CHAPTER 2 : REVIEW OF RELATED LITERATURE

This chapter offers an overview of academic literatures on the topics related to this research. The various studies conducted over the past years till today (2010-2023) in India and other countries are all described in this chapter. The research gaps emerging from the previous literature reviewed are also presented in this chapter. Further, the objectives and hypotheses of the present study also form important constituents of this chapter.

2.1 Studies on Brain hemispheric dominance and Academic achievement

2.1.1 Studies conducted in other countries

The study conducted by Marquez (2023) aimed to investigate the impact that the Mathematics Engagement Clinic (MEC) had on the critical thinking skills, problem-solving abilities, and mathematical accomplishment of senior high school students in the eleventh grade who were attending a National Comprehensive High School in Iloilo. The MEC was based on Brain dominance and produced distinct effects on individuals with left and right brain dominance. Individuals who exhibit left-brain dominance possess a distinct cognitive pattern known as affirmation behavioural learning, as described by the researcher. The application of affirmation behavioural learning to the whole brain paradigm implied that brain dominance groups may display unique behavioural cognition. Regarding the current study, it was discovered that individuals with left brain dominance demonstrated distinct signs of affirmation behavioural learning. The findings demonstrated that the improved MEC curriculum effectively strengthened critical thinking and problem-solving abilities, while also significantly improving Mathematics performance, as seen by the considerable increase in the scores of before versus after the programme.

Li et al. (2022) investigated the correlation between Brain Dominance, Reading, and Speaking Skills in a group of English sophomores. The sample comprised of 230 students, and the results indicated that 62% of the subjects demonstrated whole-brain dominance, 24.8% exhibited moderate left-brain dominance, and 11.7% showed moderate right-brain dominance. Merely 1.3% of the students exhibited strong right-brain dominance, whereas none of the participants were found to possess strong left-

brain dominance. There was shown to be a highly significant correlation between brain dominance and reading skills, however there was found to be no significant connection between brain dominance and speaking skills.

Aburayash (2021) studied the correlation between metacognitive awareness and brain dominance. The findings indicated that the most prevalent pattern seen was right dominance, followed by left dominance and integrated dominance. Males and females showed significant differences in cognitive organising and cognitive processing, with females exhibiting higher performance. The observed outcome can be ascribed to the inclination of female students to prioritise participating in structured and prearranged activities, in contrast to their male peers, and their lesser inclination to depend on intuitive decision-making. Significant differences in cognitive organisation and cognitive processing were observed between students in the Humanities and Science disciplines, with the results favouring those of Humanities students. This can be attributed to the tendency of Humanities students to prioritise the broader relevance of knowledge integration, in contrast to Science students who tend to prioritise specific facts.

An investigation was conducted by Arabmofrad et al. (2021) to determine the connection between the hemisphere dominance in primary English learners, the utilization of metacognitive reading strategies, and the level of reading comprehension that these learners possessed. The study's findings indicated that the problem-solving strategy was the most preferred metacognitive technique, with the global and support strategies being the next most favoured. The level of reading strategy usage among basic EFL students was evaluated to be moderate, followed by high and low. A substantial positive correlation was found between brain dominance and reading comprehension, as well as between brain dominance and reading strategies.

Cornelius et al. (2021) examined the cognitive styles of Science students and determined that the field dependent cognitive style was their most favoured preference. Among males, the predominant cognitive style was field independence, while among females, the field dependence cognitive style was more common. The regression study revealed a weak positive correlation between cognitive style and academic performance. Specifically, cognitive style explained 6.4% of the variation in science students' academic performance. Moreover, the obtained B coefficient of 0.727 signifies

that with each additional unit rise in cognitive style, together with other factors, there is a corresponding increase of 0.727 in academic performance.

Montero (2021) studied the hemispheric dominance of Filipino senior high school students enrolled in Accountancy, Business & Management, and Science, Technology, Engineering & Mathematics (STEM) programmes. The results suggested that a majority of students, namely 78.33%, demonstrated left-brain dominance. Furthermore, a significant majority of responders (89.17%) displayed right-handedness. In addition, the finding showed that there was no statistically significant association between age, sex, classes (grades), strand, and handedness with brain hemisphere dominance.

Ramly et al. (2021) aimed to examine the brain dominance patterns displayed by students studying Animation and those studying Applied Sciences. The study found out that Science students displayed left-brain dominance, whereas Animation students displayed right-brain dominance, thereby supporting the theory. It also suggests that individuals who have dominance in either the left or right hemisphere of their brain display unique cognitive and behavioural characteristics. Individuals with left brain dominance display a preference for analytical and rational thinking, logical reasoning, and linguistic abilities. On the other hand, right brain dominance is linked to intuitive thinking, holistic perception, emotional cognition, non-verbal activities, creative writing, artistic expression, and imaginative thinking. It is commonly believed that students in scientific fields have a dominant left cerebral hemisphere, as they are highly involved in analytical tasks. Contrary to popular belief, art students are often thought to have a dominant right hemisphere of the brain as a result of their involvement in creative pursuits.

Gholasi et al. (2020) studied how the brain dominance of medical science students affects their academic performance, with metacognitive awareness serving as the mediator. The study's findings revealed a notable association between brain dominance and academic achievement, with self-directed learning acting as the mediator. Moreover, there was a significant relationship between the two variables and the results indicated that the proposed model displayed a high degree of congruence.

Inad and Jabbar (2020) investigated the brain dominance of individuals from three different age groups, using Herrmann's brain dominance theory as a framework. The

results showed that 14-year-old adolescents displayed inadequacies in their utilisation of Quadrants A, B, and D, while exhibiting competence in Quadrant C. Adolescents who were 16 years old exhibited weakness in Quadrants A and D, while demonstrating strength in Quadrants B and C. Adolescents and individuals in their twenties, specifically those aged 18, 20, and 22, exhibited strength in all four quadrants, indicating that brain dominance patterns experience alterations as individuals grow older. Moreover, it was noted that gender had no influence on brain dominance patterns across all age cohorts.

Joven et al. (2020) investigated the correlation between cerebral dominance and hand laterality of Science, Engineering, Technology, and Mathematics students. The results indicated that 84.42% of students had left brain dominance, whereas 15.58% exhibited right brain dominance. In addition, all students who displayed a preference for their right hand demonstrated left brain dominance, while a notable percentage of students who classified as left-handed indicated right brain dominance. This discovery offers validation for Sperry's (1981) hypothesis of lateralization. The Humanities and Social Sciences stream had distinct characteristics as compared to the STEM and Accounting and Business Management (ABM) streams.

According to the study conducted by Alghraibeh and Alshalawi (2019), a large number of students had a dominant right cerebral hemisphere, with Quadrants C and D displaying greater strength compared to Quadrants A and B. The former two quadrants are attributed to the right hemisphere of the brain and are responsible for generating emotional responses. They are also associated with intuition, feelings, creativity, and imagination. Moreover, it evokes both visual and aural stimuli, as well as emotional reactions. Regarding gender differences, research demonstrated that males displayed a significantly higher level of left-brain dominance compared to females.

Ayadi et al. (2019) investigated the cerebral hemisphere dominance of 74 students. The results indicated that 24% of the participants exhibited right-brain dominance, while 54% displayed left-brain dominance, and 22% demonstrated whole-brain dominance. According to the findings, there is no significant disparity between the academic achievements of the students exhibiting left brain dominance against those exhibiting right brain dominance in a problem-solving course. In addition, both students with a

dominant right hemisphere and dominant left hemisphere outperformed those with whole brain dominance in both hemispheres.

Belicina and Ocampo (2019) investigated the correlation between brain dominance and learning styles, specifically visual, auditory, or kinesthetic, in pre-service mathematical teachers. The results showed that pre-service mathematics teachers were evenly distributed across different brain dominance characteristics. The majority of pupils who had left brain dominance demonstrated low levels of achievement, whereas most of those with balanced brain dominance and right brain dominance exhibited high levels of performance. The majority of kinesthetic learners had average scores in mathematics, but the majority of visual learners achieved either average or below-average scores. Every individual with an auditory learning style showed high performance. Most auditory learners exhibited either balanced or right-brain dominance, while all kinesthetic learners and visual learners displayed right and left-brain dominance, respectively. There was a strong correlation between their learning styles, brain dominance, and mathematics performance.

Koju et al.'s (2019) study found that out of the 400 students, 117 (29.25%) exhibited a preference for the left brain, 96 (24%) exhibited a preference for the right brain, and 187 (46.75%) did not demonstrate a clear preference. Furthermore, no substantial correlation was found between handedness and hemisphere brain preference, as well as between different study techniques (individual/group/both) and hemispheric brain preference. Students who exhibited a preference for the left side of their brain demonstrated exceptional academic performance, whereas those who did not display a distinct preference exhibited significantly poor academic performance.

