content remotely. Student assessment before and after the learning process in digital learning systems is also used and recognized as important in other research[1]. In our case, the results are compared before and after learning the content.

Further research would be needed to better understand the visual presentation of knowledge acquisition on the KAS, thus improving the interpretation of the KAS results for a permanent update of learning content and delivery approach.

7 Acknowledgement

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