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Abstract. The research aims to identify the factors associated with learning physics in older students. A quantitative investigation is carried out with a field-type factorial analysis method, correlational in a sample of 80 physics students, university students over 30 years of age, who apply science, technology, art and physics through designs and simulations in vector fields, perceptual geo-materializations and electrical physics. The research used as a technique the metacognitive skills inventory test ($\alpha = 0.82$), the educational motivation scale ($\alpha = 0.71$), the Tennessee self-concept scale ($\alpha = 0.725$), the psychological well-being scale adult ($\alpha = 0.75$) and the social skills scale ($\alpha = 0.801$). The results show that variables associated with the learning of physics in elderly were the extrinsic motivation index, the motivation intrinsic and demotivating; the active, reflective, theoretical and pragmatic learning style; performance variables, level of learning, spatial reasoning and sensitivity. The results obtained indicate an acceptable fit in the proposed model ($X^2 = 652.55$ /gl $= 3.05$), GFI (goodness of fit index) $= 0.894$, AGFI (corrected goodness of fit index) $= 0.848$, RMSEA (mean square approximation error) $= 0.09$, IFI (incremental adjustment index) $= 0.930$. The explained variance is 31.9% regarding learning style, 38.8% regarding motivation and 15.1% regarding cognitive score and 15.1% regarding consciousness deficit. It is concluded that the predictive factors of learning of physics in older adults were learning style, motivation indices, cognitive score and consciousness deficit.

1. Introduction

Teaching physics to older adults differs from youth-oriented physics; conceptions, fields of action generally associated with the technique and the need to observe its practicality have led to the implementation of studies of methodologies where the design and generation of prototypes are implemented, related to science, technology, art and applied mathematics Steam [1]. However, beyond obtaining models, generating and analyzing physical variables in the designs or simulations, low yields and desertion of adults over 30 years are observed [1]. On the other hand, this situation is even more critical in architecture programs and has been observed in civil engineering courses in which civil works technologists are professionalized. The architecture program does not address physics subjects, which does not allow a real approach to population dynamics, use of vector fields, and there is a lack of temperature analysis in the geometries made by students. Similarly, in engineering, students study these subjects but do not include in their curriculum the corresponding to geometrization. This leads to a low

level of application of physics in architectural design and absence of interrelationships between students in training.

On the other hand, there are marked differences in the physics to be oriented to addressing a formal sequence, understanding the nature of the logic characteristic of the place, where the first protagonist is the user who impacts on their territory with each of its dynamics manifested and configured daily. Likewise the difference between the chronological and mental ages of students in physics in night-time higher education programs and day-time students implies that they have different emotional, social, and cognitive development, and that the academic performance of students is a problem that teachers face in courses with students of different ages, genders, and occupations [2]. When a teacher of physics takes a course, he or she prepares a lesson plan to guide his or her students with the same methodology and the same pedagogical strategies [3], however, when he arrives in the classroom and begins the pedagogical process he finds students with high performance and students with low performance, some quickly interpret the results, others do not, and some students do not manage to acquire basic skills required in the program. Thus, adults who attend training programs during the night have special characteristics, namely, they are over 30 years of age, 95% work, 20% lead companies [3], and it is important to know their capacity for abstract reasoning, whether they have learning styles and skills in certain areas related to physics, and whether cognitive, affective and physiological traits are an indicator of how they perceive, interact and respond to learning environments. Understood as reasoning ability, the human faculty that allows for problem solving and the capacity for abstraction in physics, would imply extrapolating a previously lived situation to a concrete problem to be solved [4] or to design prototypes. Likewise, a correct evaluation of the cognitive abilities of the adult, student of physics, will require a series of prior considerations, such as adapting the exploration to the subject to be evaluated, selecting appropriate tests, determinate physical and psychological abilities of the subject, pre-morbid intelligence level, experience and social characteristics of the adult, where perceptive system, subjective attention is conditioned to tastes or interests [5].