Wei and Sulaiman (2018) conducted a study to examine the mediating function of the two brain dominances in the association between Academic Achievement in the Japanese Language and Learning Styles. Both the brain dominances completely mediated the relationship between learning styles and their academic achievement, according to the study's findings. In addition, the findings of the study demonstrated that the learning styles of a student did not have a major impact on the Japanese language competency of the student.

Alibeigi (2017) sought to examine the impact of brain dominance of 90 pre-intermediate students on the ability of second language learners to retain vocabulary, both

immediately and over time. The Michigan Test of English Language Proficiency was administered first, followed by the brain dominance inventory. There were a total of sixty students that were randomly assigned to one of three groups, with each group consisting of twenty individuals. Following six consecutive therapy sessions, the subjects were subjected to both immediate and delayed examinations assessing their vocabulary production. The findings indicated that children with whole-brain dominance outperformed pupils with either left-brain or right-brain dominance on both examinations.

Mansour et al. (2017) studied the hemispheric dominance of nursing students and its correlation with their academic performance. 61.6% of the pupils were found to have a dominant right brain, according to the findings of the study. A significant statistical difference was observed in the grade point average and brain dominance of the two groups. Significant associations were observed between birth order, grade point average, selected specialty prior to entering the nursing field, and brain dominance.

Wei et al. (2017) investigated the relationship between brain dominance and academic success in the Japanese language. Significant correlations were found between left-brain dominance and academic achievement, as well as between right-brain dominance and academic achievement. Nevertheless, the relationships exhibited a low level of strength. The concept suggesting the allocation of cognitive tasks between the left and right hemispheres of the brain asserts that the right hemisphere demonstrates superiority in spatial aptitude, perception, visual imagination, and musical cognition. Proficiency in visualising and possessing a strong spatial sense are highly esteemed abilities when learning the Japanese language, as its writing system is derived from pictorial representations known as hieroglyphics.

Nazemi et al. (2016) conducted research on the association between learning styles and brain dominance, as well as personality types, among the pupils who participated in the study. The results of the study showed that there is a correlation that is statistically significant between the learning styles of students and the percentage of their brains that are engaged in certain activities. According to research, the A and B brain quadrants are specifically connected with the convergent and accommodating learning styles, however the C and D brain quadrants are especially related with the divergent and absorbent learning types.

The study conducted by Ozyel (2016) aimed to examine the relationship between brain dominance and the implementation of language learning strategies among non-native English speakers attending Cyprus International University's English Preparatory School. The results showed that individuals with left-brain dominance demonstrated a greater utilisation of social and metacognitive techniques in comparison to those with right and whole brain dominance. The occurrence of learners with different brain dominances is an inevitable presence in the classroom context. This study highlights the need of acknowledging learners' brain dominance, as it is anticipated to influence their preferred learning styles.

Weisi & Khaksar (2015) studied the correlation between the brain dominance of Iranian English as a foreign language (EFL) learners and their aptitude for creative writing. A group of 50 junior and senior English translation students at Islamic Azad University in Iran were selected based on their performance in the writing component of the TOEFL exam. The study findings indicated that individuals with a dominant right hemisphere demonstrated superior creative writing skills during the examination.

Soyoof et al. (2014) investigated the association between language retention and the brain dominance of pupils. A sample of forty-five pre-intermediate students was selected by using convenience sampling. Among them, fifteen were classified as right-brained, fifteen as left-brained, and fifteen as both-brained, resulting in an equal distribution. Each participant was given a set of 15 vocabulary words to memorise during each session, and this process was repeated for a total of four sessions. The results suggested that individuals with whole brain dominance exhibited a considerably greater ability to retain vocabulary compared to those with left or right brain dominance, as observed in both immediate and delayed post-test evaluations. In addition, individuals with a dominant right hemisphere demonstrated a higher degree of information retention in comparison to those with dominant left hemisphere or individuals with balanced brain hemispheres in both examinations.

In a study conducted by Dulger (2012), the author examined the correlation between Brain Dominance and the utilisation of Language Learning strategies among Turkish EFL Learners. The study's findings indicated that the technique most frequently used was Metacognitive Strategies. Next was Cognitive Strategies, and the last strategy used was Affective Strategies. The study revealed that 41.3% of the learners exhibited right-

brain dominance, 37.8% exhibited left-brain dominance, and 20.9% exhibited bilateral dominance. The findings also demonstrated a statistically significant correlation between right hemisphere dominance and the utilisation of memory strategies and cognitive strategies, as well as between overall brain dominance and social strategies.

Kim and Cho (2012) examined the relationship between brain dominance and academic achievement specifically in the domains of mathematics and science. The study involved a sample of 131 middle school students. The study found that individuals who excelled in Mathematics and Science showed a greater inclination towards the left lower brain (LLB), whereas those who performed poorly in these subjects had a higher prevalence of the right lower brain (RLB). The examination of LLB scores indicated a statistically significant disparity in scientific performance between the group with above average scores and the group with below average scores. The findings demonstrated a significant correlation between lower-level behavioural traits (LLB) and upper-level behavioural traits (LUB) with academic achievement in the subjects of mathematics and science.

In Fernandez's (2011) research, the focus was on examining the relationship between brain hemisphericity and mathematical achievement among high school pupils. The findings revealed that the left hemisphere of the brain was dominating, and individuals had average performance in Mathematics. No difference was detected in brain hemisphericity based on gender and IQ. In the same way, there was no discernible difference in their mathematical skill depending on the hemisphericity of their brains. Left-brained students typically utilised equation formulation and logical reasoning as their primary problem-solving approach, while right-brained students predominantly relied on visual aids such as diagrams and drawings to support their problem-solving process.

Oflaz (2011) aimed to investigate the impact of brain dominance on academic performance of pupils in English language acquisition. The results revealed that pupils with a dominant right hemisphere of the brain demonstrated a strong ability to understand and adhere to instructions that were presented visually, as well as a high degree of skill in the Vocabulary part. Furthermore, they demonstrated proficiency in writing as well. Students that possessed a prominent left hemisphere, which is distinguished by strong logical problem-solving skills and high perceptual

discrimination, performed admirably in usage and reading comprehension. The outcomes of those with whole brain capabilities seemed to be well-balanced as they were able to effectively employ both hemispheres of the brain in a nearly similar manner. The study's findings indicated that brain dominance significantly influenced students' academic achievement in English lessons.

Ozgen et al. (2011) conducted research on the brain dominance and learning style profiles of 273 individuals who were preparing to become mathematics instructors. According to the findings, there was a preference for the "converger" and "assimilator" learning methods. Their cerebral quadrants "C" and "D" were the ones that showed the most dominance. In addition, the research discovered significant statistical disparities between the A, B, and C quadrants in respect to the various learning styles present in the population. The C quadrant demonstrated the highest results among the various learning styles, whilst the A quadrant demonstrated the lowest scores among the different learning types. No statistically significant association was observed between the dimensions of learning styles and dominating brain quadrants.

In their study, Bawaneh and Salmiza (2010) aimed to determine the thinking styles exhibited by secondary students in Jordan and investigate the correlation between these patterns and their favoured educational trajectory. The results indicated that the participants' cognitive patterns were equally distributed throughout the four thinking categories delineated in Herrmann's framework (A, B, C, and D). Science students had a greater prevalence of the externalised (QA) thinking style, whereas Literature students shown a preference for the procedural (QB) thinking style. Nursing students showed a preference for the interactive thinking (QC) style, whereas students specialising in Sharia demonstrated a propensity for the internalised (QD) thinking style.

Kok (2010) conducted research to investigate the relationship between students' reading comprehension skill and their attitudes toward learning English, as well as their abilities to apply reading strategies in relation to the hemisphere of their brain that is dominant. The research was conducted using a randomised control group design with a pre-test and post-test. According to the data, there was not a statistically significant variation in the levels of reading comprehension achieved by individual students. One thing that emerged, however, was that there was a statistically significant difference between the attitudes of the students in the experimental group and those in the control group. The

experimental group displayed a more positive attitude. This distinction was observed in both left and right brain dominant students.

2.1.2 Studies conducted in India

Nandhini and Subramanian (2021) examined the cerebral hemisphericity of higher secondary school students in Chennai, India, with a particular emphasis on its correlation with school management. Significant differences were observed in left-brain dominance across students in private, government, and government-aided schools, with students from private schools achieving higher scores. Comparable results were observed in the case of right brain dominance, with the scores showing a preference for private school students.

