Identification of Dominant Learning Styles of Students to Support Differentiated Chemistry Lessons in International Advanced Level

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DOI: https://doi.org/10.47772/IJRISS.2026.10100496

Received: 26 January 2026; Accepted: 31 January 2026; Published: 14 February 2026

ABSTRACT

This study investigates the dominant learning styles of students following Pearson Edexcel International Advanced Level Chemistry in a Sri Lankan private school context in the aim of supporting differentiated lessons. The objectives of the study are to identify the learning styles of the students, to find the dominant learning style of Advanced Level students, to analyze the distribution of learning styles among Advanced Level Chemistry students and to detect association between individual student and preferred learning style. The study employs survey research design. The sample consists of seventeen students of one Advanced Level Chemistry class of international school selected through purposive sample. Standardized VARK questionnaire data is used as quantitative data collection method. Data is analyzed using descriptive statistics and Chi square test in SPSS. The computed percentage values are Visual = 19.35, Auditory = 30.32, Read/Write = 21.29, and Kinesthetic = 29.03. Auditory and kinesthetic learners together represent nearly 60% of the total learning preference. VARK questionnaire results demonstrate that there is no rigid learning style that sticks to a particular child and students exhibit a multimodal learning pattern dominated by auditory and kinesthetic styles. It indicates that students are more responsive toward interactive, discussion oriented, and hands on learning environments. This is because learning styles vary according to the context of learning. The findings of Chi-square statistics of VARK questionnaire data analysis show $\chi^2(128, N = 17) = 136.00$, $p = 0.298$, indicating that students' learning style preferences are not strongly tied to individual differences, suggesting a balanced representation of VARK modalities within the sample.

Key words: Achievement Level, Learning Style, Lesson Plans, Advanced Level

INTRODUCTION

All the students do not reach their full potential in education globally (UNESCO, 2021). Only 67.8% of students who attempted Chemistry in Pearson Edexcel International Advanced Level exams in 2024 in Sri Lanka received scores higher than C while 558 students had failed the subject (Grade statistics of Pearson Edexcel IAL, 2024). In the private school where I do my research study, the pass rate in science stream was 44%. The pass rate of Chemistry in the school is 56% in 2024 (Grade statistics, @RIS). Poor teaching strategy is one of the reasons behind poor academic achievement of students (Almoslamani, 2022). Traditional teaching strategies are used to deliver lessons in Advanced Level sections as the syllabus completion is prioritized (Ellapola, 2022). It is necessary to cater the lessons according to the diverse learning needs of students (Rao, K.,2015).

Students vary in a class in terms of learning styles. As mentioned by VARK Learn Limited (2020), four types of leaners are identified and they are visual, auditory, reading/writing and kinesthetic learners. After identifying their learning styles, lessons are catered according to students' learning styles and they can choose the learning mode according to their preference. Activities and assessments are designed based on the learning styles of the learners in the classroom identified by using the VARK model (Fleming & Mills, 1992). Lessons are embedded with information and activities in various formats such as visuals, video, hands on activities and reading materials.

By integrating varying modalities into lesson planning, diverse learning needs, academic equity, and achievement in an internationally recognized curriculum in a local context can be addressed. Also, it supports

linking international curricula and inclusive and equitable education which is one of the national education priorities. Additionally, it bridges the gap between curriculum expectations and classroom strategies while contributing modern pedagogical practices to global and local scientific literature.

Learning styles are defined in terms of cognitive, affective, and behavioral dimensions. According to Fibriyana Safitri et al. (2024), learning style is a "combining cognitive, affective, and psychomotor factors, which are relatively stable aspects of how individuals perceive their learning environment, interact with it, and respond to it"

Similarly, (Naro et al., 2023) also highlight cognitive, affective, and psychomotor factors by mentioning it as the composite of characteristics of cognitive, affective, and psychomotor factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment.

In contrast, Taş and Minaz (2024) define learning style as a student's attempt to choose and use suitable ways to learn new information which is characterized by individual preferences and methods to perceive and process material. The focus has been changed from student's traits to student's decision making. But, in reality, all learners are not aware of their own learning style fully which needs guidance.