The preliminary study points out, with reference to learning, the need to analyze factors such as the adaptation to each student and his or her way of learning, and the identification of the educational profile of the older student through the identification of talents and learning patterns complements the educational plans that seek their full development [6]. Gardner identified eight different types of intelligence [7], studies maintain that there is a set of relatively autonomous human abilities that make up the intellectual structure of man, intelligences that can be modeled and combined in multiple ways at early ages. However, in adults, intellectual capacity, leadership and other values of people require the use of a type of intelligence or potentiality developed in function of the environment, the education received; furthermore, it should be considered whether an education in physics focused on types of intelligence is the most appropriate for preparing adult students to live in an increasingly complex world whose technological advances are emerging at an incredible speed. Taking into account the characteristics of the adult, the research analyzes learning style, teacher style, motivation indexes, intelligence, sociodemographic variables, implementing methodologies based on science, technology, art and physics in order to determine the factors associated with learning physics, prototyping in vector fields, design and geometrization in physics, the relationship between the type of intelligence of physics students over 30 years of age, their learning style and the results of academic performance obtained in physics courses, it was sought to answer the question: what factors influence the learning of physics in the elderly?

2. Method

The research follows a quantitative approach, factorial analysis methods, it follows a correlational design, field type, non-experimental approach, exploratory scope, descriptive, cross-sectional, correlational. The Universidad Francisco de Paula Santander, San José de Cucuta, Colombia, has a population of 11700 students, of which 3150 of them study physics programs. The sample studied included 80 students over 30 years of age, 70 are studying physical in civil engineering program and 10 are studying in architecture undergraduate programs. The tests were carried out in the second semester

of 2016, 2017 and 2018, using them to assess each of the variables included in the model. Each participant responded to the questionnaires in three sessions. A group of factors associated with teacher training, institutions, and sociodemographic, psychosocial, and pedagogical factors were used as independent variables.

Different tests are implemented, using scales metacognitive abilities inventory [8], $\alpha = 0.82$, educational motivation scale [9], $\alpha = 0.71$, the Tennessee Self-concept scale [10] whit $\alpha = 0.725$, the adult psychological wellness scale (BIEPS-A) [11] $\alpha = 0.75$, and the social skills scale [12], $\alpha = 0.801$. Variables related to the level, by means of an instrument aimed at the teacher, were considered: gender, mastery of subjects, academic grade, updating, importance given to training, methodology, academic demand, resources, frequency of assignment of work and time allocated to the subject of electrical physics, as well as activities carried out around it. Is applied Howard Gardner's multiple intelligences questionnaire [7] and Kolb's learning styles inventory [7], which allowed us to identify personal characteristics of the student regarding the way they processed the information. To verify assumptions of factorial analysis, is used a complementary test of sample adequacy measurement of Kaiser-Meyer-Olkin (KMO) [8] that represents the partial correlation of two variables eliminating the effect of the remaining ones, this measure oscillated between 0 and 1, values lower than 0.50 were considered unacceptable [13], and values close to higher than 0.70 advised the application of factorial analysis, values higher than 0.80 are desirable [14]. Principal component analysis was used as a technique based on the correlations of the variables analyzed; it is desirable that there be an adequate correlation and not too high, since it can cause the phenomenon known as multicollinearity [14]. For the consideration of the optimal number of factors, the magnitude of self-values (greater than 1) was taken as an important indicator [15]. In this case, the percentage of variance explained for each factor and the number of theoretical factors present was considered, with which a fixed number of factors to be extracted was established, fixed at 5; the factorial loads represent the weight of each of the variables, for the factors obtained in the factorial solution [13]; it was considered that the observed variable saturates the factor better, whose factorial load is higher.

In the first scenario, it starts with the presentation of problem situations to be solved, in particular in the design of prototypes of tools, decorative artifacts and blocks, then this phase involves the generation of ideas, search for materials, design and drawings of prototypes, here lies the propositional; the designs involve vector analysis, digital design, analysis, theories, where the ability, discipline or talent of each physics student is diagnosed. The second face includes structural analysis, the use of geometric sequences, which are born on the dates of the mappings conceived associated with vector fields, characterizing the study from five categories: the territory, the physical built, mobility, the environmental and the intangible of the place. Determining that in each of these aspects a variety of mappings originated from the figurative and rasterized will be projected so that in each of these conditions the characteristic of the place is manifested with each of the different geometries that in its nature is exalted. Geometric nature that is materialized and built with the support of digital tools for an evolution of digital manufacturing, supported by physics, as well as resistance analysis, buckling, light, heat and temperature analysis, vector analysis, its interpretation and validity from architectural components of buildings symbol or icons of the city. Once it is designed, simulations, generation of models are carried out, after their interpretation and analog content to integrate an adequate management of knowing how to see, knowing how to project and knowing how to visualize with new analyzes in physics, vector fields, electromagnetism and geometric shapes both two-dimensional with three-dimensional projections, with content in physical and spatial processes.