Singh et al. (2020) investigated the correlation between IQ and brain laterality indicators, including handedness, footedness, eyedness, and hair whorl orientation, in children aged 3 to 11. The scores for left-handedness, left-footedness, and left-eyedness were higher than their right-handed counterparts, under the assumption that individuals with a dominant right hemisphere of the brain possess better intelligence than those with a dominant left hemisphere. This study has the potential to be valuable in eliminating negative preconceptions associated with individuals who are left-handed or left-footed, so safeguarding the cognitive development of a child with left-lateralization in a society that predominantly favours right-handedness.

In their study on Brain dominance and academic achievement of medical students in Bengaluru, India, Suresh et al. (2020) found that the most prevalent dominance among the participants was left-brain dominance, accounting for 37.55% of the sample. This was followed by whole brain dominance at 33.06%, and right brain dominance at 29.39%. Boys had a strong preference for the right hemisphere, whereas girls exhibited a large preference for the left hemisphere. No correlation was found between brain dominance and academic achievement.

Singh and Gera (2018) examined the relationship between high order thinking skills and brain dominance among mathematics students using an experimental study. The findings showed no statistically significant difference in higher order thinking skills across students based on their brain dominance, whether it was left, right, integrated, or mixed. Nevertheless, notable disparities were observed in the Higher Order Thinking

Skill of students who received instruction through Duval's Semiotic Approach compared to those who were taught using conventional learning methodologies. Furthermore, the combined influence of Brain Dominance and instructional techniques on Higher Order Thinking Skill did not yield a statistically significant result.

Humera (2015) conducted a study to investigate the correlation between hemisphere dominance and mathematical achievement among students in the tenth grade in the city of Aurangabad. Based on the findings, it was determined that a sizeable percentage of the students demonstrated a strong right hemisphere learning and thinking style. It was not possible to identify any discernible differences in the level of mathematical achievement among students based on the hemispheres that they typically dominated. In terms of mathematical achievement, there was no discernible difference in the performance of boys and girls.

Kaur & Rani (2015) investigated the cognitive aptitude of senior secondary pupils by assessing their cerebral hemisphere dominance. Their study considers an individual's cognitive ability as their overall intellect, disregarding their proficiency in language and the influence of their social surroundings. The findings indicated that students with integrated brain hemispheres exhibited markedly superior cognitive abilities compared to those with dominant left and right hemispheres. However, there were no significant differences in the cognitive abilities of students with dominant right and left hemispheres. It was determined that children with integrated brain hemisphere dominance exhibit superior cognitive abilities compared to children with left and right hemisphere dominance.

Deshmukh et al. (2014) assessed the learning styles of MBA students by employing a Brain dominance and a VAK (Visual, Auditory and Kinesthetic) questionnaire. The brain dominance test categorised the learner group into two distinct hemispheric groups: the group with dominant right brain function and the group with dominant left brain function. Following that, these two groups were split up into three groups, each of which was based on the preferred learning styles of the individuals involved. Right-brain dominance was demonstrated by the majority of the pupils, followed by left-brain dominance and then whole-brain dominance. A preference for auditory learning styles has been observed among students who are left-brained, with visual and kinaesthetic learning styles following closely behind their preference. The children who were right-

brained, on the other hand, demonstrated a substantial preference for auditory learning styles, followed by visual and kinaesthetic learning types.

Sharma & Devi (2014) investigated the correlation between the academic performance of teenage students and their learning and thinking styles, taking into account their brain dominance and gender. The results indicated that pupils with a dominant right hemisphere achieved higher academic performance compared to students with a dominant left hemisphere. Regarding gender differences, there were no statistically significant disparities in academic achievement between males and females. This means that both right-brained and left-brained individuals of both genders fared equally well.

2.2 Metacognitive awareness and Academic achievement

2.2.1 Studies conducted in other countries

Barri et al. (2023) investigated the impact of video demonstrations on the metacognitive abilities of students in Science disciplines. A pre-test post-test quasi-experimental study was performed on a sample of 38 students, revealing that these video presentations were deemed beneficial by the participants. The students exhibited a low level of performance on the pre-test, but demonstrated a high level of performance on the post-test, suggesting that the implementation of instructional approaches such as the use of video presentations was a successful intervention in enhancing students' performance levels.

Cini et al. (2023) investigated the metacognitive awareness of upper elementary school pupils by analysing their situation-specific views during collaborative learning activities. The findings indicated that conditional knowledge (CK) exhibited the strongest connection with task comprehension, followed by declarative knowledge (DK) and procedural knowledge (PK). The subcategories of metacognitive awareness exhibited a significant correlation, indicating a connection between personal metacognitive views and contextual interpretations of task perceptions. Furthermore, it was discovered that students who possessed high degrees of metacognitive awareness possessed a clear comprehension of the task's requirements, particularly when they were provided with increased opportunities for collaborative learning.

Karaoglan et al. (2023) investigated the ways in which students' academic self-efficacy is affected by metacognitive awareness, reflective thinking, problem-solving, and

community of inquiry. Self-efficacy, reflective thinking, metacognitive awareness, and the ability to solve problems were found to have a significant positive link with one another at higher levels. The relationship between academic self-efficacy and community of inquiry was found to have a moderate degree of association. Additionally, the prediction model demonstrated that the community of inquiry, reflective thinking, metacognitive awareness, and problem-solving skills were all significant determinants in influencing academic self-efficacy and its subdimensions.

Ashfaq et al. (2022) conducted research to determine whether or not there is a connection between prospective teachers' academic performance and their level of metacognitive awareness. The sample included a total of 80 persons who were working toward earning a Bachelor of Education (B.Ed.) degree and 70 individuals who were working toward earning a Master of Education (M.Ed.) grade. Among the candidates for the Bachelor of Education and Master of Education degrees, the findings indicated a substantial difference in the levels of metacognitive awareness. M.Ed students demonstrated a greater degree of metacognitive awareness compared to those pursuing B.Ed. Furthermore, a strong positive association was found between their metacognitive awareness and academic achievement.

Aydin & Mocan (2022) investigated the motivation of middle school children towards science learning and their metacognitive awareness. The study involving a total of 637 students focused on many factors related to science education. The analysis demonstrated that factors such as gender, experimentation, engagement in science projects, practical application of science in daily life, grade level, and grade point average have a substantial influence on students' willingness to acquire scientific knowledge. Furthermore, it was discovered that there were differences in students' metacognitive awareness based on their engagement in experimentation, participation in science projects, practical application of science in everyday life, and their grade point average in science courses. There was also a moderate positive correlation between their motivation to learn science and their metacognitive awareness.

Asy'ari et al. (2022) examined the metacognitive awareness of high school students' natural science learning, with a particular emphasis placed on the role that gender plays in this knowledge acquisition. According to the findings of this study, the level of metacognitive awareness among students was classified as either average or low. In

addition, there were no discernible differences in metacognitive awareness across the sexes examined.

Bedir and Dursun (2022) conducted a with the purpose of determining whether or not there is a connection between the ability of high school pupils to comprehend metacognitive English reading strategies and their self-efficacy views. Upon analysis of the outcomes, it was discovered that the students primarily utilized problem-solving techniques, followed by global reading strategies and support reading strategies. Gender and grade were found to have a substantial impact on metacognitive awareness, while age did not. There were notable variations in the self-efficacy attitudes of individuals on their English language skills, namely in the areas of reading, writing, and speaking, based on age. A strong and favourable association was observed between metacognitive awareness and self-efficacy beliefs.

In Celik's (2022) research, the impact of metacognitive strategies employed by university students on their self-efficacy, motivation, and academic achievement was examined. A path analysis model was constructed and evaluated to investigate the correlations among the variables. The empirical analysis demonstrated that self-efficacy exerts a favourable influence on academic achievement in reading courses, both through direct and indirect pathways. Furthermore, motivation had an indirect impact on students' academic performance, with metacognition serving as the mediator. The study revealed that self-efficacy was the primary factor influencing academic achievement, with metacognition being the subsequent influential factor.

Goren and Kaya (2022) investigated the correlation between middle school students' comprehension of the nature of science (NOS) and their metacognitive awareness. A total of 701 students were interviewed, consisting of 180 fifth graders, 167 sixth graders, 170 seventh graders, and 184 eighth graders. Additionally, three students from each grade level were included, resulting in a total of 12 students, who exhibited different levels of knowledge of nature of science (NOS) and metacognitive awareness. The results revealed a statistically significant association between the metacognitive awareness of middle school pupils and their understanding of the nature of science. Furthermore, the interviews revealed that students' responses to questions on their knowledge of the nature of science (NOS) and their awareness of metacognition were coherent and aligned with each other. Students with strong metacognitive awareness

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demonstrated a greater comprehension of NOS, while those with poor metacognitive awareness had a weaker understanding of NOS.

