

Learning Styles Theory: Could Students' Learning Preferences Make STEM Subjects Easier to Learn?

Julio Garay¹ and Jairo Orjuela-Segura^{1,2}

¹*Department of Chemistry, Earth Sciences and Environmental Sciences,
Bronx Community College, City University of New York, 2155 University Ave,
Bronx, NY 10453, USA*

²*JGO Scientific Learning³, Business Administration,
University Colegio Mayor de Cundinamarca, Funza-Cundinamarca- Colombia
E-mail: ¹<julio.garay@bcc.cuny.edu>, ²<jgoscilearn@gmail.com>*

KEYWORDS Academic Success. Education. Perception. Pragmatic. Teaching

ABSTRACT This paper focuses on exploring how the learning process is perceived by the students. The researchers have chosen Kolb and VARK learning models, in order to identify the participant cohorts' preferred learning pathways, so the researchers can clearly understand their expectations, strengths and preferences utilising the evidence-based inquiry method. The results indicate that none of the two learning models applied can in actuality include all the broad range of learning expectations of the students, regardless of their age. Youngsters seem to be more aligned with the active learning mode, while older students can perform better with more abstract concepts. The geographic origin seems not to have any noticeable impact on the learning styles preferences of the students participating in these trials.

INTRODUCTION

Understanding how the learning really occurs, seems to be the logical pathway to tweak the teaching approach in order to maximise effectiveness in the learning process. Nevertheless, the complications of this method start once one puts more than one student together in the same classroom, as the ways how each person learns can be truly unique. In this study, the researchers wanted to explore the following objectives.

Objectives

The purpose of this study is to explore whether the learning styles model can effectively make a meaningful difference in the students' learning outcome by helping them to identify their natural abilities to assimilate new information or situations, utilising two of the most popular learning styles models, namely, Kolb's learning style model and the VARK model. The intention is also to determine whether the input of these two models will facilitate their work and engagement with STEM related subjects/careers.

Brief Review of the Topic

There is still a debate whether the learning styles really contribute to the students' learning

process in a meaningful and significant way (Kirschner and Van Merriënboern 2013; Ismail et al. 2022; Obloberdiyevna and Odilkhonovna 2022). Most of the studies published in the literature are restricted to some very specific subjects such as mathematics (Biber et al. 2022; Perienen 2020), English (Agustina 2022; Yu-Li and Chun-Chin 2020), biology (Greener et al. 2022; Andrews et al. 2017) and many more. It is noticeable how early in history, some very influential people like Aristotle already realised around twenty four hundred years ago, how his pupils learned at different paces and under different sets of conditions (Cohen et al. 2016). This idea was dusted off in the early 1900s by Alfred Binet leading as a result of these studies to the first intelligence test (IQ test) in modern history (Fancher 2017). Later on, Maria Montessori introduced the idea of using different academic materials to drive students' interest (Moos 2013), instead of the traditional and purely memory-driven strategy of the traditional teaching system. In the mid- 1900s, some additional and more elaborated learning styles and scales emerged such as, the broadly used Bloom's Taxonomy scale, where the objective was to classify the knowledge in hierarchies based on six cognitive skills of knowledge, comprehension, application, analysis, synthesis and evaluation, that the students should progressive-

ly accomplish (Pujawan et al. 2022). Few years later, Isabel Myers-Briggs and Katherine Briggs developed the Myers-Briggs Type Indicator (MBTI), which focused the attention mainly on the judgement of order and consistency of the information, organised by the following dichotomised categories of *judgement/perception*, *sensing/intuition*, *thinking/feeling* and *extroversion/introversion*, which ultimately will facilitate to classifying the MBTI test takers into different abilities and set of skills according to the scores obtained in the test (Ontoum and Chan 2022). In spite of the fact that many more other well-structured classifications have appeared over time, the attention will be focused on two widely used models of Kolb's learning model first proposed in 1984 (Rehfeld et al. 2022), and the VAK first proposed by Walter Burke and later developed and renamed as VARK by Neil Fleming in 1987 (Willis 2017). The reason why these two models have been chosen is that Kolb's model covers the internal sphere of the learning process, which includes perception and processing, while the VAK or VARK model addresses the external components such as visual, additive, writing/reading and kinesthetic, such that by combining these two models a more complete idea about someone's learning process can be established.

Kolb's model considers three basic components in the learning process (Casey and Goldman 2010). First, the subject's previous learning experiences, second, the inherited learning skills and finally, the learner's present conditions as the matrix to evaluate the efficiency of the learning process. In Kolb's view, learning happens in a cyclic process composed of four stages rooted in the actual experiences (Cunliffe and Easterby-Smith 2004). These four stages are concrete experience, and reflective observation, where the student is guided by their feelings and information coming from the senses as abstract conceptualisation. In this stage, the learner should interpret and correlate the acquired knowledge to what is known, and identifying similarities with past-related experiences, and active experimentation, which is the opportunity that the students have to learn from experimentation and direct exposure to practical tasks, where the principles have a concrete application (Ibáñez et al. 2014). The exposure to these different conditions favours the creation of preferred learning styles that Kolb

called *accommodators* that correspond to the type of learners that prefer the concrete real experience. *Converges*, they usually understand the theoretical ideas but still want to have concrete examples, they deal with abstract concepts but they should be translated into real-world examples. *Diverges*, which prefer to use concrete ideas and personal experiences to propose theories with broader applications and finally, *assimilators*, which prefer to work on abstract ideas and theories in order to expand the theoretical frame based on their own proposed ideas and contributions (Kolb and Kolb 2005; Schmitt and Domingues 2016).

