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THE DESIGN OF AN INSTRUMENT TO ASSESS COGNITIVE LEVELS OF INFORMAL INFERENTIAL REASONING IN HIGH SCHOOL PHYSICS

Abstract.
Informal logical reasoning (English Informal Inferential Reasoning, IIR) is a cognitive process, the main characteristic of which is to take into account the student's environment, informal and formal reasoning, and the latter, as a rule, is promoted in high school science courses such as physics, and in courses that are developed and consolidated during adolescence. The study aims to consider the construction of methods for measuring IIR with elements based on the educational goals of the Marzano and Kendall taxonomy, which are detailed in terms of the performance that must be achieved in each cognitive process. Similarly, the key concepts of physics are considered from the topics of Uniform Rectilinear Motion (URM) and Uniformly Accelerated Rectilinear Motion (UARM). The method was evaluated by 12 experts for understanding and relevance, and a pilot test was conducted with a sample of 212 high school students aged 15 to 18 years. The results showed the reliability and reliability of the method (V Aiken = .73) to evaluate the cognitive processes necessary for the study of physics. This experiment is a useful method for teachers who want to adapt the thematic content of the curriculum to gradually encourage cognitive processes, ranging from recall to analysis and use of knowledge.
Key words: informal logical thinking, cognitive processes, high school physics, high school students, Marzano and Kendall taxonomy.

Introduction.

Informal Inferential Reasoning (IIR) is a relevant cognitive process that originates in the area of statistics since it links contextual knowledge with that of a formative nature in schools. This type of reasoning allows judgments, statements or predictions to be made about populations based on samples, but without using formal statistical procedures and methods [1] rather, it focuses more on *how* students generated logical responses and how they have been constructed and related from their knowledge and informal reasoning, that is, from what they learned outside the classroom.

The RII not only considers aspects of the student's environment but also serves as a first step towards formal reasoning *per se* [1. – 45]. That is, given the age of the students (15 and 18 years old), formal reasoning begins to consolidate at this stage since it allows subjects to generate conclusions, hypothesize, and solve problems without the need to physically manipulate objects. Likewise, this reasoning is generally prioritized during the academic career of the high school student. On the other hand, the RII is enhanced when students are asked to solve problems that refer to cases associated with their context, the presence of this element as an ingredient of the reasoning processes favors the development of arguments on which the solution to these problems is based.

In the case of physics, the RII has not been explored, so it is convenient to study it in this disciplinary field due to the advantages that refer to the contextual link with the formal knowledge offered in the classrooms, to evaluate the cognitive processes that students develop in problematic situations that the field of physics demands such as solving problems to natural phenomena without them having to witness them.

That is why this study focuses on the design of an instrument to measure Informal Inferential Reasoning in Physics following established methodological guidelines to guarantee its validity and

reliability [2]. Its target is to serve as a tool that teachers can apply in their classes to adapt the tasks or activities, they carry out with students to consolidate and promote gradual learning based on the consolidation of cognitive processes related to certain areas of opportunity in physics.

It intends to serve as a tool that teachers can apply in their classes to adapt the tasks or activities they carry out with students to consolidate and promote gradual learning based on the consolidation of cognitive processes related to certain areas of opportunity in physics.

Finally, it is important to mention that the instrument's items have been based on the Taxonomy of Marzano and Kendall. Similarly, it is highlighted that, since the RII involves non-formal methods, the conditions in which the pilot was applied did not control the variables in their entirety, such as noise, ventilation, temperature, and the number of students per classroom, to measure cognitive processes in the most everyday classroom situations possible.

Materials and methods of research.

Instrument. The planning of an assessment instrument is a systematic and rigorous design process that has various purposes, including defining the objectives and competencies to be assessed, selecting the format and types of questions to be used, refining and revising the content, defining the assessment criteria, and validating them. Each of these steps requires ensuring its quality and reliability.

As a starting point for the planning of the instrument, research was carried out within the educational field on tests to measure reasoning. The results of this search show that the tests used, for the most part, refer to formal reasoning and its location based on the types that are defined for that purpose [3]. On the other hand, in the case of the IRI, only activities and suggestions of tasks were identified to promote this type of reasoning with application to disciplines [4].

Therefore, designing an instrument for the evaluation of cognitive processes in high school physics would allow measuring the students' ability to understand the concepts and apply them to new situations; offering teachers the possibility of adapting teaching based on two types of diagnosis: that of prior knowledge about the contents and about the execution of the cognitive processes that have to do with the appropriation of the knowledge subject to teaching and learning.