In a study conducted by Güneş (2022), the focus was on examining the failure attributions and metacognitive awareness of English as a Foreign Language (EFL) learners in Turkey. The findings indicated that females had higher metacognitive awareness as compared to males. Females also demonstrated a statistically higher metacognitive regulation than males, but not for metacognitive knowledge. This suggests that women were more proficient in using and executing their metacognitive knowledge while engaged in the learning process. Furthermore, the subcomponents of debugging, declarative, and contextual knowledge exhibited a statistically significant difference among high achievers, suggesting that these language learners possessed a greater proficiency in metacognitive knowledge compared to regulation.

Hassan et al. (2022) The correlation between metacognitive awareness and academic achievement among medical students in their third and fourth years. The research findings demonstrated substantial correlations among metacognitive awareness, cognition knowledge, and cognition regulation. However, small correlations were observed between these variables and levels of academic achievement. This indicates that there is a need to enhance curriculum implementation by providing explicit instructions on metacognition.

Kesebir and Oksuz (2022) examined the impact of Mathematics diaries on the academic performance, metacognitive awareness, and motivation of students in a Mathematics class. The case study employed a hybrid research methodology, incorporating qualitative and quasi-experimental techniques. The sample for the experimental study consisted of 32 fourth graders, with 16 assigned to the experimental group and 16 to the control group. A total of 16 students from the experimental group, who utilised Math journals, participated in the qualitative investigation. According to the research findings, math diaries are more effective than traditional schooling in promoting students' metacognitive awareness. Furthermore, there was a significant difference in the mean metacognitive awareness score of the experimental group before and after the introduction of math journals, highlighting the crucial influence of math diaries on students' metacognitive awareness.

Küçükakça et al. (2022) investigated the effects of metacognitive strategies on the metacognitive awareness of sixth-grade mathematics students. The students in the experimental group underwent a total of 40 mathematics sessions over a period of 8 weeks in order to improve their metacognitive awareness. The pupils in the control group were provided with conventional mathematics teaching. The first results indicated that there were no significant differences in the levels of metacognitive awareness between the experimental and control groups. Nevertheless, the analysis of post-test scores demonstrated a substantial increase in students' metacognitive awareness levels within the experimental group. This suggests that the instruction of metacognitive techniques in mathematics courses indeed yielded a beneficial impact on students' metacognitive awareness levels.

Shah and Modna (2022) conducted a study to assess the levels of metacognitive awareness among medical students and their academic performance. The findings revealed a significant and positive association between the overall MAI scores and the course grade in physiology. High achievers had considerably superior performance in the subcomponents of declarative knowledge, procedural knowledge, implementation of techniques, debugging, and evaluation compared to low performers. Furthermore, individuals who excelled in their performance demonstrated notably superior abilities in declarative knowledge, planning, monitoring, and evaluation compared to those who achieved average results. In general, the level of metacognitive awareness had a notable influence on their academic performance.

Siraj et al. (2022) investigated the correlation between metacognition and academic performance in universities located in the Punjab Province of Pakistan. The sample comprised Chemistry students from four universities in the Punjab area. The findings indicated that there was no statistically significant association between metacognition and academic performance at the university level.

In a study conducted by Souhila (2022), the impact of metacognitive awareness and learning strategies on academic achievement was studied. The study sample consisted of third-year university students from the English Department. The findings indicated that learning techniques had a predictive ability of 64% on academic achievement, whereas metacognitive awareness and learning strategies accounted for 49% of the variability. Additionally, the findings demonstrated that the utilisation of information

processing processes and the capacity for self-testing are reliable indicators of academic success.

In their investigation, Tak et al. (2022) studied the correlation between mathematical reasoning and self-efficacy as a means of assessing the relationship between metacognitive awareness and self-efficacy among university students. The results of the structural equation modeling analysis indicate that students' mathematical reasoning ability is substantially impacted by both high self-efficacy and metacognitive awareness. Thus, the presence of metacognitive awareness and self-efficacy among undergraduates facilitated the development of their mathematical reasoning abilities. Additionally, the results revealed a marginal but statistically significant correlation between the self-efficacy beliefs of the students and their metacognitive awareness.

The study conducted by Wulandari et al. (2022) aimed to investigate the connection that exists between the metacognitive awareness of English students and their academic performance. According to the data, there was not a significant difference between the metacognitive capacities of male and female students' levels of comprehension. The findings of the Pearson's correlation analysis suggested that there was no statistically significant association between the academic accomplishment scores of students and their metacognitive awareness. This was the conclusion reached by the researchers. It may be deduced from this that students who have higher degrees of metacognitive awareness may have lower grade point averages, but students who have lower levels may have better quality point averages.

Abiodun et al. (2021) studied the metacognitive abilities of senior secondary school pupils in Ondo state, Nigeria, and assessed whether these abilities might serve as a predictor of their academic achievement in Mathematics. With regard to the relationship between their metacognitive abilities and their academic success in mathematics, the data suggested that there was no significant association between the two, and gender did not play a role in determining the nature of this relationship.

Ahmad and Sultana (2021) examined how metacognitive abilities and selective attention impact academic achievement. The study sample consisted of three hundred adolescents, with an equal distribution of 150 boys and 150 females. The selection process was both convenient and purposeful. The results unveiled a substantial relationship between the two factors. Academic achievement was strongly predicted by

selective attention and metacognitive abilities. Furthermore, significant differences in selective attention based on gender were observed, with females showing superior performance compared to males. Nevertheless, there was no difference in academic performance and metacognitive ability between males and females.

The academic achievement of university students was investigated by Cetin (2021) in relation to gender, weekly study hours, academic motivation, metacognition, and self-regulated learning levels. The objective of the research was to ascertain whether the cumulative scores of self-regulated learning, academic motivation, and metacognition could serve as a predictor of the students' overall academic performance. The results of the study revealed a notable association between the participants' self-regulated learning, academic motivation, and metacognition with their grade point averages (GPAs). Furthermore, these variables significantly predicted their GPAs. Nevertheless, neither gender nor the number of study hours per week significantly influenced these variables.

Mäkipää et al. (2021) investigated the association between the students' MA and their grades in general upper secondary foreign language language classes. children attending urban schools were found to have higher levels of MA when compared to children attending rural schools, according to the findings of the study. Furthermore, it was shown that students who achieved high GPAs had higher metacognitive awareness. Knowledge of cognition and linguistic attitudes were found to be predictive of academic achievement. The results indicated that to enhance the reflective practices of underperforming pupils, it is necessary to focus on improving their metacognitive awareness in rural schools.

Oyovwi and Iroriteraye-Adjekpovu (2021) aimed to improve the academic performance and student retention rates in science subjects by implementing metacognitive strategies in the Delta Central Senatorial District of Nigeria, located in West Africa. A major influence on the academic successes of scientific students was proven by the findings of the quasi-experimental design, which demonstrated that metacognition played a big role. In addition, the retention rates of students were significantly influenced by the use of metacognition strategies and also lecture style of teaching. There was no discernible difference between the mean scores of males and females on metacognitive strategies.

Based on the research, metacognition is a more favourable method for teaching and acquiring knowledge in the field of science.

Samuel and Okonkwo (2021) conducted research on the relationship between academic achievement, locus of control, metacognition, and pupils who were enrolled in secondary schools in the state of Anambra in Nigeria. Knowledge, which includes declarative, procedural, and conditional knowledge, as well as the regulation components of metacognition, which include planning, information management, monitoring, debugging, and assessment, were discovered to have a favorable correlation with academic accomplishment. According to the findings, however, there was no association found between metacognition and the students' external locus of control.

Arami and Wiyarsi (2020) examined the relationship between students' metacognitive abilities and their academic performance in Chemistry. The data were analysed using the product moment correlation method. The assessed metacognitive skills were conditional knowledge, planning, and evaluation. The results indicated a strong and positive association between planning and evaluation and academic achievement. However, there was a very weak correlation between conditional knowledge and student achievement. In general, the two variables exhibited a positive correlation, indicating that higher levels of metacognitive skills are likely to be associated with higher levels of student achievement.

In their study, Chytrý et al. (2020) investigated the correlation between learners' metacognitive knowledge and mathematical intelligence. The results showed that both factors had a notable influence on students' academic performance, but mathematical intelligence had a stronger impact.

Eriyani (2020) investigated the metacognitive awareness of students enrolled in Indonesian language and literature courses at a private university in Jambi, Indonesia. Student teachers in their third, fifth, and seventh semesters comprised the sample. The findings of the study revealed that there were no statistically significant differences in the metacognitive awareness scores between male and female student teachers, or between their second, third, and fourth years. In addition, a weak correlation was observed between the academic achievement of students and their degrees of metacognitive awareness.