The VAK (Visual, Auditory and Kinesthetic) model, later modified into the VARK model by Fleming, has a somewhat unclear origin. Some literature sources attribute it to the early work of Fernald, Keller, Orton, Gillingham, Stillman and Montessori in the early 1920s according to Wickramasinghe and Hettiarachchi (2017), while some other sources mention Walter Burke as the creator of this model. Burke and his collaborators proposed that anybody has a preferred modality to become more engaged with the process of learning, depending on how the information is delivered. Some people will be more motivated by the visual details of the presented information, some other learners might become more comfortable with the information containing sounds, and some other types of learners may be more engaged with the dynamics of the message. Burke also proposed that although it might be a preferred inclination to one of these models, there is also room for combinations of them to get through the message. Some critics have classified this approach as too deterministic (Archambault et al. 2022), because it encloses the learners' options into a very small sphere of possibilities that will prevent the learner to expand and to consider alternative approaches to knowledge (Sadi and Ergas 2022).

The most popular learning methods do not address the importance of the STEM subjects in modern society. It is predicted that by year 2025 the needs to have more professionals in engineering will be higher (Li 2022). Nonetheless, the statistics of motivation for the students to choose these subjects is rapidly dropping from the fifth elementary grade to the eleventh grade of high school by more than 50 percent in the United

States (Bureau et al. 2022). Another critical problem with STEM subjects is the so called “math-phobia” or also called maths anxiety, which has been widely discussed in many papers for a long time (Martel and Mehallis 1985; Miller and Mitchell 1994; Neelofar et al. 2022) This is a particularly concerning issue, as mathematics is the spinal cord of STEM subjects, as if this topic is problematic on its own, the repercussions on students’ choices will necessarily be severely affected as well. Unfortunately, traditional methods of teaching mathematics have not evolved quickly enough to incorporate new technologies to address this negative image issue, as in most of the educational institutions the choice is quantity of information instead of quality of it. Studies have also been conducted on the willingness of the teachers to adopt new teaching technologies in the classroom (Baylor and Ritchie 2002; Gomez et al. 2022), as the technology itself seems to also create uneasiness on teachers’ sense of security around their pupils. Since the objective of the learning styles theory is primarily to understand how the learning process occurs, and also to find better ways to make the learning more effective, potentially, it could become an instrumental tool to help address the first negative impression left in the students after being exposed to this subject. Identifying the most accepted learning style in a maths teaching class could truly make the learning process more enjoyable, fun and interactive. If the students are capable of comprehending the real value of maths and its multiple potential applications when it comes to solving critical problems that are present in society, it will most likely change their perception and perhaps their attitude towards it, making it more appealing and eventually attractive to them.

Research Question and Related Hypotheses

Will identifying a preferred learning style be compelling enough to drive students to a successful academic experience? Can the scores of these two learning style tests or any other for that matter, help students to identify their path to STEM careers? The learning style theory has been criticised due to lack of sufficient data to back up its claims and also due to the restricting nature of labelling individuals, which is a limitation on its own. Perhaps, the real value of the learning styles

theory lies in its potential to provide a tool to identify students’ innate abilities and preferences to acquire knowledge and to explore their options.

METHODOLOGY

This study utilises both Kolb’s Learning Style form and VARK form. These two forms were applied to two separated cohorts of students in two different countries in order to identify any noticeable differences due to cultural reasons. By using evidence-based inquiry methods (Abdi 2014), it was expected to collect students’ answers within a two-week window, and then apply statistical analysis methods to process the data.

Subjects

Both the Kolb’s form and the VARK form were electronically distributed among participating students by week 05 to 08. The formats utilised in the surveys are scale close-ended type and the students were asked to fully answer all the questions presented to them. Data were collected over a two academic periods from 2 of the 18 sections of an introductory-level chemistry course offered every semester by the Department of Chemistry at the Bronx Community College/CUNY, and the second cohort from the Calculus I class from Universidad Colegio Mayor de Cundinamarca in Bogotá, Colombia. The two courses are part of the STEM field and are required for students majoring in basic sciences, engineering and some health related careers. The Chemistry Department at BCC shows a mean annual enrolment of 311 students according to a study of historical enrollment and course outcomes rates between spring 2005 and the summer 2017 (BCC Chemistry Department 2015). From this average, the researchers have taken about 10 percent of students to run the study. The students answering the two tests represented a range of majors and grade levels, with a median age of 21 years. The trials also included middle school students coming from public schools in Bogota-Colombia with ages between 12 and 13 years of age, all taking both maths and sciences as part of their academic curriculum.

Instrument

Kolb’s survey contains 80 visual analog and Likert scale close-ended type of questions to match

their feelings or opinions with either a positive or a negative answer. VARK's survey is a 16 multiple-choice questionnaire, where students can choose more than one answer if they need to. The collected answers will allow the researchers to identify the preferred learning style if materials, lectures and labs are customised to improve class methodology and delivery, in order to make it more meaningful and impactful on the students. The distribution of the VARK questions is as seen in Table 1.