Smith & Renzulli (1984) provides a rigid categorization to learning style which can be used in classroom settings by defining it as "the way in which learners characteristically prefer to learn." It is the consistent patterns or preferences in which students favor certain modalities (visual, auditory, kinesthetic, read/write).

Finally, Mohsenipouya et al. (2024) has identified genetics, experiences and expectations as influences on learning style. According to Mohsenipouya et al. (2024), learning style is a "personal approach to receiving and processing information, influenced by an individual's genetics, experiences, and expectations." This definition is broader as it includes both innate and environmental factors. In overall, these definitions collectively demonstrate the link of learning style to personal trait and learning strategy. Based on this study, learning style is A/L students' preferred modes of accessing and demonstrating Chemistry knowledge such as visual, auditory, read/write, and kinesthetic which are identified by the VARK model.

Research Objectives

RO 1: To identify the learning styles of Advanced Level students.

RO 2: To find the dominant learning style of Advanced Level students.

RO 3: To analyze the distribution of learning styles among Advanced Level Chemistry students

RO 4: To detect the association between individual student and preferred learning style.

Abbreviations

VARK: Visual, Auditory, Read/Write, Kinesthetic; IAL: International Advanced Level; STEAM: Science, Technology, Engineering, Arts, and Mathematics

LITERATURE SURVEY

Chemistry Education at Advanced Level

Advanced Level Chemistry is delivered under any curriculum to prepare students for STEAM degrees in the future by equipping them with conceptual understanding, quantitative problem solving and experimental competence in Chemistry. Effective Chemistry programs balance disciplinary concepts in Chemistry such as structure, energetics, kinetics, equilibria, and organic chemistry, core concepts like models, systems and structure property relationships and hands on science practices of planning, investigation, analysis of data and construction of explanation (Hofstein & Lunetta, 2004).

Pearson Edexcel IAL Chemistry is mainly adopted by international schools and private candidates to obtain pre university qualification. The syllabus is presented as a specification which consists of content across physical, inorganic, and organic Chemistry with practical skills, data analysis, and mathematical skills. It covers three

assessment objectives knowledge and understanding (AO1), application of the knowledge (AO2), and experimental design and errors (AO3) for preparing students to align with international standards in undergraduate chemistry (Pearson, 2023).

In the A Level classrooms, teachers commonly use mini lectures with symbolic representation of information, whiteboard problem solving, and worked problems to ensure transfer of knowledge. But mega data analysis has shown that replacing didactic lecturing with active methods such as short cycle of explanation, clicker questions, think pair share, and structured problem solving reduces the failure rates and improve exam performance in STEAM subjects including Chemistry also (Freeman et al., 2014).

In Sri Lanka, delivery of the General Certificate of Advanced Level Chemistry curriculum is exam oriented, highly competitive, lecture dominated instruction and has less emphasis on inquiry or practical design (Vithanapathirana, 2014). Assessments are dominated by theoretical papers, leading to a culture of rote memorization and private tutoring. These methods have been adopted by teachers who have been raised in this context and deliver Pearson Edexcel IAL Chemistry curriculum in international and private schools as well. Across the world's Advanced Level programs, including Pearson Edexcel IAL, is characterized by active, inquiry based, more inclusive methods. In Sri Lanka, however, the rote based, and exam centered pedagogy is still dominated and they limit the students' readiness for university chemistry education. This gap can be filled with ICT integration, inquiry-based labs, and active learning methods.

Learning Styles

Naturally, learners have a variety of traits, interests, requirements, and skills and these personal characteristics could have an impact on their learning process and academic achievement (Al-Azawei et al., 2016). Physical, visual, auditory, sensory, attentional, and communicative disabilities are also included in learner diversity. However, from the standpoint of human rights, such restrictions shouldn't deny anyone access to equal educational possibilities (Burgstahler, 2011).

Neil Fleming in 1992 introduces the VARK model to explain how individual learning styles may differ (Nguyen, 2021). The model includes four learning styles; Visual, Auditory, Read/Write and Kinesthetic. Educators use VARK model to develop multimodal learning materials. Simply, visual leaners learn by seeing, Auditory learners learn by hearing, Read/Write leaners learn by reading and writing and Kinesthetic learners learn by doing.