3. Results
The results show that in adults over 30 years of age who study physics there is no incidence of variables social status, work performed, family training. Results of the different tests show that in the category knowledge in physics-cognition, $\dot{X} = 65.14$, this reflects a score high own knowledge in physics. In the category regulation of cognition, $\dot{X} = 131.41$ was obtained, a score higher than the average. Those who score high in this category have adequate control of the thoughts that intervene in the learning process.

As a total score of the inventory, $\dot{X} = 190.55$ was obtained, higher than the average, students with metacognitive abilities above the average have greater knowledge about their own cognitive processes. In the category knowledge of cognition physics, $\dot{X} = 69.00$, and 52.7 as a cut-off point, in the category regulation of cognition, $\dot{X} = 131.41$ and 105 as a cut-off point, in the general total of the inventory, $\dot{X} = 198.55$ and 156 as a cut-off point. With respect to the inventory of metacognitive abilities (MAI), it is evident that in the subcategory organization, $\dot{X} = 39.95$, reflecting favorable management of information and organizing activities related to learning in a correct manner, planning $\dot{X} = 25.3$, monitoring $\dot{X} = 24.8$; declarative knowledge $\dot{X} = 32.7$; conditional knowledge 28.8; the subcategory evaluation with $\dot{X} = 20.85$, and procedural knowledge with $\dot{X} = 18.40$ with lower scores. $\dot{X} = 36.28$, in the subcategory evaluation, $\dot{X} = 19.18$ was obtained, and in the subcategory called procedural knowledge, $\dot{X} = 15.33$ was obtained. Among the variables performance and metacognitive skills, there is no statistically significant correlation between such variables ($r < 0.2$; $p > 0.05$), only a very low relationship was perceived between declarative knowledge and performance ($r = 0.6$).

In the educational motivation scale (EME) with average 116 shows motivation to perform academic processes and activate cognitive resources for the fulfillment of goals and objectives; within it, in the category called extrinsic motivation, $\dot{X} = 56.00$, score within the average, that is to say, they perform work and laboratories associated with grade improvement, that is to say, as a reward; in the category of intrinsic motivation, $\dot{X} = 50.00$ score above, that is to say, they perform tasks for the gratification of the academic activity generated. In amotivation, $\dot{X} = 10.09$, score below average, reflects that they perceive contingencies between their actions and consequences. As for academic performance and total educational motivation, it was obtained that: $r = 0.60$; this means that there is a statistically significant correlation between these variables because $p < 0.05$. Standardized scores of the abbreviated subtest similarities by age ranges showed how scores for adults over 30 years of age ranged from 12.7 to 13.9 points on average with a standard deviation of 1.2; sensitivity SE = 83, specificity SP = 79, so that the students were in a normal range of intelligence on an abstract reasoning test, taking into account age and previous studies. Analysis of the effect of diagnosis and awareness of deficit on performance in spatial reasoning using a linear model showed preservation of awareness of deficit (95%, $p < 0.0001$). Likewise, students with awareness of deficit had better performance; awareness of deficit was associated with a greater capacity for abstraction, since a statistically significant effect was found in both awareness of deficit ($F = 58.77$; $p < 0.001$) and diagnosis ($F = 3.41$; $p < 0.001$), but not in interaction. Students at this level had a high probability of achieving learning outcomes corresponding to the average level in physics in topics associated with electromagnetism, correctly solving items related to laboratory application of polarization, conduction, magnetic phenomena, magnetization, and dispersion. Regarding the domain of reading comprehension, its level was low; in relation to the domain of graphic expression, students had high possibilities of graphing (95%, $p < 0.0002$) but average capacity to interpret results and graphs when facing an applied situation.