The planning of an assessment instrument is essential to ensure its effectiveness and validity. In this study, an instrument was designed to measure IIR in the specific context of high school physics. The literature review revealed a notable scarcity of instruments in Spanish designed to assess the RII, especially in the field of high school physics. Although some studies were found that addressed the characterization and determination of this type of reasoning, only two were validated instruments in Spanish to assess the IIR [5], but none in the context of high school physics.

Considering this, it was decided to focus on topics related to Uniform Rectilinear Motion (URM) and Uniformly Accelerated Rectilinear Motion (UARM), due to their relevance in the high school physics curriculum and their potential to assess students' RII in concrete and relevant situations. It is important to note that the evaluation of the RII is not limited to a simple dichotomous classification of students' reasoning, but involves considering the influence of the context and recognizing the complexity inherent in the reasoning process. Therefore, assessment instruments should avoid simplistic categorizations and consider the diversity of cognitive processes involved in the development of reasoning.

To summarize, the design of this instrument represents a crucial step towards the understanding and improvement of teaching and learning processes in high school physics. By addressing the complexity of the RII and its relationship with disciplinary knowledge, this study contributes to filling an important gap in the educational literature and offers new perspectives for the evaluation and development of reasoning in the school setting.

Marzano and Kendall's Taxonomy in the Design of Instrument Items.

Concerning the elaboration of the items that finally made up the instrument, the task begins with the formulation of a pertinent taxonomy in which the performance criteria of each taxonomic

level are specified. To achieve this objective, it has been taken into account guidelines that are recommended to be considered in the preparation of the items, such as aspects to be evaluated (the traits to be assessed) and the levels of skill, execution, or competence (indicating the score assigned to each aspect to be evaluated, which adequately represents the judgment about how good the execution of the task was) [6].

In this study, the Taxonomy of Marzano and Kendall was taken as a basis, so at this stage, it is suggested to prepare a table containing how the reagents have been constructed and their justification, including the method used, which responds to the educational objectives referred to in the taxonomy. It is recommended that at this point in the design, before submitting the reagents for approval by expert judgment, they are checked for errors in spelling and wording, thus guaranteeing their clarity [7].

However, within the framework of the URM and UARM themes, a set of concepts was chosen for the design of the items, among which are: velocity, instantaneous velocity, average velocity, acceleration, vector, and scalar magnitudes. However, it should be noted that in the design of the items not only were the aforementioned topics decisive, but the design criterion prevailed that the content of the item allows the evaluation of the reasoning processes within the framework of these topics, as suggested by the taxonomic levels supported by the Taxonomy of Marzano and Kendall.

In this regard, it is important to note that opting for the Marzano and Kendall Taxonomy has advantages over other taxonomies used to evaluate the IRI. For example, it is common to use the SOLO Taxonomy and Bloom's Taxonomy, however, these do not have the specifications that Marzano and Kendall's Taxonomy call *educational objectives*, which serve as references when specifying the type of tasks that would allow locating a specific cognitive process.

Table 1 shows the cognitive processes that the taxonomy assesses and the objectives to be evaluated in each of them. These objectives have the function of determining the level of the task to design the items that will comprise the test. Thus, the design of the reagents finds a first guideline in its approach, however, it is also necessary to know how the reagents will be able to obey what the objectives refer to.

Table 1 – Educational Objectives to Evaluate Cognitive Processes in the Taxonomy of Marzano and Kendall at Level 4 corresponding to the "Cognitive System"

Levels of the Cognitive System	Educational Objectives	Cognitive Process
Recall	Students recognize the characteristics of information, but they do not necessarily understand the structure of knowledge or differentiate criticism from non-critical components.	Recognize
	Students produce information features, but they do not necessarily understand the structure of knowledge or differentiate critical from non-critical components.	Name
	Students produce information features, but they do not necessarily understand the structure of knowledge or differentiate critical from non-critical components.	Execute
Comprehension	Students identify the basic structure of knowledge and critical versus non-critical characteristics.	Integration
	Students identify the basic structure of knowledge and critical versus non-critical characteristics.	Symbolization
Analysis	Students identify important similarities and differences between the components of knowledge.	Relates
	Students identify super-ordered and subordinate categories related to knowledge.	Classification
	Students identify errors in the presentation or use of knowledge	Error analysis