Teachers can use specialized teaching techniques catered to each learning style to effectively accommodate the wide range of learner preferences (Peace & Donald, 2024). The figure 2 illustrates the different techniques which focuses on each learning style. Creating a dynamic and inclusive classroom environment requires incorporating the variety of learning styles into instructional strategies (Peace & Donald, 2024). It creates a more stimulating and efficient learning environment in alongside satisfying the various demands of the pupils.

Visual	Auditory	Read/Write	Kinesthetic
Charts Graphs Visual aids Pictures Power point presentation Mind Maps	Pod casts Recording Discussions Verbal Instructions Music Debates	Books Note taking Making lists Case studies Dictionaries Journals	Role playing Experiments Hands on activities Flashcards Manipulatives Simulations

Figure 1: Learning Techniques for Learning Style (Nguyen, 2021) and (Peace & Donald, 2024)

Addressing learning styles prioritize diversity that learning is enhanced when education is tailored to each student's particular learning style (Boysen, 2021). Learning styles stress the value of individual differences in learning rather than uniformity. Both claim that instruction should be tailored to each student's unique learning style because they place a strong focus on diversity in learning (Boysen, 2021). Emphasizing diversity in learning leads one to the natural conclusion that teaching should also be diverse. In particular, it implies that good teaching should accommodate students' varied learning styles (Boysen, 2021).

Every student in a classroom has different learning methods. When lessons and instructions are presented in a classroom in an unfriendly and inflexible manner, students struggle to learn (Javed et al., 2024). They encounter difficulties with idea persistence, concept retention, disengagement, and the inability to express what they understand (Al Hazmi & Ahmad, 2018).

As mentioned by VARK Learn Limited (2020), four types of learners are identified, and they are visual, auditory, reading/writing, and kinesthetic learners. Lessons are catered according to students' learning styles, and they can choose the learning mode according to their preference. Learners are exposed to several learning environments during the same lesson, and they learn by their style.

Information is presented in various formats, such as video, text, visuals, and audio. Learners can choose a preferential learning environment according to their style. Learner engagement can decline if lectures are the only format used. Therefore, various techniques for active engagement, such as presenting learning material through open discussion, question and answer sessions, peer guidance, and problem-solving methods, can preserve student motivation in order to maintain interest levels during the active lecture (Al-Azawei et al., 2016). Role-playing, collaboration, and group activities provide multiple means of engagement for learners to engage actively during the lessons. Such multiple means of engagement also focus on the preferential learning style of the learner.

The limited time and structured nature of tests make them unpopular with most students as the only means of evaluating their knowledge and comprehension (Al-Azawei et al., 2016). Students can be exposed to multiple means of action and expression based on their preferential learning style during and after the lessons. Students' knowledge can therefore be more accurately reflected by asking them to communicate it in a variety of formats, such as assignments, interviews, quick tests, portfolios, scientific articles, and multimedia presentations, rather than just one test (Al-Azawei et al., 2016).

RESEARCH METHODOLOGY

Research Design

The research design of this study was rooted in the survey research paradigm because it was primarily aimed at identifying learning styles of students following Pearson Edexcel International Advanced Level Chemistry in a Sri Lankan private school. The research was conducted in an international school in Sri Lanka, where the Pearson Edexcel IAL Chemistry curriculum is offered as a core subject in the science stream. The participant group consisted of seventeen students aged from 17 to 18 years enrolled in the A/L Chemistry class taught by the researcher. The choice of the sample size was guided by the principle of purposive sampling.

The objective of the study was to identify the learning styles of the students to reveal their preferred methods of learning and engaging during lessons. The intention of this objective was to find out the most common learning styles of the learners to decide the lesson planning to suit diverse learning needs. The standard VARK questionnaire was used to collect data from a group of Advanced level Chemistry students. Student responses were analyzed quantitatively by calculating individual scores for each learning style. Results were compared to determine individual preferences as well as the overall distribution of learning styles within the group.