On the other hand, the student's socioeconomic index, perception of pleasure or difficulty towards physics, index of perception of socio-affective relationships ($t = -0.73, p = 0.47$), age ($e > 28$ years, $t = 1.17, p = 0.27$) and gender did not show any association ($z = -0.97, p = 0.33$), there was no relationship between the student's family's expectation of achievement and his/her academic performance. Thus, when controlling for the variables, when the family's expectation of achievement increases (1 point), there is no significant difference on average ($p > 0.05$); when the index of available resources increases by one unit, on average, the students obtained the same academic performance ($z = 1.02, p = 0.07$), when the student's scale of perception of the teacher's mastery of the subject increases by one unit, they increase their academic performance by 0.05 points ($z = -2.83, p = 0.01$). And, by increasing by one unit the student's perception of the teacher's academic proficiency, students increased their academic performance. Students perceived an association between teacher experience with degrees and teacher's mastery of the subject.

In the case of the total obtained in the scale, Self-concept with average $\bar{x} = 85.5$ Self-esteem $\bar{x} = 89.23$ Self-behavior $\bar{x} = 82.57$ physical 49 moral-ethical 66 personal 57.2 family 49.2 social 48.9 total

257.89, finding that between self-concept and academic performance there is a low positive correlation, statistically significant, the results determine that r = 0.5. In scale of psychological Welfare (BIEPS-A.), in acceptance or control, $\dot{X} = 8.4$, in subscale autonomy $\dot{X} = 7.7$, in subscale links $\dot{X} = 8.1$, in subscale projects was obtained $\dot{X} = 12.7$; as total was obtained $\dot{X} = 37.1$, it means that the students that were part of the study sample have social, psychological and subjective states that lead them to be positive. Results of the factors of the Social Skills Scale (EHS) [15], self-expression factor in social situations the mean is $\bar{x} = 30.5$ and standard deviation is $s = 20.2$, in the factor defense of rights as a consumer the mean is 29.2 and standard deviation is 18, in the factor expression of anger or disagreement the mean is $\bar{x} = 48$ and standard deviation is $s = 21.1$, in refusing and cutting interactions the mean was 30.44 and standard deviation is 23, in making requests the mean was 31.1 and standard deviation is 30, in initiating positive interactions with the opposite gender the mean is 45.5 and standard deviation is 28.2; the total result of the scale is slightly above the mean; that is, students have fluidity in interpersonal relationships. However, there is no statistically significant correlation between psychological well-being and academic performance, since $p > 0.05$.

When analyzing the type of learning, students had a marked dominance by visual learning (n = 60, $p < 0.05$); in 31.25% of the students kinesthetic learning predominates; in 8.75% ($p < 0.01$) auditory learning dominates. It should be noted that there are students in whom all three types of learning were present. Regarding the learning style, a tendency to high scores in pragmatic style was observed, however, in average the adult students, in their great majority, have made use of the reflexive style (25 points, $p < 0.01$); the dispersion of the data with respect to its average value was 1.80, which indicated that the students had a good formative process, the active style (25 points, $p < 0.01$) also used, that is to say, there is interest in direct experience, and in the accomplishment of new tasks. It was observed the very low preference, by the theoretical style (8 points, $p < 0.05$), and average in pragmatic (20 points, $p < 0.05$); first consequence of a process of abstract conceptualization and deduction of conclusions, process that required them to be methodical, logical, critical, structured; the second, meant them to risk implementing applications. On the other hand, data associated with the type of dominant intelligence allowed us to observe that intrapersonal and interpersonal intelligence were the most significant with 78.3% and 69.6% respectively ($p < 0.01$). This was followed in order by verbal/linguistic, musical/rhythmic, logical, visual/spatial and finally kinesthetic/corporal intelligence. 26.1% of the students identified themselves with two types of intelligence, 39.1% identified themselves with three types of intelligence, 8.7% possessed four types of intelligence, likewise, 13% five types of intelligence, 4.3% identified one type of intelligence and 4.3% manifested the presence of six types of intelligence.