Table 1: VARK questions distribution grouped in four different categories of A, B, C and D

Question	A category	B category	C category	D category
1	K	A	R	V
2	V	A	R	K
3	K	V	R	A
4	K	A	V	R
5	A	V	K	R
6	K	R	V	A
7	K	A	V	R
8	R	K	A	V
9	R	A	K	V
10	K	V	R	A
11	V	R	A	K
12	A	R	V	K
13	K	A	R	V
14	K	R	A	V
15	K	A	R	V
16	V	A	R	K

Kolb's scale has the following distribution of answers as seen in Table 2.

Procedure

The study began by sending the digital forms utilising Google Forms format to the participating students, wherein they had the option to answer the questions at their own time. The form remained active for a couple of weeks, which gave them plenty of time to accommodate their schedule accordingly, in order to make time to answer the proposed questions. The answers were all collected in a database to later be processed, assessed and interpreted.

RESULTS

In order to have a more precise idea about the outcome of this part of the study, the researchers examined the results of the VARK's test, which were collected from freshmen college students

Table 2: Answer key to evaluate Kolb's test results

Activist	Reflector	Theorist	Pragmatist	Preference
20	20	20	20	Very strong preference
19	19	19	19	
18	18	18	18	
17		17	17	
16		16		Strong preference
15				
14				
13				
12	17	15	16	Strong preference
11	16	14	15	
	15			Moderate preference
10	14	13	14	
9	13	12	13	
8	12	11	12	
7				Low preference
6	11	10	11	
5	10	9	10	
4	9	8	9	
3	8	7	8	Very low preference
2	7	6	7	
1	6	5	6	
0	5	4	5	
	4	3	4	
	3	2	3	
	2	1	2	
	1	0	1	
	0		0	

and middle school students, classified based on age and gender, following the same sequence as the questions appear originally in the survey, just to identify the predominant tendency of the students' preferences. Each of the questions offers a visual, kinesthetic, auditory and reading/writing option, which was picked by the test taker based on their preferred learning style (Fig.1).

The first question in the VARK test was an open-ended question about learning preferences in general, wherein 83 percent of participants preferred to use examples and applications, which corresponded to (K) kinesthetic learning style, and these results reflected the preferences that students have for learning situations where they can experience the concepts, which involve their emotional cognitive sphere and give them an experiential approach to the topic under discussion.

The second one was a situational question, wherein 50 percent of the preferences were more inclined towards the auditory (A) type of learning, which suggests that the participants value the experiences that someone else has gone through and their impressions and opinions some-

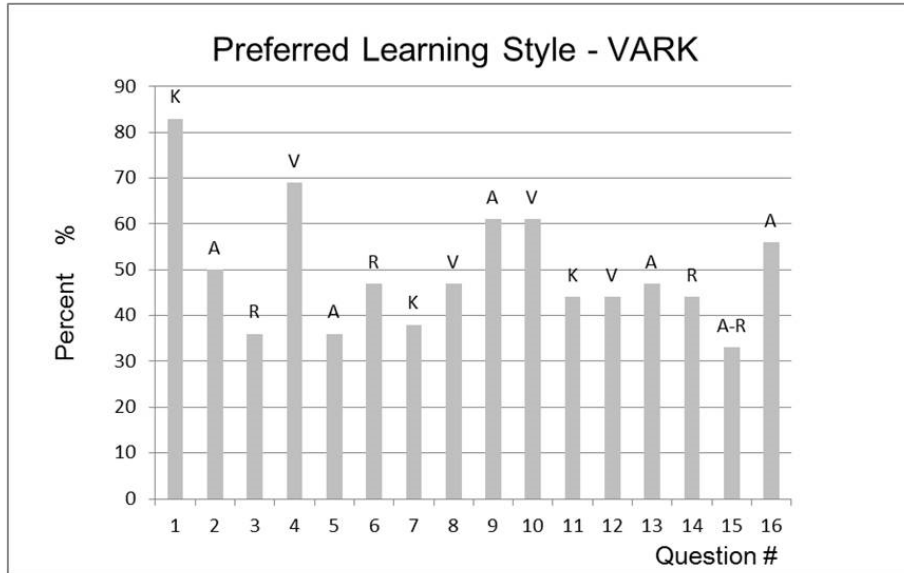


Fig. 1. Distribution of answers collected to elucidate the cohort's preferred learning style

how will help the test takers to shape their own decisions. This is an interesting finding, as the social component becomes relevant and influential at the moment of making decisions, and it shows that the collective opinion can strongly influence one's preferences.

The third question involves a situation where the decision has a stronger impact on the individual's stability, such as the choice of a place to live. In this case, the third party opinions seem not to have the same influence in the decision, and it looks like a written document will give the test taker a better sense of certainty and confidence. Perhaps it is so because it represents a reference to back up any future conflict between the expectations and the reality, once they confront the place of their choice. 36 percent will prefer printed (R) description of the property, another 30 percent of the test takers have chosen to see (V) the plan showing room and maps of the area, which makes them more certain about what they can expect from the property. Written information comes in a sort of legal guarantee, which gives the individual a sense of peace of mind, which in combination with the opportunity to see the actual item becomes the ideal condition to make a final decision.