Data Collection Instrument

Data collection instruments implied in this study are standard VARK questionnaire. The standard Visual, Auditory, Read/Write, and Kinesthetic (VARK) questionnaire **(Annex 1)** which consists of 16 MCQ questions, has been adopted from https://vark-learn.com/the-vark-questionnaire/ to identify students' preferred modality of

learning. Each question provided four options with instructions for students to choose one or more options for each question based on their learning preference. Since the VARK questionnaire was adopted from the official VARK learning website, it ensures the validity through prior studies. The VARK Questionnaire (Version 8.01) was administered to all the students in the class. Students were given 20 minutes to complete the questionnaire in the classroom setting while the chemistry teacher was supervising their answering so that no one copied the answers of others. They had been instructed to select the best positions that described their preferred learning style, with the flexibility to select more than one option per question.

Data analysis

Both quantitative and qualitative methods are used in data analysis. VARK questionnaire data was analyzed using SPSS by calculating the percentage of each learning modality preferred by students to identify dominant learning styles in the classroom. Percentage of each modality preferred by students for each question was also calculated to identify any contextual bias for choosing the modality by students.

A Chi-Square test was conducted to determine whether there was a statistically significant association between individual students and their learning styles (Visual, Auditory, Read/Write, and Kinesthetic) by analyzing the results obtained by the VARK questionnaire in SPSS software.

Delimitations of The Study

The data collection was done with only 17 students. Due to the limited sample size and sparse data, Chi-Square results may not fully describe the research findings.

Research Ethics

Throughout this study the rights of the research participants, research validity, and academic integrity were maintained and ensured. Also, ethical considerations have been taken into account to ensure the protection of participants' rights and well-being. Firstly, informed consent was obtained from students. Participants were informed about the study's purpose, and benefits. This enabled them to make an informed decision about whether or not to participate. Confidentiality and anonymity were also be prioritized. All data collected during the study will be kept confidential, meaning that it will only be accessible to the researcher involved in the study. Participants' identities will be anonymized to further protect their privacy. Effort was made to minimize any potential harm or distress to participate. This is achieved by carefully designing the study procedures and ensuring that they do not cause any unnecessary discomfort or harm.

Data Analysis

Table 1 represents the VARK questionnaire data.

Table 1: The VARK Questionnaire Results

Learning Style	Frequency	Percentage
Visual	90	19.4
Auditory	141	30.3
Read/Write	99	21.3
Kinesthetic	135	29.0

The descriptive analysis of the VARK questionnaire data was performed to determine the most common learning modalities of students based on the four learning styles, namely visual, auditory, read/write, and kinesthetic. According to **Table 1** data, the computed percentage values were Visual = 19.35, Auditory = 30.32, Read/Write = 21.29, and Kinesthetic = 29.03. The results clearly show that the auditory learning style, with 30.32%, had the highest percentage score, closely followed by the kinesthetic learning style, with 29.03%. Comparatively, Read/Write (21.3) and Visual modalities (19.4) recorded lower percentages. These findings reveal that auditory

and kinesthetic learners together represent nearly 60% of the total learning preference, highlighting a strong tendency toward listening- and discussion-based and experiential learning approaches among students.

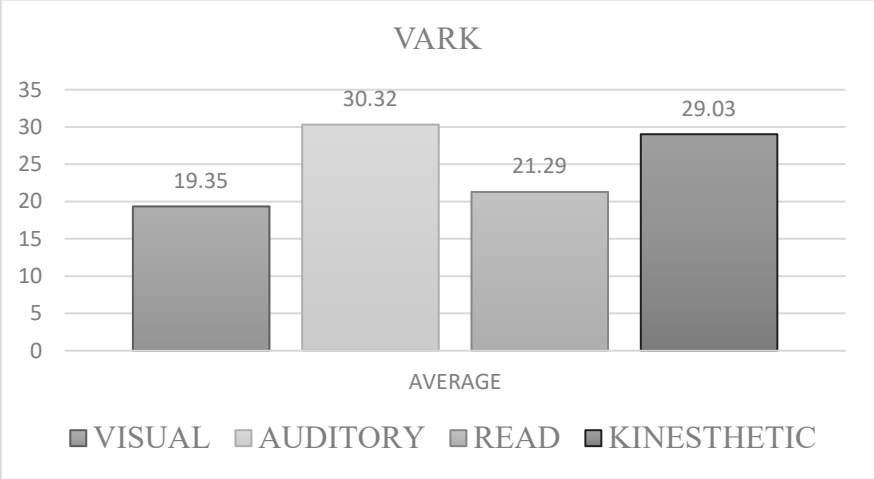

Figure 2: VARK Questionnaire

Figure 2 illustrates how learning styles are distributed among students.