In general, students have three or more types of intelligence, reaching a high level of performance in learning, 24% of students with verbal intelligence, 55% of students with mathematical logical intelligence, 28% with visual-spatial intelligence, 35% with body kinesthetic, 23% with musical intelligence, 30% interpersonal and 20% intrapersonal. In terms of performance in electromagnetic physics, for each student in the study, the minimum average is 50.8, while the maximum is 60.55; the average is 55 and the standard deviation of the sample is 4.65. Students with interpersonal and intrapersonal intelligence had average performance, students with logical-mathematical intelligence achieved higher performance, and students with kinesthetic-corporal, musical, verbal, and visual intelligence had low performance in physics. On the other hand, associations between type of learning and type of intelligence, there is no relationship between theoretical learning, pragmatic learning and type of verbal intelligence, where the verbal intelligence variable only explained 0.4% of theoretical learning (r = 0.006324555), and 2% of reflective learning (r = 0.014). These results in learning about the physics of Architects, are in line with the results and hypotheses raised by Bastian [16], regarding emotional intelligence, they differ from what is stated by Gonzales [17], in the face of negative effects in this case of stress; Likewise, they agree with the results of Joseph and Newman [18].

Physical thought intelligence explained theoretical learning by 23.8%, reflective learning by 5% and active learning by 2%. Spatial visual intelligence explained theoretical learning by 40%, pragmatic learning by 20%, active learning by 13%, reflective learning by 12%, kinesthetic-corporal intelligence

explained theoretical learning by 50%, pragmatic learning by 11% with a negative relationship, active learning by 16%. Musical intelligence explained pragmatic learning by 26%, reflective learning by 0.06%, active learning by 46%, theoretical learning by 41%. Intrapersonal intelligence explained pragmatic learning by 16% (negative relationship), reflective learning by 35.2%, active learning by 40%, theoretical learning by 45.4%. Interpersonal intelligence explained pragmatic learning by 0.2%, reflective learning by 55%, and there was no relationship with active learning. In general, no significant relationship was found between the type of intelligence and the type of learning of the students.

The results of the verification of assumptions showed a value of the determinant of $v = 0.0001527$, the KMO reached the value of 0.6 and the Barlett's sphericity test yielded $X^2 = 652.55$ and $p = 0.00$, levels of evidence that ensured the adequacy of the analyzed data to perform the factorial analysis. A tetra-factorial configuration was obtained (Table 1), in which the factorial weights ranged from 0.56 to 0.92. The results obtained indicate an acceptable fit in the proposed model ($X^2/gl = 3.05$), GFI (goodness of fit index) = 0.894, AGFI (corrected goodness of fit index) = 0.848, RMSEA (mean square approximation error) = 0.09, IFI (incremental adjustment index) = 0.930. The first factor, motivation explained 38.8% of the variance composed by extrinsic motivation (load = 0.70), intrinsic motivation (load = 0.56), amotivation (load = 0.51); second factor, learning style, explained 30.9% of the variance, composed by active variables (load = 0.69), reflexive (load = 0.8), theoretical (load = 0.6), pragmatic (load = 0.86); a third factor score, explained 15.1% of the variance, with variables performance (load = 0.89), learning level (nl = 0.92), and factor Consciousness deficit explain 7.8%, with variable spatial reasoning (0.9), sensitivity (0.71). Obtaining the development of prototypes and developing processes of vector analysis of incidence of rays, fields and thermal and acoustic analysis in architectural processes allows the student, particularly in adulthood, to perform perceptual processing, where the methodology involves and impacts on emotions of students, promoting the development of physical thought as well as the logical understanding of recognizing and configuring each of the physical and geometric dynamics that characterize a small territory, where it is proposed from a geometry to a spatial, particular and complex materialization.

Table 1. Analysis of factor.

Factors	Indicators	load	r
Motivation (M)	Intrinsic motivation (IM)	0.56	0.910
	Amotivation	0.51	
Learning style (LS)	Active (A)	0.69	0.751
	Reflexive (R)	0.81	
	Theorical (T)	0.60	
Cognitive score (S)	Learning level	0.92	0.767
Consciousness deficit (D)	Spatial reasoning (VS)	0.92	0.718
	Sensitivity (S)	0.71	0.60

4. Conclusions

Factors associated with learning of the physics in students elderly are motivation, with variables extrinsic, intrinsic and amotivation motivation, associated with teacher knowledge; learning style with variables active, reflexive, theoretical, pragmatic; cognitive score with variables performance, learning level and factor deficit awareness with variable spatial reasoning and sensitivity.