Learning from the internet has become the preferred choice for many people nowadays, as there are almost unlimited sources of information online, which makes the approach to a new situation more certain, as one can actually see how the process is performed and what the outcomes will be. It saves people the trouble of having to read and perhaps even to understand what the instructions for a particular procedure are really trying to communicate. Often times, it occurs that manuals or instructive procedures fail to clearly and unambiguously communicate the right message, not to mention, the amount of time that it might require to go thoroughly through it, so people give up in the middle of the process in order to start a sequence of trial-error attempts to complete a task, which might lead to an undesirable outcome. All these problems can be easily avoided just by watching an explanatory video, which will save time and trouble. So then, 69 percent of students preferring the visual learning option (V) makes a lot of sense.

The lack of financial literacy is a common issue for the vast majority of people, and the outcome of question 5 confirms this issue. This question addresses the decision about what to do with a lump of money that has been saved over a peri-

od of time, wherein 36 percent of the answers favoured the choice of talking (A) to an expert to get advice on the kind of investment that one must make, while almost the same amount of people at 33 percent, will prefer to read (R) more information about it, so they can learn enough to make a smart decision, while another 25 percent will go for a choice where they can see (V) graphs to learn more about their options. It looks like with very sensitive matters such as the finances, people do not have a clear picture of what their options are, and so uncertainty seems to be the dominant characteristic. In this regard VARK allows one to get a glimpse not only of a preferred learning system, but also, a phenomenological issue hidden in the shadows of an apparently simple exercise.

The introduction of the so called “ready-to-assemble furniture stores”, about seventy years ago, propelled a new culture of self-assembling one’s own furniture wherein back on those days, the technology of instructive videos was not available, so the preferred way was the written (R) instructions inserts, where the steps to set up the item were included in the package. Perhaps this tradition explains why 47 percent of the choices favoured that option, and nonetheless, the age of internet arrived in the late nineteen hundreds, changing completely the landscape of the self-assembling practice, raising to a 33 percent nowadays, and surely, it will continue growing even more, as the stores continue their technological upgrades to make these resources even more available to their customers.

When learning about a new project (question 7), the answers favoured the kinesthetic (K) approach again with a 39 percent, meaning that the students would prefer to get involved in the concept, with a real experience component that allows them to be fully immersed in the subject. This is a very similar outcome to the one that the researchers found for question 1, where the theme was the learning process as a general concept. It looks like having direct contact with the subject is the preferred way to go. The second preferred method of learning about a new project is visual (V) at 33 percent, where working with charts, designs and maps help the students to have a good grasp of the subject, allowing them to become more involved and interested in the project. There

is another almost 30 percent left where the learning style will split between auditory (A) and written (R).

Question 8 pertains more to finding directions to get to a place, wherein the preferred option is visual (V) looking up the address in a map will help at least 47 percent of test takers. This method is probably going to become even more prevalent, as most of the smartphones have geographic positioning systems (GPS) built in, so the preferences for the visual strategy must probably skyrocket in the near future. Both auditory (A) and written information, come to 22 percent. The auditory method (A) method has the disadvantage that memorising the exact steps to get to a place must be part of the process, and oftentimes, people have trouble remembering detailed information in a precise sequence. The written directions certainly might help, but again, it requires figuring out how to find the way as the person goes.

When it comes to choosing a career path, listening to other people’s experiences is highly regarded by the participants in this study, wherein 61 percent considered that communication with others through discussion will make a very important difference during the process of choosing a career. What others have gone through can be a source of inspiration when they can find successful stories to emulate, and in contrast, the unsuccessful trials can also help to save people from negative experiences, or at least, to avoid the same mistakes that someone else has made, which ultimately will save time and effort. The situations might not necessarily be exactly the same, but some similarities could be sufficient to tweak the approach and perhaps get a better outcome. The second preferred learning system is visual (V) by studying maps, designs and charts.

Question 10 is a good example of the power of the visual (V) learning system when the situation seems to present the possibilities all together, such as, getting instructions in the video format. In that case, visual, auditory, kinesthetic and writing learning methods all seem to have the same chances to be the preferred method of learning, nevertheless, the visual pathway becomes the way to go with 61 percent overall. Perhaps in this case, it is more difficult to clearly distinguish whether a synergistic effect is taking place, as differentiating the visual from the auditory components in a video might be certainly tricky. The limits to where students can separate these two

methods of learning could be just a matter of attention, or better to say, perception of the message, it could also be a matter of speed of information processing, is it the visual a faster and more complete form of perception, or is it the auditory one, or both of them work synergistically in helping one to figure out and interpret new information. The data also shows that listening is the second choice with 25 percent preference.

When one has done an activity, getting objective feedback could be desirable, if one can get some constructive critique. These comments could spark a process of improvement in order to become better in whatever the activity might be. It can help one to identify where the weaknesses are and to establish also where the opportunities of improvement lay. Nevertheless, a critique can elicit a high emotional response, due to the fact that the way how a critique may be taken always runs the risk of being negatively interpreted, independently of the original intention, or it can also be positive and one can use it to make their performance even better. The participation of the senses makes the process to be perceived as a kinesthetic one in 44 percent. Another 25 percent of the participants have chosen the visual learning style as the preferred method.