In their study, Sari et al. (2020) examined the metacognitive awareness of Biology students and found a substantial difference in the degrees of metacognitive awareness between commuter and resident students. Moreover, commuter students exhibited superior performance in biology learning compared to resident students, a result that can be ascribed to their diverse experiences. First-time boarders must overcome the challenge of adapting to their new environment. Resident students have several challenges as they adapt to the strict norms and conditions that are exclusive to boarding programmes. Metacognitive awareness may have a direct correlation with biological age and experience, as it is anticipated that mature or experienced students will be capable of adapting quickly.

Cakir and Guven (2019) investigated the extent to which prospective teachers' academic achievement may be predicted by their metacognitive awareness and their enthusiasm to learn science. According to the Pearson product moment correlation, there is a high positive link between Knowledge of cognition and academic achievement. Additionally, there is a moderately significant association between Regulation of cognition and academic accomplishment. Furthermore, the results of the multiple regression analysis demonstrated that the knowledge of cognition, research motivation, performance motivation, collaborative work motivation, and participation motivation, all of which are sub-factors of science learning motivation, accounted for 37% of the variance in academic achievement scores while taking science classes.

Joshua (2019) conducted research which investigated the relationship between creative thinking, metacognitive thinking, and academic accomplishment among students who were enrolled in secondary schools in Tanzania. Both divergent and convergent thinking were found to have significant favorable connections with academic achievement, according to the findings of the present study. Although it was a positive association, the correlation between metacognitive thinking and academic achievement was not great. It was shown that the association between academic accomplishment and convergent thinking was stronger than the relationship between divergent and metacognitive thinking. This finding suggested that divergent and metacognitive thinking are less influential and more hard in the setting of education.

Oyelekan et al. (2019) studied whether the self-efficacy and metacognition of senior secondary school students might serve as predictors of their academic progress in

Chemistry. The findings indicated that the combination of self-efficacy and metacognition accounted for 69.1% of the participants' performance in Chemistry. The findings also demonstrated a significant and positive association between the students' metacognition and their chemistry achievement, suggesting that high metacognitive awareness and understanding of one's own thought processes and strategies in relation to chemistry tasks can result in improved performance in the subject.

Using first-year college students as their subjects, Ward and Butler (2019) investigated whether or not there was a connection between metacognitive awareness and academic accomplishment. Furthermore, they studied the possible benefits of participating in metacognitive awareness training in order to improve memory retention in higher education. An extremely substantial and favorable link was found to exist between academic achievement and metacognitive awareness, as demonstrated by the findings.

Cook (2018) conducted a study to ascertain whether or not the completion of a metacognition course, grades on online homework, the amount of time spent on online homework, or gender might be used as predictors of final course grades in undergraduate biology classes. The findings suggested that there is a correlation between metacognition and academic accomplishment grades that is favorable to a moderate degree. The results of the multiple regression experiments showed that a linear combination of the factors, which included the length of time that students were required to do homework, the grade of the homework, the gender of the student, and their involvement in a metacognition course, was able to accurately predict sixty-one percent of the variability in the final grades for the course.

Palennari et al. (2019) conducted a study to classify students' metacognitive abilities according to their learning styles. The sample comprised 82 freshmen from the Biology Department, Mathematics Department, and Natural Sciences Department of Universitas Negeri Makassar in Indonesia. The results revealed that biology students exhibited a preference for visual, aural, and kinesthetic learning modalities, alongside with elevated metacognitive abilities. In addition, the metacognitive abilities of visual, auditory, and kinesthetic learners were individually well-honed. The study determined that Biology students exhibit consistent metacognitive capabilities regardless of the learning modalities used.

Adigüzel and Orhan investigated the potential correlation between metacognitive and self-regulation skills of preparatory class students and their academic performance in language learning. The study also aimed to identify any differences in metacognitive and self-regulation skills based on specific variables. The findings indicated that the pupils had high levels of metacognitive abilities. Although factors such as age, student faculty, and type of education did not have a significant impact on metacognitive skills, gender had a significant impact with the scores in favour of female students. There was no significant association between their metacognitive abilities and academic achievement.

Hakeem et al. (2017) examined the correlation between metacognitive awareness, concept representation, and academic performance in physics among senior secondary school students. The results demonstrated a strong correlation between students' metacognitive awareness and their academic performance. The study also showed that the relationship between students' conceptual representation and metacognitive awareness had a significant impact on their academic achievement.

Wu (2017) conducted a study to investigate the cognitive, metacognitive, and academic performance of Taiwanese students. The results revealed that girls had greater proficiency than boys in employing memorization and control strategies. Furthermore, the ability to memorise and exert control showed a strong correlation with their academic achievement. Female students showed better performance in self-regulated learning and feedback management, while male students demonstrated more proficiency in self-efficacy.

Baltaci et al. (2016), investigated the relationship between metacognition, learning styles, gender, and mathematics grades among students in the fifth grade. Based on the findings, it was determined that there was no statistically significant connection between gender and learning styles. On the other hand, there were significant connections found between degrees of metacognitive awareness and grades in mathematics, learning styles and grades in mathematics, metacognitive awareness and learning styles, and metacognitive awareness and gender.

Rahmani and Samavi (2016) investigated the correlation between metacognition, academic motivation, problem-solving, and the academic achievement of female secondary school students in Chemistry. Results indicated that metacognition explains

38% of the academic achievement scores, 26% of academic motivation scores, and 2% of problem-solving assessment. The results of this study indicate a strong and positive relationship between all the variables and their academic performance in Chemistry.

Using students from a government senior high school in Makassar, Daud and Hafsari (2015) conducted an investigation into the critical thinking abilities and metacognitive awareness of Biology students of the school. 114 students (74.51%) had high learning outcomes, 25 students (16.34%) had medium learning outcomes, and 11 students (7.19%) had low learning outcomes from the analysis of the data. Three students (1.96%) were classified as having very high learning outcomes, 114 students (74.51%) had high learning outcomes, and 11 students (7.19%) had low learning outcomes. According to the findings of the regression analysis, metacognitive awareness was a significant predictor of 27 percent of the accomplishment scores of Biology students.

Kristiani et al. (2015) conducted research to evaluate the ways in which metacognitive skills and scientific attitudes influence academic achievement. The metacognitive abilities of the students were evaluated through the use of an essay test. According to the findings, the combination of metacognitive abilities and scientific attitudes was responsible for 71.42% of the academic achievement of the students. A scientific mindset contributed 9.49% to academic accomplishment, while metacognitive skills contributed 61.93%. The difference between the two was that the scientific mindset contributed more. According to the findings of this study, educators should give serious consideration to implementing instructional strategies that assist in the development of students' metacognitive abilities.

Aljaberi and Gheith (2014) investigated the correlation between the metacognitive thinking of university students and their proficiency in solving mathematical and scientific problems. The results indicated that students exhibited a moderate level of metacognitive thinking, and the variables of gender, academic stream, and current university year did not influence their metacognitive thinking. There was no significant correlation between the two variables. Nevertheless, a significant association existed between procedural knowledge, evaluation and the proficiency in solving mathematical problems.

Ayazgök and Aslan (2014) investigated the academic perception, metacognitive awareness, and reflective consideration skills of university students majoring in science

and mathematics. An additional objective of the research was to assess the correlation between these variables and others, including age, gender, and academic standing. The findings revealed that no statistically significant distinction existed in the MAI scores of male and female students. Moreover, there was no discernible impact of the students' grades on their metacognitive awareness. A noteworthy correlation was identified between reflective thinking abilities and metacognitive awareness. The sub-dimensions of reflective thinking skills comprised 27% of the metacognitive awareness scores, while reflective thinking skills comprised 25% of the metacognitive scores.

Ciascai and Haiduc (2014) investigated the correlation between metacognitive abilities and academic achievement in the field of science. The researchers reported significant associations between them. The pupils who had superior reading comprehension exhibited superior performance in the subjects of physics and chemistry, in comparison to students who did not possess this skill. Nevertheless, the students who possessed knowledge of the teacher's intended curriculum exhibited superior academic performance in biology, although this advantage did not extend to physics or chemistry. There was no association between the students' prior scientific knowledge and their academic performance. The academic performance in science showed a strong positive relationship with evaluation and planning.

Samadi and Davaii (2012) examined the correlation between cognitive, metacognitive, and motivational strategies of learning with academic performance and found that there was a strong correlation between them. The results of the multiple regression analyses indicated that cognitive strategies accounted for 15%, metacognitive strategies 30%, and in combination accounted for 45% of the variance in achievement scores. Motivational strategies accounted for about 1% of the variance. Cognitive, metacognitive, and motivational strategies in combination were able to predict 46% of the academic achievement scores.