Students employed a specific approach for some questions, according to the qualitative question analysis. In response to question number 14, 95% of students indicated that they preferred visual learning, while 90% of students indicated that they preferred an auditory learning technique in response to question four as well **(Annex 2).**

Table 2: Chi-Square Test Results for Association Between Students and Learning Styles

Table 2 data represent Chi-Square Tests results obtained by analyzing the results obtained by the VARK questionnaire in SPSS software.

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	136.000[a]	128	.298

A Chi-Square test was conducted to determine whether there was a statistically significant association between individual students and their learning styles (Visual, Auditory, Read/Write, and Kinesthetic) by analyzing the results obtained by the VARK questionnaire. In this analysis, each student was considered as an independent variable, while four learning style frequencies were treated as dependent variables.

Ho: There is no significant association between individual students and preferred learning styles; the two variables are independent.

H_1: There is a significant association between individual students and preferred learning styles; the two variables are dependent.

According to **Table 2**, The Pearson Chi-Square statistic, $\chi^2(128, N = 17) = 136.00$, $p = 0.298$, indicates that there is no significant association between individual students and their preferred VARK learning styles. Since the p-value is greater than the alpha level of 0.05, the null hypothesis is accepted. That is there is no significant difference between individual students and preferred learning styles and learning style is independent of the individual student. This reveals that the distribution of learning style preference among students is relatively uniform and not dependent on individual differences.

CONCLUSION AND DISCUSSION

VARK questionnaire results demonstrate that students exhibit a multimodal learning pattern dominated by auditory and kinesthetic styles. It indicates that students are more responsive toward interactive, discussion

oriented, and hands on learning environments. Therefore, the most effective teaching strategies in this classroom should integrate verbal explanation, active discussions, experiments, and demonstrations. These results are consistent with the previous studies that emphasize that auditory and kinesthetic orientations achieve greater understanding and retention when there are opportunities for verbal interaction, discussion, and practical application (Fleming & Mills, 2019; Boysen, 2021).

In reality, there is no rigid learning style that sticks to a particular child that can be identified. All the students observed is multimodal. This is because learning styles vary according to the context of learning. The findings of Chi-square statistics of VARK questionnaire data analysis imply that students' learning style preferences are not strongly tied to individual differences, suggesting a balanced representation of VARK modalities within the sample. This balance is necessary to prepare lessons across diverse preferences rather than being dominated by one particular style, which can enhance the inclusivity aassuming that learner variability is the norm rather than the exception (CAST, 2018). This variability reinforces the necessity of designing Chemistry lessons that incorporate multiple means of representation, recognizing that no single instructional pathway can accommodate all learners. The presence of such diverse preferences aligns with Al-Azawei et al. (2016), who emphasize that learners differ not only in cognitive capacities but also in perceptual tendencies and motivational patterns.

The study's VARK results demonstrate that mono modal instruction disadvantages certain learners. This mirrors Boysen's (2021) argument that learning styles theory emphasize diversity over uniformity and that effective teaching should intentionally vary representational formats. More importantly, the findings align with learning barriers often stem from the design of the environment, not the learner (Moore et al., 2007). Thus, the identification of learning styles confirmed the need of design of differentiated Chemistry lessons.

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ANNEX

Annex 1: VARK Questionnaire adopted from VARK Learn Limited (2020)

Instructions: For each question, tick the option(s) that best describe how you would prefer to learn. You may select more than one if necessary.