To the question, “*I have a problem with my heart*” (Q 12), 44 percent of the test takers preferred to have examples where they can see in actuality the implications of the issue that they are facing, as it will help them to have a better understanding of the problem and perhaps anticipate some solutions to the problem. Another 19 percent of the participants are more inclined towards reading about the issue, in order to educate themselves in the details of the problem and identify possible consequences and solutions. There is also another 19 percent that preferred to have hands-on experience utilising a model that can help them to identify some likely causes and also some possible ways to get out of the problem.

Question 13 is somewhat related to question 4, both of them involving the usage of computers, nevertheless, the outcome is different. In question 4 the preferred learning style was visual, in contrast to the preferred option for question 13, which is auditory in 47 percent. It looks like talking to someone who has already experienced the task that one is about to face could be a reliable source of information, as they can help to

save time and perhaps provide some non-explicit information that usually is missing or confusing in conventional operative instructions. 25 percent of the test takers would be more comfortable using explanatory book diagrams (V) where the details of the steps are disclosed facilitating the learning process. Another 25 percent will be happier working with the instructions included in the computer program, which corresponds to the (R) category.

When it comes to following directions about how to play a new game (Q14), the preferred learning style is reading the instructions (R) at 44 percent, in order to get a sense of what the rules are and how they should be played. Reading instructions would be actually the ideal choice when facing a new game, nevertheless, oftentimes, the instructions might not necessarily be readily available, and people are more exposed to the game without necessarily having access to the rules. In that case, the watchers will end up learning the rules and the do’s and don’ts of it just by being involved in its practice. In fact, 20 percent of the test takers have chosen the visual (V) method as the preferred way to learn how to properly play a new game.

For the question on “*I want to learn how to take better photos*” (Q15), the answers are equally split between the students that would prefer to read instructions on how to do the activity properly (R), and the students who would prefer to talk to experienced photographers in order to get the tips to perform a better work. Practice will always be paramount to the theoretical approach in activities where getting involved is necessary and repetition becomes a requirement, until sufficient amount of practice is accumulated, and the techniques become second nature.

The final question (Q16) is about the preferences between a teacher or a presenter that uses different resources to help their pupils to become familiar with the concepts and content understanding. Interestingly enough, the students would prefer question and answer sessions, talks, group discussions or participation of guest speakers, so they can learn directly from the people who have already gone through the experiences. This is somewhat an unexpected result, as modern generations have an enormous content of visual resources available to utilise, so the fact that they preferred someone who is capable to communi-

cate the message at 58 percent is truly surprising and encouraging for teachers and instructors. 33 percent of the participants would like to have materials that they can read and get to know better about the topic under discussion.

According to the results obtained, 37.5 percent of the participants are more inclined to learn with the auditory learning style (A), followed by a 25.0 percent of participants that would prefer the visual learning style (V). The other two learning styles, write/read and kinesthetic, share an 18.75 percent each. These are the results for the first choice option, the highest scored alternative, but in some cases, these percentages are not significantly different from other options presented to the participants. The second most popular choice is actually split between visual learning style (V) with a 33.3 percent score and write/read (R) learning style with a 33.3 percent score as well. Kinesthetic came third 19 percent and finally auditory (A) 14.3 percent. All these results are displayed in Tables 3 and 4.

The second model considered in the approach was the Kolb learning system. In this model, learners are classified based on their affinity with one of the four classifications of accommodator (pragmatist), where the connection to learning is concrete from real experiences, the second type of learners are convergers (activist) who display a very good understanding of the

theoretical background but the experimental part must also be part of the learning process. Divergers (reflectors) prefer concrete ideas and personal experiences as the main approach to learning, while the last component of Kolb classification is assimilators (theorists) who thrive in an environment of abstract ideas and theories. The survey was answered by 146 students distributed in three different groups classified based on age. The results obtained are shown in Tables 5, 6, and 7.

The survey was given to three different groups of age with the intention to find out whether fundamental differences on the way they per-

Table 5: Radial distribution of the answers obtained from students averaging 11.1 years of age participating in the survey

Accommodators	Divergers	Assimilators	Convergers
23 Pragmatics	19 Reflectors	14 Theorists	16 Activists

Table 6: Distribution of the answers obtained from students averaging 12.3 years of age participating in the survey

Accommodators	Divergers	Assimilators	Convergers
14 Pragmatics	20 Reflectors	18 Theorists	20 Activists

Table 3: Number of answers per choice per question asked, and the correspondent percentages

Choice	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16
V	1	6	8	25	9	12	13	17	8	22	9	16	9	7	6	0
A	2	18	4	6	13	5	6	8	22	9	7	6	17	6	12	21
R	3	6	13	4	12	17	3	8	2	1	4	7	9	16	12	12
K	30	6	11	1	2	2	14	3	4	4	16	7	1	7	6	3
Q#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
V	3.0	16.7	22.2	69.4	25.0	33.3	36.1	47.2	22.2	61.1	25.0	44.4	25.0	19.4	16.7	0.0
A	5.6	50.0	11.1	16.7	36.1	13.9	16.7	22.2	61.1	25.0	19.4	16.7	47.2	16.7	33.3	58.0
R	8.3	16.7	36.1	11.1	33.3	47.2	8.3	22.2	5.6	2.8	11.1	19.4	25.0	44.4	33.3	33.3
K	83.3	16.7	30.6	2.8	5.6	5.6	38.9	8.3	11.1	11.1	44.4	19.4	2.8	19.4	16.7	8.3