	Students construct new generalizations or knowledge-based principles	Generalization
	Students identify specific applications or logical consequences of knowledge	Specification
Utilization	Students use knowledge to make decisions or make decisions about knowledge.	Decision-making
	Students use knowledge to solve problems or solve problems about knowledge.	Solving problems
	Students use knowledge to generate and test hypotheses or generate and test hypotheses about knowledge.	Experimentation
	Students use knowledge to conduct research or conduct research on knowledge.	Investigation
Note: Adaptation by Marzano and Kendall		

Therefore, for its elaboration, Marzano and Kendall first propose certain conditions that the items or tasks must have to evaluate a cognitive process. Second, given the conditions, they offer some tasks or activities that are appropriate to what is requested. For example, Table 2 shows the cognitive process of "Classification" with its respective educational objective, so to achieve this, it is required that the three characteristics described in this table are met. Based on these conditions, it is then suggested that some tasks involving pictograms, graphic organizers, and graphics be carried out. However, Marzano and Kendall state that they can also promote other cognitive processes, so it is therefore necessary to always take into account the domains of knowledge, the educational objectives, and the conditions for which mental processes occur.

About the above, it was also decided to rely on the teaching-learning tasks suggested by Pimienta-Prieto to develop competencies such as inquiry into prior knowledge and promote the understanding of information, since the author also offers ways for the writing of instructions to involve task-specific cognitive processes.

Table 2 – Suggested Accomplishments in Tasks to Assess the Cognitive Process of "Classification"

Classification Definition: organization of knowledge into meaningful categories Note: Although it is a process that occurs naturally in human beings when talking about classifying within the level of analysis, the process can be very challenging	For classification to be effectively achieved, the following is required: - Identify the characteristics that define the elements to be classified - Identify a higher category to which the elements belong and explain why they belong to it - Identify one or more subordinate categories of the items to be classified and explain why they are related
Note: Adapted from Marzano and Kendall	

Along these lines, Table 3 presents two examples of items that were chosen for the RII instrument. Likewise, it must be remembered that for reliability, that is, the consistency of what the items intend to measure in an instrument for the evaluation of learning [8], It is necessary that five items measure the same category, with three being the minimum items, because in this way chance is avoided, so in the end, to be submitted to the judgment of experts, a total of 22 items were obtained.

Table 3 – Example of the reagents that were designed for the RII instrument

Items	Expected responses to assess cognitive processes	
	Symbolizes	Classified

Item 1. Reagent 1. Make a comparative table between the types of rectilinear movement described in the text.	They differ in that the MRU carries a constant velocity, while the MRUA its velocity changes over time. It does not consider the similarity that both are in a straight line, they use the same variables and they do not consider the mass of the object	They are distinguished by the fact that the MRU carries a constant speed, while the MRUA changes its speed over time. It also considers the similarity that both are in a straight line, uses the same variables, and does not consider the mass of the object
Item 5. Reagent 1. He argues what would happen if the screwdriver encounters some obstacles in its path.	Generalizes	
	The expected answer should contain: 1. There would be a change in speed or 2. There would be acceleration or deceleration or 3. It would be MRUA or 4. There is a change of direction	
Note: Some of the items are generated by an activity such as a reading or previous exercise. According to the Technical Manual for Developing Items to Assess Competencies, a task can generate several items, leaving a total of 26 items distributed in 12 items. Own elaboration.		

Once the design of the instrument to evaluate the reasoning processes has been completed, it is necessary to have a reference that allows the components of the RII to be located with the cognitive processes of the levels that make up the Marzano and Kendall Taxonomy. The purpose of this is to provide a means of translating cognitive levels in terms of components of the RII, in addition, this will allow us to collect evidence on variations in the RII.

Table 4 – Correspondence of the Cognitive System of Marzano and Kendall's Taxonomy and the Components of the RII

Cognitive System	Cognitive Process	Level	Component of RII
Recall	Recognize	I	Making judgments or predictions
	Name		
	Execute		
Comprehension	Integration		
	Symbolization		
Analysis	Relate	II	Use or integrate priority knowledge
	Classify		
	Analyze for errors		
	Generalize		
	Specify		
Utilization	Decision-making	III	Articulate argument-based evidence
	Solving-problems		
	Experimentation		
	Investigation		
Note: The four cognitive levels used in the Cognitive System of Marzano and Kendall's Taxonomy correspond to the three components of the RII. I feel that Remembrance and Understanding those who refer to the first component. Likewise, each of these cognitive levels has the implicit processes that are executed. Own elaboration.			