Wong (2012) examined the impact of metacognitive skills and punctuality on self-regulation. The findings indicated that metacognitive awareness and a minimal inclination towards procrastination had positive effects on academic learning. The data analysis involved categorising the students into four groups based on their levels of metacognitive awareness and procrastination: high metacognitive awareness and high procrastination, high metacognitive awareness but low procrastination, low

metacognitive awareness and low procrastination, and low metacognitive awareness but high procrastination. It was unexpected to see that pupils who possessed two positive factors did not achieve a higher GPA compared to those who just had one positive element. Furthermore, students lacking any of these favourable components exhibited notably lower GPAs compared to students belonging to the remaining three categories.

Aurah et al. (2011) examined the impact of Metacognition on problem-solving skills in a sample of 150 kids from Muraka Primary School in Kenya. The researchers discovered that metacognition serves as a reliable indicator of problem-solving aptitude. Grade had a significant impact on problem solving and metacognition. Metacognitive ability had a positive correlation with age and grade level. They concluded that recognising the significance of metacognition in children's daily problem-solving can assist educators in developing more efficient instruction that integrates metacognitive abilities to aid children in improving their problem-solving skills and overall academic performance.

Akyol et al. (2010) investigated the many ways in which students in the seventh grade in Turkey applied metacognitive and cognitive techniques. According to the findings, there were significant differences in the level of competency that students possessed in terms of the use of cognitive and metacognitive methods. Additionally, there was a positive association between the use of metacognitive self-regulation procedures, organization, and elaboration, and the scientific accomplishment of students. Furthermore, this correlation was shown to be significant. Additionally, a noteworthy correlation was observed between the implementation of cognitive and metacognitive strategies and science achievement, as well as several other variables including prior knowledge, the educational attainment of parents, the quantity of reading materials available at home, the frequency of daily newspaper purchases, the provision of a separate study room, and the presence of a computer with internet access in the household.

2.2.2 Studies conducted in India

Acharya (2021) examined the metacognitive abilities of secondary school pupils and discovered a statistically significant association between these abilities and their academic performance. The results demonstrated a significant association between the

selected variables, highlighting the necessity of cultivating metacognitive awareness and skills in adolescent students to enhance their academic achievements.

In their study, Pradhan and Das (2021) examined the influence of metacognition on the academic performance and learning preferences of undergraduate students. Data were gathered from students majoring in Science, Social Sciences, and Engineering. They had equal preferences for all five learning methods rather than favouring just one. The three groups of students displayed considerable variations in their academic achievement and metacognitive abilities. Metacognitive skills accounted for 43% of the variance in academic achievement scores. The learning preferences exhibited by the undergraduate students, on the other hand, did not take into consideration the variations in metacognitive abilities.

Gupta (2017) conducted a study to investigate the correlation between the metacognitive abilities of secondary school pupils and their self-efficacy, academic achievement, and locus of control. The investigation also considered the residential context of the students and the school. There was no statistically significant difference in metacognitive abilities between the residential background of the school and gender, according to the findings. Strong and positive correlations were found between metacognitive abilities and academic achievement among both high-achieving and average-achieving pupils, according to the study. On the contrary, a noteworthy inverse correlation was identified between metacognitive abilities and academic achievement among students who performed poorly. Among high-achieving individuals, the study found a negative correlation between knowledge of cognitive processes and academic achievement, but a positive correlation between management of cognitive processes and academic success. A positive correlation was observed between knowledge of cognition and academic achievement, however a negative correlation was observed between regulation of cognition and academic achievement among students with average performance. Low achievers demonstrated a negative correlation between both aspects of metacognition and their academic performance. The metacognitive skills of secondary school students were found to have a positive correlation with their locus of control, self-efficacy, and academic achievement.

In their study, Jaleel and Premachandran (2016) examined the metacognitive awareness of secondary school students, with a particular focus on the impact of gender and school

location. The sample consisted of 180 secondary school pupils who were selected from a variety of institutions located in the Kottayam district. Statistically, there was no significant difference in the level of metacognitive awareness between secondary school pupils of any gender or school location, according to the findings.

Balya and Khimnani (2011) investigated the relationship between metacognition and academic achievement among student teachers specialising in the Science stream. The results demonstrated a significant positive correlation between the knowledge of cognitive processes and academic performance, between the regulation of cognitive processes and academic performance, and also between the overall assessment of metacognitive abilities and academic performance.

2.3 Perceptual learning style preferences and Academic achievement

2.3.1 Studies conducted in other countries

Chen (2023) conducted a comprehensive analysis of numerous studies on learning styles to ascertain the correlation between learning styles and language acquisition. He focused on perceptual learning styles, encompassing visual, auditory, and tactile methods. Discovering the importance of employing suitable learning methods is essential for both students and teachers, since it has the potential to greatly enhance students' language scores. Visual modalities are superior and more effective than alternative forms of input when it comes to enhancing vocabulary acquisition, suggesting that the acquisition of foreign languages is enhanced by visual stimuli. Recent research suggests that employing tactile learning methods may hinder students' ability to acquire foreign language skills. This is because children tend to favour visual and auditory modalities, such as reading and listening, during classroom instruction. Another study indicates that the kinesthetic learning style surpasses the other two styles in terms of enhancing student accomplishment. Therefore, it can be asserted that each of these three learning styles has a unique impact on students' acquisition of foreign languages, and students should strategically embrace them to enhance their academic achievement.

Liu and Liu (2023) studied the learning styles of medical students enrolled in a Chinese institution. Their findings revealed that a significant majority (73.97%) of the participants exhibited a preference for visual information over verbal information. Reflective information was assigned a higher level of importance (51.82%) compared

to active information, while sensory information was given more significance (67.15%) than intuitive information. The majority (59.85%) of them preferred sequential information processing over global information processing. Their research findings also demonstrated that female students exhibited a preference for reflective learning as opposed to active learning, whereas male students displayed a preference for active learning over reflective learning. The predominant learning modalities employed by medical science students included active, visual, sensory, and sequential approaches.

Almasri (2022) examined the correlations between learners' learning styles and their levels of engagement and satisfaction when utilising simulations for science learning. The study investigated the perceptions and utilisation of simulations for physics, chemistry, and biology learning among 1034 college students. The study findings revealed that the utilisation of simulations for science education led to exceptionally high levels of participant involvement and satisfaction. The individuals' self-esteem and VAK learning preferences, namely the preference for physical movement, significantly influenced their level of involvement and contentment with the learning experience.

Balci and Çalışkan (2022) studied the correlation between chronotype, learning preferences, and academic performance. The study sample consisted of 1884 undergraduate volunteers from 58 distinct universities in Turkey. The findings indicate that individuals classified as morning (M) types showed a preference for a visual learning approach, while those classified as evening (E) types showed a preference for an aural learning style. There was no correlation discovered between academic achievement and chronotype. Participants who exhibited a preference for kinaesthetic learning demonstrated lower CGPA scores in comparison to those who favoured auditory and visual learning. Females had greater Cumulative Grade Point Averages (CGPAs) compared to males.

Cuizon et al. (2022) examined the learning styles, study habits, and academic performance in mathematics of pupils. The survey's findings indicated that students had a preference for tactile, group, and individual learning methods as supplementary modes of learning, despite their inadequate study habits. Additionally, a high level of academic achievement was found. Study habits showed significant differences with respect to course and gender. There were no significant differences in academic performance or learning preferences based on profile traits.

Pocaan (2022) assessed the learning styles and multiple intelligences of 250 education students in their second year and 200 engineering students. The results indicated that engineering students exhibited a preference for individual, group, auditory, and visual learning styles, whereas education students showed a preference for auditory, visual, and kinesthetic learning methods. Moreover, engineering students primarily exhibited interpersonal, quantitative, and kinesthetic intelligence. Education students showed proficiency in visual, linguistic, interpersonal, and kinaesthetic domains.

Siddiquei and Khalid (2022) investigated the academic performance and learning style preferences of Pakistani e-learners. The findings revealed that visual learning constituted the most prevalent learning methodology employed by online learners. Aural and kinesthetic methods ranked subsequently. All learning strategies exhibited a strong and positive correlation with academic achievement (GPA).

Al-Seghayer (2021) investigated the learning-style preferences of Saudi EFL learners and assessed the influence of various events and experiences on their preferred modes of learning. The findings indicated that EFL learners exhibited a major preference for auditory, social, and kinesthetic learning modalities. The least preferred learning approach was the individual learning style. Their selected learning methods may have been influenced by cultural socialisation factors and personal experiences. Individual work is not highly esteemed in Saudi society. Hence, spontaneous individual or small ensemble activities in English classrooms elicit discomfort among Saudi EFL students. These students possess a strong inclination towards collaborative learning, characterised by their tendency to ask questions and engage in group work with their peers. This behaviour can be attributed to the impact of their collectivist culture.