Table 4: Frequency of answers classified for first choice (based on data shown in Table 1 and secondary choices, which data appears in Table 3)

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Preference	K	A	R	V	A	R	K	V	A	V	K	V	A	R	A/R	A
Percent	83	50	36	69	36	47	38	47	61	61	44	44	47	44	33	56

Table 7: Number of students classified according to Kolb category, group 3 (46 subjects, average age 13.2 years)

<i>Accommodators</i>	<i>Divergers</i>	<i>Assimilators</i>	<i>Convergers</i>
9	22	20	21
Pragmatics	Reflectors	Theorists	Activists

ceive the learning process really exist. Table 8 shows the results of the participants' preferences.

Table 8: Weighted percentages based on learning styles preferences

<i>Learning style</i>	<i>Group # 1</i>	<i>Group # 2</i>	<i>Group # 3</i>
Accommodators	32.0%	19.4%	12.5%
Divergers	26.4%	27.8%	30.5%
Assimilators	19.4%	25.0%	27.8%
Convergers	22.2%	27.8%	29.2%

According to these results, the group formed by the youngest students preferred to be in an environment where experience and concrete actions must be the main component of the learning atmosphere. They will be more involved in the process of learning if the materials include active learning contents, because it will allow them to be fully immersed in the activity. The second chosen learning style was the group of divergers. This group similarly preferred concrete ideas combined with experiences, which is an important clue to tweak the teaching practice to a more experiential type of learning, where the students have the opportunity to be immersed in a situation that should resemble the real concept as closely as possible. These results also indicated that their connection with abstract ideas and theories is not necessarily fully developed, and in consequence, this approach will not favour the teaching practice. Instead this issue may be connected to the difficulty experienced by large percentages of students when learning mathematics, where abstraction is a main component of the process. The third group is convergers with 22.2 percent, and this group also strongly prefers experiential learning with some theoretical foundation. Once again, becoming involved with the concept during the learning process is very important for the process to be completed. The last category in this age group corresponds to assimilators with a 19.4 percent. Assimilators have the best learning

experience when the content has mainly a theoretical orientation, as they will feel totally aligned with intangibles, ideas and abstract concepts.

The second group of age 12.3 years old, shows a variation compared to the 11.1 years old, as the higher percent is shared between divergers who prefer to work with concrete ideas and personal experiences with a 27.8 percent, and convergers, where the experience and theoretical background facilitates the learning with a 27.8 percent as well. These two categories have a strong experiential component, and both, the concrete idea and the theoretical component become important as well. It looks like there is a transition between the mainly experiential part to a more analytical orientation, where understanding the fundamental basis becomes relevant. In fact, the third preferred learning style is assimilators with a 25 percent, in which the theoretical part is essential for the learners to become engaged and interested in the topic under study. The lowest percent corresponds to accommodators to whom experience is the preferred way to learn. This is a very valuable finding as the empirical approach to knowledge does not entirely satisfy one's learning expectations. These results indicate that only experience by itself might not be sufficient to fulfil one's learning needs, as it seems that a deeper understanding of the laws and abstract concepts serve as anchors to comprehend the purely phenomenological manifestation of an event. One needs to engage their reasoning system in order to become truly involved in a constructive learning process.

When analysing the oldest group of students, the tendency is very similar to the 12.3 years old one, wherein for divergers concrete ideas plus personal experiences is the preferred learning style. In this category, the learning process is the product of a combination of concrete ideas and personal experiences. The learner must be involved in an experiential environment, fully immersed in the real life experience, and simultaneously their brain is engaged in a process of understanding the superstructure of the activity, trying to identify a connection between the world of physical phenomena and the world of laws and abstract concepts that somehow regulate the sensorial perception of physicality. The second preferred approach to learning is that of convergers at 29.2 percent. This component, where experience and theoretical background merge, indi-

cates that being part of a learning scenario and understanding the laws that regulate such an environment is critical to be fully engaged in the learning process. The assimilators (theoretical) become relevant with 27.8 percent preference, which indicates that reasoning and comprehension of rules become important as one's thinking structure becomes more refined and relevant in one's understanding of their surroundings. Finally, accommodators, who are only interested in the experience component, fall to 12.5 percent, which shows that age somewhat changes one's perception of the physical world where one lives and deeply understanding the rules and laws that maintain the present order.

DISCUSSION

The definition of kinesthetic learning in the VARK system refers to the process where learning takes place when the students are fully immersed in the experience, rather than passively listening or watching a lecture (Terzieva et al. 2022). Perhaps, that is why, it is not surprising that answers to question 1, that is, "When I am learning, I...", were significantly high at 83 percent, meaning that students prefer to be actively involved in constructing concepts from their direct involvement with the topics taught to them, rather than simply hearing about or just watching it. The reason why is because in participating in an activity, the emotional body must be fully engaged, which in turn, favours the conditions for a meaningful learning process to occur, as the emotional core is a powerful modulator of human behaviour (Yip 2022). A good attitude toward learning will favour the process itself, as the students will be prompted to be more involved and attentive in the process at both, intellectual and emotional levels.