Instrument Piloting. In this phase, different technical and content reviews are carried out to ensure that the reagents are error-free and free of confusion in what is sought to be evaluated [9]. Therefore, in this stage, actions are carried out such as submitting the items to the judgment of experts to promote the correspondence of the items with what is sought to be measured, carrying out a subsequent validation taking into account the comments and suggestions of the experts to eliminate the irrelevant variance in the items [10]. Once this validation is completed, it is necessary to launch (pilot) the IIR instrument with a similar population [11] to which we would work in future research, which in this case are students between 15 and 18 years old who study high school,

to perfect the relevant details, such as instructional design, understanding of the task, among others before its administration [12].

Thus, the actions carried out in this step are intended to provide evidence that supports that the RII instrument measures the cognitive processes that it must measure. That is why, based on the design of the items of the RII instrument, the test was submitted to the judgment of 12 experts, and each of the 22 items was validated in terms of comprehension and relevance under a Likert scale, whose weighting was: 4 is "high level of understanding/relevance, and 1 is "not understandable/relevant". This questionnaire was sent through a Google form.

Validation by the experts yielded the following results: the instrument had a general satisfaction of the items in comprehension and relevance of 73, corresponding to the reliability range of the global Aiken V coefficient. This means that, in general terms, the instrument is reliable, since a confidence of 95% and a coefficient between the 7 and 1 ranges were considered [13].

However, it should be recognized that as a result of some of the suggestions and recommendations of the experts, such as those shown below, an analysis of the experts' agreement was carried out, which resulted in a second drafting of items to be submitted to the pilot test with NMS students.

1. For item 2, item 4: “Change the question to in which units were time represented? as only reading is referred to”.
2. For question 1 of item 5: "The question loses a little context by simply asking you to draw a motorcycle, it would be better to add it to the context of item 3, ask “Make a drawing where you represent Juan's journey on a motorcycle at a speed of 20km/h”, in this way it is already required to identify the beginning (his work) the end (his house) the distance (10km) and the speed of the motorcycle that is necessary for the next question.
3. Of the items in general: “In general, all the questions have a good level of belonging, only one or two I consider would be outside the range that is sought. My suggestion is to seek to rethink them”.

Thus, in response to the recommendations to separate, modify, and/or add some reagents (“*Extra items for the MRU-MRUA connection with Space-time*”; “*here I would ask to calculate considering the MRU variables, at what time would Juan arrive at your house?”; “Differentiate between Fundamental and Derived units for a better understanding and generate greater scope in the question”*), RII's instrument to carry out the pilot test resulted in an extension/separation of the reagents to four more, resulting in a total of 26.

Once the adjustments have been made per the suggestions and recommendations of the expert judgment, it is necessary to remember that a minimum of three items that evaluate the same cognitive process are necessary to avoid random answers [14] and, in this way, consider the correct execution of the cognitive process in question. It is also important to clarify that the instrument is intended to be applied under the real conditions that occur in the classrooms. On the other hand, according to the number of items, it is the size of the sample for piloting.

Concerning the above, the sample was selected in a simple probabilistic way at random, taking care that the characteristics of the population were similar to the population where the instrument would be applied [15]. In this way, the sample size was obtained through an arithmetic operation where the total number of items is multiplied by the minimum number of items to evaluate the same task [16], in this case, a cognitive process. In this way, since there are 26 items, multiplying by 5 (assuming that each cognitive process has several items), results in a minimum sample of 130 individuals. However, given the access facilities that the institution provides to carry out the piloting, it was carried out with 212 students who have similar characteristics to the students with whom the intervention would be carried out. Thus, there were 26 items whose responses evaluate cognitive processes according to the Taxonomy of Marzano and Kendall.

Thus, the inclusion criteria of the subjects that were chosen for piloting were the following:

1. Adolescents aged 15-18 years
2. Graduated from public secondary school
3. Public high school students
4. Attending 2do. the 4th. semester
5. Have had a previous Physics course (high school or previous semesters)

Exclusion criteria:

1. Not having answered all the items

Results and its discussion.

Once the design of the instrument was completed, the piloting of the 26 reagents to 212 high school students was carried out. This resulted in only 41% of the students in the sample achieving an ideal cognitive level (integration, classification, or specification). However, some approached the minimum number of items necessary to consider the execution of the cognitive process, which are shown in Table 5. As for the average time to perform the test, it was 60 min.