Getachew (2021) examined the learning styles and strategies utilised by secondary school students in learning mathematics. The investigation also explored the relationships between different learning methods, such as memory, cognitive, compensation, metacognitive, and social approaches, and the preferred learning styles, including visual, auditory, kinaesthetic, tactile, individual, and group preferences. The results indicated that the participants exhibited a preference for both individual and group learning methods, as opposed to kinaesthetic and tactile learning approaches. The metacognitive strategy was most preferred. Learning techniques did not vary

significantly based on gender and age. Furthermore, a strong association was observed between all types of learning styles and all kinds of learning strategies.

Ortega et al. (2021) conducted a study to identify the sensory preferences of Secondary students based on gender and age. Additionally, they investigated any potential correlations between these preferences and the students' academic performance in science. The researchers administered the VARK questionnaire to a sample of 582 students, comprising both males and females, ranging from seventh to eleventh grade. The results indicated a strong preference for the kinaesthetic mode, whereas the visual mode was the least favoured. Both males and females exhibited similar preferences. The regression analysis revealed a significant impact of the kinesthetic mode on academic achievement, as well as a low but significant impact of the reading/writing score.

Awadallah and Frehat (2020) investigated the learning styles of students at a Technical University in Palestine. They also studied the impact of the university branch, gender, educational programme, academic year, specialism, and cumulative average, on these learning styles. The study's findings indicated that the active-reflective learning method was the most preferred, followed by visual verbal, sequential-global, and sensing-intuitive. The study also identified significant gender-based differences in both visual-verbal style and sequential-global style, with females demonstrating better performance. Furthermore, there were no statistically significant differences seen in the educational programme and cumulative average.

Bawalsah and Hadda (2020) conducted a study to establish the preferred learning styles of 10th grade students with Learning Disabilities (LD) and to examine if these styles differed based on gender and grade point average (GPA). A total of 184 students took part in the survey. The results indicated that 45 students had characteristics that put them at risk of developing learning disorders (LD). Furthermore, the predominant learning styles among these pupils were kinesthetic and auditory. The study found a correlation between these learning styles and gender (males and females) and between GPA (students with higher achievement chose kinesthetic and auditory learning styles), respectively.

Cornelius-Ukpepi et al. (2019) studied the sensory learning preferences and academic achievement in Social Studies among primary school pupils in Calabar Education Zone,

Cross River State, Nigeria. The results indicated a strong correlation between students' academic achievement in social studies and their preferences for verbal and visual learning. The research indicated that social studies teachers can enhance the academic performance of visual learners by frequently utilising visual aids such as charts, diagrams, and pictures, as well as employing various colours of chalk or whiteboard markers to clearly annotate notes on a chalkboard or whiteboard.

Malacapay's (2019) study suggested the predominant learning style preference among students was auditory, accounting for 47% of the entire sample. Visual and kinesthetic learners were the next most common preferences. When respondents were classified based on their learning methods, visual learners achieved a mostly satisfactory performance, auditory learners achieved a highly satisfactory performance, and kinesthetic learners achieved a satisfactory performance. Learning styles did not vary much based on gender or access to education. There was no significant association between academic achievement and learning styles.

Ratna (2019) studied the English learning methods of non-English speaking students and their favoured learning tactics. The results revealed that students learn English through a range of approaches, depending on their preferences. Furthermore, it was found that Maths students had the greatest inclination towards visual learning, with a preference rate of 34.46%. In contrast, Counselling students showed a higher preference for auditory learning, with a rate of 35.64%. Similarly, Informatics Engineering students displayed a strong preference for kinaesthetic learning, with a rate of 35.61%.

Suarez-Embalsado (2019) did a study to investigate the relationship between learning styles and academic achievement in Grade Six Students. The findings indicated that among the 152 participants, 30.26% had a preference for visual learning, 10.53% demonstrated a preference for both visual and auditory learning, 39.74% favoured auditory learning, 15.97% preferred kinaesthetic learning, 2.63% had a preference for both auditory and kinaesthetic learning, and 1.32% had a preference for both visual and kinaesthetic learning. VA, AK, and VK were excluded due to their classification as outliers. There was a strong correlation between academic achievement and visual learning, but no significant correlation with auditory and kinaesthetic learning.

Derakhshan and Shakki (2018) examined the correlation between the learning styles of Iranian English as a Foreign Language (EFL) learners and their competence levels at

Golestan University in Gorgan, Iran. The participants were categorised into two groups based on their language proficiency: learners with high proficiency and learners with low proficiency. The results indicated significant associations between students' learning modalities and their levels of achievement. The study revealed that highly skilled students exhibited a preference for kinesthetic and tactile learning methods over auditory, visual, group, and individual learning approaches. The students with low skills showed a preference for learning methods that involve visual aids and group activities.

Ojeh et al. (2017) studied the learning styles of pre-clinical medical students and investigate the correlation between learning styles and academic performance. The results indicated that the majority of students were multimodal learners, with tetramodal being the most common. The read/write and kinaesthetic learning modes were the most favoured. 34.2% of females showed a preference for the read/write sensory modality, whereas 40.5% of males favoured the kinaesthetic sensory modality. There was a substantial correlation between learning styles and learning awareness, but no significant correlation was found with academic achievement, age, or gender. In total, 60.7% of high achievers and 56.9% of low achievers employed multimodal learning.

Barnes-Jones (2014) investigated the impact of learning styles on the academic performance of at-risk high school students. The results indicated that there was no association between the level of match scores and the subject areas of science, mathematics, and English language arts. However, a significant relationship was observed in the case of social studies. Based on a qualitative analysis, students demonstrated enhanced performance when their preferences for the learning environment, instructor type, and learning style were aligned, as opposed to when they were not.

Budiasih (2013) examined the learning style preferences of ESL students, taking into account their gender and academic performance. The results revealed that the kinaesthetic learning style was the most preferred by both male and female students, followed by the visual learning style and auditory learning style. The majority of pupils exhibited right-brain dominance, followed by left-brain dominance, in both males and girls. The distribution of preferences for visual, auditory, and kinaesthetic learning styles was equal among high achievers, whereas the kinaesthetic learning style was the

most favoured among low performers. This indicates that those who excel academically are flexible learners who can acquire new knowledge through many methods such as physical exercises, visual aids, lectures, audiotapes, or debates.

Abdollahi and Tahriri (2012) examined the correlation between visual and auditory learning preferences and the ability of English as a Foreign Language (EFL) learners to remember vocabulary. The findings indicated a significant difference between the visual and auditory scores of the participants. Moreover, it was shown that the visual learning technique had a greater efficacy and influence on the recall of EFL vocabulary. Furthermore, the correlational study revealed no significant relationship between the individuals' learning styles and their gender.

Saadi (2012) examined the relationship between learning styles and reading achievement among students in preparatory schools in Saudi Arabia. The sample consisted of students in grades 7 and 8, along with their Arabic language teachers. The results indicated that children in both the high and low reading achievement groups had a preference for multimodal learning approaches. Students in the low achievement category preferred the kinaesthetic method as their sole learning style. A strong chi-square association was discovered regarding students' preference for a multimodal versus single mode learning technique. Despite the overall tendency for multimodal learning among both genders, females had a considerably higher preference for the single mode of learning. Strong connections were seen between reading achievement and the specific components of reading instruction, reading resources, and reading activities.

Avni (2011) conducted a study to determine the impact of classes that integrate different teaching styles (visual, auditory, reading/writing, and kinesthetic) on the learning outcomes of primary school pupils who have specific preferences for certain learning styles. These lectures were presented to three classes of 75 kids each in a primary school in Israel for a whole academic year. Prior to the implementation of the experimental lessons, the pupils filled out the VARK questionnaire. The results demonstrated that students derived significant advantages from the lectures when they incorporated a diverse range of learning styles (VARK). Furthermore, the visual aspect of the presentation was highly efficient in captivating the students' focus and augmenting their comprehension. Furthermore, it was evident that the components of the course that were

not aligned with their individual learning preferences did not impede their progress but instead contributed to enhancing their desire and elevating their level of achievement. This was particularly accurate for the pupils who performed poorly.

Marin-Pantelescu (2011) investigated the learning preferences of Marketing students by utilising the VARK questionnaire. The results indicated that 20% of the students exhibited multimodal learning styles. 80% of the students had a unimodal learning style, out of which 36.67% showed a preference for auditory learning, whereas 23.33% preferred read-write learning, 20% preferred kinesthetic learning, and none of them favoured visual learning. 16.67% of students who favoured multimodal learning chose bimodal learning (A-K, V-K, and A-RW), whereas 3.33% chose trimodal learning (V-A-K). Based on the gender breakdown, 83.33% of females and 75% of males expressed a preference for a single modality. The majority of females shown a preference for auditory learning, while the majority of males exhibited a preference for kinesthetic learning.