The results show that 37.5 percent of the participants did prefer the auditory learning style (A), as questions 2, 5, 9, 13, 15, 16 all favour the A style better, with an internal average of 47.5 percent. All these questions share a common theme, that is, the participants in the survey can interact with more experienced individuals, which simply makes it easier and faster to ask the question and to get an instantaneous answer, or they can also reach out to a specialised source of information. This advantageous condition allows participants

to have quick and direct access to a reliable source of the information. The percentages of students' preferences ranged between 33 percent and 58 percent, which shows that students are still open to finding additional sources of learning support, in order to reinforce their own learning process. The data show that they will rely whether on visual or written/read sources to accomplish their objective.

Questions 4, 8, 10 and 12 are related to a specific process in which the visual learning style is preferred. Question 4 about learning from the internet, question 10 about learning from a video, question 8 about finding a location, and question 12 asking for understanding a medical issue, are all activities that inheritably favour the use of the sight rather than any other sense. It is also not a surprise to see that the percentages on visual learning style at 55.3 percent reflects a suitable supporting alternative in order to complete a better picture of the concept that the students are trying to grasp. Another important source of information is the written/read material, as it strongly supports the learning process. The written material summarises the efforts made from previous generations towards learning the same subject as the one that one is trying to learn in the present. The average value found for this style is 40 percent, which is an important percent, as it clearly requires more discipline, time and disposition to properly take advantage of the information contained on this kind of resources. The setback would perhaps be the fact that this source is not dynamic, and it might not be as enticing as a good story, capable of engaging multitudes of audience at once.

From these results, it looks like the preferred learning pathway is the one that favours the access to the information faster, and to that effect, senses like hearing or sight, will give one the upper hand, as the speed of processing is instantaneous (Eva 2022), so one can make decisions faster as well. Reading and writing will come after, as these processes are much slower compared to sight or hearing. Nevertheless, the quality of information will be also filtered out and better structured. It seems that the learning style that one will choose is going to depend on the format in which such information is presented. One can get a quick picture in the mind about the meaning of a given topic, by using one of the quick sen-

sors such as sight or hearing, and then elaborate more into this preliminary idea by refining the details utilising slower methods of learning such as reading or writing. These alternative methods are more time consuming, and probably might also have to be supported by a real interest or pressure from the outside to be learnt.

In the Kolb learning system, the learners are classified based on their affinity with one of his four categories of pragmatist/accommodators, where the learning outcome is tied to concrete life experiences, and activist/convergers in which the learning process happens by blending a good grasp of theoretical background with the experimental component (Alqarni 2022). The third category is reflectors/divergers, where a mixture of concrete ideas and personal experiences produce the best result for the learning process to occur, and finally, the theorist/assimilators in which abstract ideas and theories fuel the learning process. The experimental design included the age of the participants as an additional variable that will help one to identify any significant difference in the cognitive process that could be influenced by the biological age and intellectual maturity. To this effect, the cohort of participants were divided in three age groups (11, 12 and 13 years of age), and the survey was given to all of them. Table 8 summarised the findings. Accommodators also called pragmatics, which prefer the actual experience happened to be the preferred learning style of the youngsters, with a 32 percent, and this means that for them, the level of abstraction is not part of what they really enjoy during their learning experience, as this is reflected by only 19 percent selected by the participants for that pathway. These preliminary results somehow are backed up by the second higher learning style choice, divergers, to whom concrete ideas and personal experiences are key factors to fulfil their learning expectations. It seems that the concrete reality and the interaction with it, creates a favourable learning environment, in which they can attain higher levels of cognitive understanding.

Interestingly enough, the pragmatic learning style seems to progressively drop with age, going from 32 percent for the 11 years old group, then falling to 19.0 percent by age 12, and going to its lowest, 12.5 percent, by age 13. At the same time, the reflective learning style, which involves

concrete ideas combined with personal experiences surely will require higher levels of abstraction, which will favour both the reflectors learning style, 26 percent to 28 percent to 31 percent. The theorist learning style also progressively rises up from 19 percent to 25 percent then to 28 percent, in which the level of abstraction definitively becomes more predominant, favouring even the rising of the activist learning style, which goes from 22 percent to 28 percent and then to 29 percent. The tendency of these numbers is a clear indication that the learning styles are somewhat tied to the cognitive maturity of the subject (Klahr and Wallace 2022). The comfort of dealing with abstract concepts seems to increase as the learner reaches cognitive maturity. At age 13, the reflective learning pathway becomes the most predominant one, followed by the activist pathway, in both categories, a component of experiential learning is clearly present, meaning that the students certainly become more engaged with the learning process, as they have the possibility to interact with the concepts and integrate them to their reality.