Students elderly have a visual learning style, with preference for a pragmatic and reflective learning style. Students with mathematical logical intelligence achieved a high level of learning and high academic performance. Students perceived an association between teacher experience with degrees and teacher's mastery of the subject. Including physics in architect's curricula, improves levels of emotional intelligence, enhances the development of prototypes and develops vector analysis processes of lightning incidence, fields and thermal and acoustic analysis in architectural processes allows the student, in particular in adulthood, the perform perceptual processing, where the methodology involves and impacts on the emotions of students, enhancing the development of physical thought as well as the

logical understanding of recognizing and configuring each of the physical and geometric dynamics that characterize a small territory, where it is proposed from a geometry to a spatial, particular and complex materialization.

References
[1] Maldonado H, Rojas J P, Vergel M 2020 *Innovación y Creatividad: Estrategia Pedagógica en la Enseñabilidad del Cálculo Aplicado a la Física Electromagnética* (Bogotá: Ecoe Ediciones)
[2] Albán J, Beltrán G, Zumba I, Piza N, Franco X, Figueroa M 2018 Motivación educativa en estudiantes de educación superior *Revista Dilemas Contemporáneos* **6** 2
[3] Carranza R, Hernández R, Alhuay J 2017 Bienestar psicológico y rendimiento en estudiantes de pregrado de psicología *Revista Internacional de Investigación en Ciencias Sociales* **13** 2
[4] Chong E 2017 Factores que inciden en el rendimiento académico de estudiantes de la Universidad Politécnica del Valle de Toluca *Revista Latinoamericana de Estudios Educativos* **47** 1
[5] Vizcaíno D 2015 *¿Qué es Didáctica de la Física?* (Medellín: Universidad de Antioquia)
[6] Alegret M, Espinosa A, Vinyes-Junqué G 2013 Cut-off scores of a brief neuropsychological battery (NBACE) for Spanish individual adults older than 44 years old *PLOS ONE* **8** 1
[7] García C 2005 Habilidades sociales, clima social familiar y rendimiento académico en estudiantes universitarios *Revista Liberabit* **11** 11
[8] Gardner H 1994 *Estructuras de la Mente* (México: Fondo de Cultura económica)
[9] Díaz L 2002 *Estadística Multivariada: Inferencia* (Bogotá: Universidad Nacional de Colombia)
[10] González C, Caso J, Díaz K, López M 2012 Rendimiento académico y factores asociados. Aportaciones de algunas evaluaciones a gran escala *Revista de Pedagogía Bordón* **64** 2
[11] Parra H, Suarez J, Vergel M 2019 Curricular trends in the University Francisco de Paula Santander academic program offerings *Journal of Physics: Conference Series* **1329** 012013:1
[12] Huertas A, Vesga G, Galindo M 2014 Validación del instrumento inventario de habilidades metacognitivas (MAI) con estudiantes colombianos *Revista Praxis & Saber* **5** 10
[13] Valle A, González R, Núñez J, González J 1998 Variables cognitivomotivacionales, enfoques de aprendizaje y rendimiento académico *Revista Psicothema* **10** 2
[14] Martinez M 1991 Analisis de escalas acumulativas: modelo de Mokken *Phycotema* **3** 1
[15] Zepeda S, Abascal R, López E 2015 Emociones: Factor de cambio en el aprendizaje *Revista Ra Ximhai* **11** 4
[16] Bastian V, Nettelbeck T 2005 Emotional intelligence predicts life skills, but not as well as personality and cognitive abilities *Personality and Individual Differences* **39** 1135
[17] Gohm C 2002 *Affect as Information: An Individual Differences Approach. The Wisdom in Feeling Psychological Processes in Emotional Intelligence* (New York: Guildford)
[18] Joseph D, Newman D 2010 Emotional intelligence. An integrative meta-analysis and cascading model *Journal of Applied Psychology* **95** 1