Table 5 – Summary of Pilot Results

	Cognitive processes with more correct answers		
	Integration	Classification	Specification
2 correct	30	42	39
3 correct	29	20	38
Note: The "2 correct" refers to the fact that at least two items were answered as expected, remembering that for the cognitive process level to be valid, it is necessary to have at least 3 expected answers. Own elaboration.			

These results allowed for further adjustments to be made, taking into consideration the observations made at the time of providing the RII instrument, as well as the suggestions and recommendations made by the students. For example, during the application of this pilot, recurrent doubts were found in the understanding of the concepts: of variable, magnitude, and unit. This caused some confusion when writing their answers, however, neither the experts nor the author of the instrument realized it when designing and evaluating the items, since they are concepts that are used in other science subjects (and that have been carried out since the secondary level) and familiarity was assumed.

Given that the cognitive levels of students can be located in the transition from level I to II of the RII, that is, they go from making judgments or predictions to beginning to use or integrate priority knowledge, it is evident that the cognitive processes of high school students are not reflected in standardized tests of performance and scientific reasoning. In addition to difficulties in understanding basic science concepts, some items needed modifications in the wording to avoid confusion. For example, students indicated that some instructions or questions were long and tiring, so they were adapted to be more concise and direct. Table 6 shows a comparison between the reagents used during piloting and those modified according to the students' observations and recommendations

Table 6 – Modification of RIIF Instrument Items for Better Understanding for Students

Item Pilots	Item considering the observations/recommendations of the piloting students
Item 2. Q4 According to the reading, what other units do you identify that can be measured in time?	Item 3*. Q4 Identify in the situation described in this item, the units used to measure time

Item 3. Q3 According to the text, how do you distinguish that it is a question of speed and not speed?	Item 4. Q3 Considering that the concepts of ***speed*** and ***speed*** are different, associate the following statements with an X on your answer sheet:
Item 3. Q1 According to the reading, make a drawing including the variables involved where you represent John's journey on a motorcycle, from his home to work, considering that he travels a distance of 10 km with a speed of 20 km/h.	Item 4. Q1 Make a drawing that includes the variables of the MRU and MRUA to represent the following: *a motorcycle ride from John's house to his work. Consider a distance of 10 km and a speed of 20 km/h*
Item 5. Q1 What type of rectilinear motion do the above images belong to?	Item 6. Q1 LOOK AT THE FOLLOWING IMAGE AND ANSWER THE QUESTION: What type of rectilinear motion do the images belong to?
Item 8. Q2 From the following image, answer the paragraphs: What is the distance that the second car travels with respect to the first?	Item 9. P2 LOOK AT THE FOLLOWING SEQUENCE OF IMAGES AND ANSWER THE QUESTIONS: How far does the second car travel from the first? Consider the starting point of 0 m.
Item 10. Q1 Make a drawing where you represent the previous graph. Consider the necessary variables.	Item 11. Q1 Make a sequence of drawings of the variations shown in the previous graph. Consider the variables involved.
Item 11. Q2 What variable(s) would you need to reduce or increase for the motorcycle driver to reduce the time of arrival at a destination?	Item 12. Q2 What would happen over time if: 1. The variable of speed increases with respect to distance 2. The variable of distance increases with respect to speed
Note: The modifications where the items generated more doubts in the students are shown, as well as the instruction that accompanies it. Likewise, the format of the presentation of the instrument had a modification to facilitate fluency in reading. *Item 2 was changed to item 3 because question 3 of item 1 was chosen to be an independent item. Hence, he modifies the sequence of the following ones. Own elaboration.	

Finally, after attending to the pilot's suggestions, it is necessary to administer the instrument with clear instructions, defined time limits, and considering the environmental conditions, as well as the supervision and safety of the instrument and the students. This administration seeks to guarantee standardized conditions, which contributes to the validity of the interpretation of the results. However, since the RII instrument aims to evaluate reasoning processes under usual teaching conditions, environmental factors such as external noise, ventilation, lighting, hygiene, and the volume of students per classroom were not controlled in this research.

Conclusion.

The Informal Inferential Reasoning in Physics (RIIF) instrument is useful to measure the cognitive processes of high school students, particularly teachers to carry out a cognitive diagnosis that can be the basis for the development of activities and/or tasks and consider not only the thematic contents of the curriculum and program, but also the cognitive processes that are desired to be developed in students in order to acquire learning in an activation and execution of reasoning over memorization.

Nevertheless, the instrument has thematic limitations, since it only focused on the MRU and the MRUA, so it would be convenient to extend it to other thematic domains of physics to obtain a complete diagnosis of the baccalaureate course. However, this process would require a thorough review of both the curricula and the design of the items.