1. When learning from the Internet I like:

   A. interesting design and visual features.☐

   B. detailed articles.☐

   C. videos showing how to do things.☐

   D. podcasts and videos where I can listen to experts.☐

2. I prefer a presenter or a teacher who uses:

   A. diagrams, charts, maps or graphs.☐

   B. question and answer, talk, group discussion, or guest speakers.☐

   C. handouts, books, or readings.☐

   D. demonstrations, models or practical sessions.☐

3. I am having trouble assembling a wooden table that came in parts (kitset). I would:

   A. read the instructions that came with the table.☐

B. study diagrams showing each stage of the assembly.☐

C. watch a video of a person assembling a similar table.☐

D. ask for advice from someone who assembles furniture.☐

4. When choosing a career or area of study, these are important for me:

A. Communicating with others through discussion.☐

B. Working with designs, maps or charts.☐

C. Using words well in written communications.☐

D. Applying my knowledge in real situations.☐

5. I have finished a competition or test and I would like some feedback:

A. from somebody who talks it through with me.☐

B. using graphs showing how my performance has improved.☐

C. using examples from what I have done.☐

D. using a written description of my results.☐

6. I want to find out more about a tour that I am going on. I would:

A. talk with the person who planned the tour or others who are going on the tour.☐

B. use a map and see where the places are.☐

C. look at details about the highlights and activities on the tour.☐

D. read about the tour on the itinerary.☐

7. A website has a video showing how to make a special graph or chart. There is a person speaking, some lists and words describing what to do and some diagrams. I would learn most from:

A. reading the words.☐

B. watching the actions.☐

C. listening.☐

D. seeing the diagrams.☐

8. I want to learn to do something new on a computer. I would:

A. talk with people who know about the program.☐

B. start using it and learn by trial and error.☐

C. read the written instructions that came with the program.☐

D. follow the diagrams in a book.☐

9. I want to find out about a house or an apartment. Before visiting it I would want:

   A. a discussion with the owner.☐

   B. to view a video of the property.☐

   C. a plan showing the rooms and a map of the area.☐

   D. a printed description of the rooms and features.☐

10. I want to learn how to take better photos. I would:

    A. use examples of good and poor photos showing how to improve them.☐

    B. use diagrams showing the camera and what each part does.☐

    C. use the written instructions about what to do.☐

    D. ask questions and talk about the camera and its features.☐

11. I want to learn how to play a new board game or card game. I would:

    A. watch others play the game before joining in.☐

    B. listen to somebody explaining it and ask questions.☐

    C. read the instructions.☐

    D. use the diagrams that explain various stages, moves and strategies in the game.☐

12. I have been advised by the doctor that I have a medical problem and I have some questions about it. I would:

    A. look at a diagram showing what was wrong.☐

    B. have a detailed discussion with my doctor.☐

    C. read an article that explains the problem.☐

    D. use a 3D model to see what is wrong.☐

13. I want to learn about a new project. I would ask for:

    A. a written report describing the main features of the project.☐

    B. an opportunity to discuss the project.☐

    C. examples where the project has been used successfully.☐

    D. diagrams to show the project stages with charts of benefits and costs.☐

14. When finding my way, I:

A. rely on paper maps or GPS maps.☐

B. like to read instructions from GPS or instructions that have been written.☐

C. head in the general direction to see if I can find destination without instructions.☐

D. rely on verbal instructions from GPS or from someone traveling with me.☐

15. I want to save more money and to decide between a range of options. I would:

A. talk with an expert about the options.☐

B. use graphs showing different options for different time periods.☐

C. read a print brochure that describes the options in detail.☐

D. consider examples of each option using my financial information.☐

16. When I am learning I:

A. read books, articles and handouts.☐

B. use examples and applications.☐

C. see patterns in things.☐

D. like to talk things through.☐

Annex 2: Class Scoring Sheet

Student ID	A (Visual)	B (Auditory)	C (Read/Write)	D (Kinesthetic)
Student 1	4	10	7	9
Student 2	7	4	6	4
Student 3	8	9	14	12
Student 4	2	4	4	6
Student 5	5	10	11	7
Student 6	8	8	7	5
Student 7	10	10	5	7
Student 8	8	9	7	8
Student 9	0	11	1	4
Student 10	0	11	1	7
Student 11	2	2	7	5
Student 12	1	5	4	6

Student 13	14	13	13	14
Student 14	13	15	8	14
Student 15	4	3	1	10
Student 16	2	5	2	8
Student 17	2	12	1	9