Tachie (2010) examined the learning style preferences of students at public Junior High Schools in Ghana and their impact on students' performance in science. The data indicated that auditory learning was the most desired among students, followed by kinesthetic and visual learning. Male students exhibited a predilection for a visual learning modality, whilst females for auditory learning. Grade level, age, gender, and auditory learning accounted for 12.7% of the difference in academic performance. The current study's strong inclination towards auditory learning styles can be attributed to cultural factors, wherein a significant amount of knowledge acquisition at home relies on auditory methods along with conventional teaching approaches.

Tanwinit and Sittiprapaporn (2010) conducted a study that examined the learning preferences of undergraduate musical students in Thailand. The students were categorised into five groups, namely visual, auditory, read-write, kinesthetic, and multimodal learners, according to their answers on the VARK questionnaire. 66.1% of individuals favoured multimodality, while 33.9% favoured unimodality. 62.7% of the participants expressed a preference for auditory learning, whereas 15.3% chose kinesthetic learning, 11.9% preferred read-write, and 10.2% preferred visual learning. Gender did not influence the variation in learning styles.

2.3.2 Studies conducted in India

In a study conducted by Suman (2017), the relationship between metacognitive skills, learning and thinking styles, and academic accomplishment of secondary school students was examined. The findings revealed a significant impact of metacognitive skills on academic achievement. Urban pupils demonstrated superior academic achievement compared to rural children, as did females compared to males. The interaction effects revealed that urban students possessed strong metacognitive abilities outperformed urban pupils possessing low metacognitive abilities. In addition, urban pupils who possessed advanced metacognitive abilities demonstrated superior performance compared to rural students who had limited metacognitive capabilities. Regarding learning preferences, research revealed that pupils with a left-brain dominance outperformed those with a right-brain dominance in academic achievement.

Vinitha (2016) conducted a study in Coimbatore district to investigate the metacognitive awareness, learning style preferences, and academic accomplishment of higher secondary school students. The sample comprised 1005 individuals enrolled in higher secondary school. The results revealed a noteworthy link between academic achievement and the evaluation component of cognitive regulation. It was intriguing to discover that pupils who regularly read the newspaper had enhanced cognitive regulation. Male students had superior metacognitive ability compared to their female peers. Students exhibited enhanced cognitive abilities and thinking capacity when instructed in their native language, Tamil, as opposed to learning in a non-native language. There was no significant relationship between learning styles and the type of school. However, there was a strong association between learning styles, notably visual-verbal and sensing-intuitive, and the location of the school.

A study was undertaken by Acharya (2015) to investigate the correlation between the academic achievement of upper primary school pupils and their learning style, with gender differences being considered. The results revealed a significant correlation between the academic performance of students and the variety of learning paths they selected. Furthermore, they demonstrated a predilection for visual learning as opposed to auditory and kinesthetic learning. Significantly influencing academic achievement were the kinesthetic, auditory, and visual learning modalities. Furthermore, substantial variations in learning preferences were observed in relation to gender.

Prabha and Waheeda (2015) examined the differences between genders in visual, auditory, and kinaesthetic (VAK) learning among first-year medical students in Salem, India. 14.1% of male students exhibited a preference for visual learning, 18% shown a preference for auditory learning, and 13% demonstrated a preference for kinaesthetic learning. On the other hand, 14.2% of female students showed a preference for visual learning, 17.8% displayed a preference for auditory learning, and 15% favoured kinaesthetic learning. Male students shown a greater preference for multimodal instruction, specifically utilising two modes, whereas female students showed a preference for bimodal and unimodal modes of instruction.

Ahmed et al. (2013) examined the learning styles of dental students in two distinct dental institutions in India. Data was collected using the VARK questionnaire, which assesses individuals' visual, auditory, reading, and kinaesthetic learning preferences. The results revealed that people had a greater preference for multimodal learning, with a particular preference for kinaesthetic learning.

Vaishnav and Chirayu (2013) conducted a study to examine the learning styles of 200 students in grades 9, 10, and 11 in secondary school. Additionally, they sought to determine the correlation between students' learning styles and their academic accomplishments. The results indicated a greater preference for kinaesthetic learning techniques compared to visual and auditory learning styles. There was a strong and favourable correlation between academic achievement and the kinaesthetic learning style. Visual, auditory, and kinaesthetic learning were strong predictors of academic achievement.

2.4 Research gaps emerging from review of literature

The primary objective of conducting a literature review is to apprise the researcher of any existing gaps or deficiencies in the current body of research. An examination of the existing literature on brain hemispheric dominance indicates that the majority of studies focus on language students and their proficiency in various language-related skills such as word retention, vocabulary, speech, reading comprehension, and writing. The studies primarily focused on students who were learning English as a foreign language (EFL), English as a second language (ESL), as well as students of Japanese and Korean languages (Kok, 2010; Oflaz, 2011; Dulger, 2012; Soyoof et al., 2014; Weisi & Khaksar, 2015; Ozyel, 2016; Alibeigi, 2017; Wei et al., 2017; Wei & Sulaiman, 2018; Arabmofrad

et al., 2022; Li et al., 2022). Although several studies have been conducted on Science and Mathematics students, primarily focusing on undergraduate students from various universities (Fernandez, 2011; Kim and Cho, 2012; Humera, 2015; Mansour et al., 2017; Singh and Gera, 2018; Gholasi et al., 2020; Joven et al., 2020; Suresh et al., 2020; Aburayash, 2021; Cornelius et al., 2021; Marquez, 2023), there is a dearth of research specifically examining Biology students at the senior secondary level. A close perusal of the review of studies on metacognitive awareness revealed that it has been studied in relation to different variables like academic self-efficacy (Bedir & Dursun, 2022; Celik, 2022; Karaoglan et al., 2023; Tak et al., 2022), failure attributions (Güneş, 2022), academic achievement (Young & Fry, 2008; Tok et al., 2010; Yesilyurt, 2013; Abdellah, 2014; Das, 2015; Jain et al., 2017; Hassan et al., 2022; Shah & Modna, 2022; Siraj et al., 2022), achievement in science (Rahman et.al., 2010; Alkan & Erden, 2014; Bogdanović et al., 2015), nature of science (Goren and Kaya, 2022), listening performance (Coskun, 2010), learning styles (Shetty, 2014), Academic anxiety (Saricam & Ogurlu, 2015), and various demographic variables (Rahman et al., 2010; Khan and Khan, 2013; Cihanoglu, 2013; Zailaini & Ismail, 2014; Veloo et al., 2014; Jagadeeswari & Chandrasekaran, 2014; Das, 2015; Hashempour et al., 2015; Sabna & Hameed, 2016; Fernandes & Talekar, 2016; Jaleel & Premachandran, 2016; Asy'ari et al., 2022).

Furthermore, an analysis of the literature review on learning styles indicates that there has been a lack of focus on investigating the impact of perceptual learning style preferences on Biology teaching. The incorporation of perceptual learning preferences (visual, auditory, and kinesthetic) into science education is a frequently debated topic in academic circles. However, research in this area has not progressed at the same rate. Prior research has primarily focused on establishing connections between learning styles and specific academic achievements of EFL and ESL learners (Chen, 2023; Al-Seghayer, 2021; Ratna, 2019; Derakhshan & Shakki, 2018; Budiasih, 2013; Abdollahi & Tahriri, 2012), science learners (Liu & Liu, 2023; Almasri, 2022; Ortega et al., 2021; Tachie, 2010), mathematics students (Cuizon et al., 2022; Getachew, 2021), engineering students (Pocaan, 2022; Awadallah & Frehat, 2020), and medical students (Ojeh et al., 2017; Prabha & Waheeda, 2015; Ahmed et al., 2013). The researcher encountered a scarcity of studies that explicitly investigated the academic performance of senior secondary students in the field of Biology, suggesting a lack of study undertaken on this

specific group of Biology students. Furthermore, the majority of research pertaining to metacognitive awareness and perceptual learning styles, both individually and in conjunction, has been carried out in countries other than India.

Thus, upon conducting a preliminary review of the pertinent literature, it is evident that while there have been numerous studies investigating the correlation between different psychological factors and academic performance, there is a lack of sufficient research specifically addressing the relationship between brain dominance, metacognition, perceptual learning style preferences, and academic achievement in the field of Biology. Prior studies primarily focused on examining them individually or in conjunction with other variables. The regression studies examining the influence of these variables on academic achievement were even more insignificant. It is worth noting that while there are several international studies that examine students at all educational levels, there is a dearth of research specifically focused on the academic performance of higher secondary students, particularly those in Grade 12. The studies undertaken in India in these fields are regrettably insufficient. Undoubtedly, this vacuum warrants the persistent scrutiny of researchers. The lack of research in this area highlights the necessity for additional inquiry. Being the inaugural study in this domain, it distinguishes itself as a unique research record.