On the other hand, from a statistical point of view, it is desirable to complement the results obtained with data from other statistical tests to achieve greater precision in the measurement of cognitive processes. For example, the use of structural equation modeling could be beneficial, since this technique allows identifying and understanding the underlying factors of a latent variable (set of indicators to measure the same cognitive process), such as the cognitive processes

considered in the taxonomy that supports the design of the instrument, allowing a more precise interpretation of the cognitive level to be measured.

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ОРТА МЕКТЕП ФИЗИКАСЫНДАҒЫ БЕЙРЕСМИ ЛОГИКАЛЫҚ ПАЙЫМДАУДЫҢ КОГНИТИВТІ ДЕҢГЕЙЛЕРІН БАҒАЛАУ ҚҰРАЛЫН ӘЗІРЛЕУ

Аңдатпа.

Бейресми пайымдау (IIR) – негізгі сипаттамасы оқушының қоршаған ортасын ескеру, бейресми және формальды пайымдау болып табылатын танымдық формалды пайымдау әдетте орта мектептегі физика сияқты жаратылыстану курстарында насихатталады және жасөспірім кезеңінде дамып, бекітіледі. Зерттеудің мақсаты әрбір когнитивтік процесте қол жеткізуге болатын нәтижелер тұрғысынан егжей-тегжейлі берілген Марзано мен Кендалл таксономиясының білім беру мақсаттарына негізделген элементтермен IIR өлшеу әдістерінің құрылысын зерттеу болып табылады. Сол сияқты негізгі физика ұғымдары Бірыңғай түзу сызықты қозғалыс (URM) және Бірқалыпты үдетілген түзу сызықты қозғалыс (UARM) тақырыптары қамтылған. Бұл зерттеудің өзектілігін 12 сарапшы бағалады. Пилоттық сынама 15 пен 18 жас аралығындағы 212 жоғары сынып оқушыларымен жүргізілді. Зерттеу нәтижелері физиканы оқытуға қажетті когнитивті процестерді бағалау әдісінің сенімділігі мен негізділігін көрсетті (Айкеннің V = ,73). Бұл эксперимент тақырыптық оқу бағдарламасының мазмұнын еске түсіруден бастап білімді талдау мен пайдалануға дейінгі когнитивтік процестерді біртіндеп ынталандыру үшін бейімдеуді қалайтын мұғалімдерге арналған пайдалы әдіс болып табылады.

Негізгі сөздер: бейресми логикалық ойлау, танымдық процестер, орта мектеп физикасы, орта мектеп оқушылары, таксономия Марцано және Кендалла.

РАЗРАБОТКА МЕТОДОВ ОЦЕНИВАНИЯ КОГНИТИВНЫХ УРОВНЕЙ НЕФОРМАЛЬНЫХ ИНФЕРЕНЦИАЛЬНЫХ РАССУЖДЕНИЙ В ФИЗИКЕ СРЕДНЕЙ ШКОЛЫ

Аннотация.

Неформальное логическое рассуждение (англ. Informal Inferential Reasoning, IIR) - это когнитивный процесс, основная характеристика которого заключается в учете среды учащегося, неформального и формального рассуждения, причем последнее, как правило, продвигается на курсах науки средней школы, таких как физика, и на курсах который разрабатывается и консолидируется на подростковом этапе. Целью исследования является рассмотрение построения методов для измерения IIR с элементами, основанными на образовательных целях таксономии Марцано и Кендалла, которые детализированы с точки зрения производительности, которая должна быть достигнута в каждом когнитивном процессе. Аналогично, ключевые понятия физики рассматриваются из тем Uniform Rectilinear Motion (URM) и Uniformly Accelerated Rectilinear Motion (UARM). Метод был оценен 12 экспертами на предмет понимания и актуальности, и был проведен пилотный тест с выборкой из 212 старшеклассников в возрасте от 15 до 18 лет. Результаты показали надежность и достоверность метода (V Айкена = .73) для оценки когнитивных процессов, необходимых для изучения физики. Этот эксперимент является полезным методом для учителей, которые хотят адаптировать тематическое содержание учебной программы для постепенного поощрения когнитивных процессов, начиная от отзыва до анализа и использования знаний.

Ключевые слова: неформальное логическое мышление, когнитивные процессы, физика средней школы, старшеклассники, таксономия Марцано и Кендалла.

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