The contributions of Kolb and VARK learning styles are very significant, as they allow one to get a preliminary idea about the preferred learning pathway, which in theory will help one to design more impactful and effective teaching strategies to help learners in their process (Bellarmouch et al. 2022). Nevertheless, both of these learning styles theories did not distinguish the kind of information that the learning is going to be exposed to. The very same nature of the questions in the surveys is probably too randomised, and there are no distinctions in the type of information, as it looks like the way in which one learns is more stepwise. This means that one will use at first the fastest mechanism that one has available to approach any new set of facts. In that step, the five senses will give a first filtering tool to sort facts out, and then, depending on how the information is presented it will resonate with the senses differently. Once the information is sorted out through this first filter then one will use a second slower step on this pathway, which could be reading, writing, theorising, connection theory-practice, which will be definitively more related to the previous experiences that one has been exposed to with similar matters, or the mental training one might have received to process related informa-

tion. There are many filters, already pre-set all related to cultural, religious, moral, cosmological and so on in peoples' backgrounds that can greatly influence the final interpretation of the facts presented. One set of facts, might be interpreted by one individual in a totally opposite way to another person exposed to the exact same set of facts, even within a scientific community, not all the information receive the same interpretation, as the filters throughout the information must be going through are distorted by multiple factors already mentioned.

The other weakness that these methods have is that they rule the emotional component out of the learning process. The traditional educational system has very unfortunately severely damaged a considerable percent of the student population at the emotional level, since it was first established some couple of hundred years ago, and probably the most evident effect can be seen in the STEM subjects. There are many papers in the literature debating the reasons why students fail in subjects like maths, chemistry and physics (Sauer 2022). There are also statistics showing how the interest for STEM subjects, at least in the USA, is declining (Blustein et al. 2022), in spite of the fact that the government incentivises students to take that pathway (Pearson et al. 2022), as the society will require more technological oriented careers in the near future. A traumatic experience will also create an epistemological obstacle that the learning style might not necessarily have enough influence to neutralise the deleterious effects of an emotional learning setback. One certainly can leverage the positive aspects of the learning styles theories, as they can identify some preferences, but one cannot ignore more fundamental and deep connotations that education and human psychology involve.

CONCLUSION

The abundance of learning styles models historically proposed is a clear indication that trying to reduce the complexity of the human learning process to a single model will inevitably leave out many aspects of the process on itself. The researchers have just taken into consideration two of the most commonly accepted learning models, and applied them to a cohort of students of different ages and schooling levels, and from

this academic exercise, the researchers have learnt that both Kolb and VARK learning models are incapable to fully access objectively the ideal conditions for the learning to occur. Rather, the researchers have found that the distributions of 'the percentages of learning styles are almost evenly distributed among the participants. These findings lead the researchers to conclude that rather than a central tendency towards a particular learning style, the learning process seems to follow a stepwise methodology, where the quickest pathway to access new information will trigger different mechanisms to preliminary sort such information out. In this process, the five senses will become the first filter for the interpretation of such information due to the speed of the process. One needs to see if the information somehow makes sense and/or matches with some previous experiences already installed in the memory files. Then a second slower step kicks, where writing, reading, reasoning, comparing, theorising occur to make sense of the incoming information. The two chosen learning methods will certainly help one to identify some general tendencies, but it will not be robust enough to account for the multiple complexities involved in the human cognitive process. Both Kolb and VARK learning models have the same general outcome, not a definitive learning style across the board, rather a combination of different strategies to address the problem. This is particularly important with STEM subjects, as the wrong approach to teaching these areas can have a lasting negative impact in students' perception of these topics and scare them away, causing them to miss out the opportunity to explore the great potential that STEM have as career pathways in a society that becomes more and more technological oriented.

Age is also a variable that seems to affect the specifics of the learning style, according to the results, the youngest cohort of participants are more aligned with a pragmatic type of learning, as it looks like concrete life experiences are more compelling to these students' interest. Data also shows that abstract thinking increases with age, and a preference for a combination between experience and reasoning increases as well. This tendency is also confirmed by the VARK results, where 85 percent of students preferred to get involved in the process of learning rather than simply be told or even shown. Students preferred as a

general rule, to be part of the learning process in an active form, not simply as a passive spectator.

Finally, when it comes to learning styles, it is almost impossible to predict what the preferred style will be for a given group of learners, and the reasons are related to the individual interest of students, previous exposure to the concepts presented, the psychological estate, the emotional estate, the expertise of the teacher to capture their pupils' attention, the meaning of the information, all these variables will modify the outcome of the learning exercise.

RECOMMENDATIONS

Human learning is a very complex field where many different factors interact simultaneously with one another, and synergistic effects can occur, so then, more studies need to be conducted, especially in the emotional component of the learning process, as the academic performance is tightly linked to the psychological and emotional preparedness. Oftentimes students complain about the lack of better academic results after expending many hours dedicated to study a topic and have worked judiciously on it.

ACKNOWLEDGEMENT

The authors want to thank Dr. Neal Phillip and the Department of Chemistry, Earth Sciences and Environmental Sciences at Bronx Community College for the unlimited support. The authors also want to thank the JGO Scientific Learning Company IT team for the technical support.

FUTURE STUDIES

Learning styles certainly can contribute to narrowing down epistemological obstacles helping to figure out the best ways to communicate knowledge to students. Nevertheless, one does not have as of now a definitive method robust enough that allows one to address all possibilities to improve a learning experience, so more work must be done to continue learning more about this topic.

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Paper received for publication in August, 2022
Paper accepted for publication in November, 2022