LEFT-HANDEDNESS AS AN OVERLOOKED SPECIAL LEARNING NEED

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ABSTRACT

Left-handed people represent about 10% of any random population. In the recent past, left-handers are known to have experienced challenges when functioning with the left hand was strictly forbidden. They are likely to do so even today. Every day use tools ranging from simple objects to dangerous machinery are largely designed for use by the right-handed. This makes their handling and use challenging for left-handers’. Cross-sectional studies have found significantly enhanced left-hander frequencies among elite athletes exclusively in interactive sports, boxing and music. In order to succeed, professional musicians have been found to adapt to right handed instruments. They also have to conform to the standard playing position of the right handed. Although scientific and popular literature has reported that left-handers are over-represented among populations of creative artists (Preti & Vellante, 2007) and architects (Peterson & Lansky, 1977), left-handed children experience more learning difficulties in script techniques, handicrafts and art at primary level compared to their right-handed peers. Further, research has established that there exists a cognitive disadvantage for left-handed school children compared to the right-handed (McManus, 1997). Similar studies into left-handedness also concur that left-handed children experience difficulties in school mainly because of their inherent peculiarities caused by their hand orientation (Kula, 2008; Malusi, 2014). In the classroom, studies have established that left-handed learners are adversely affected in a negative way. A mismatch between a learners’ physiology, more general cognitive abilities and the level of expertise has been shown to cause challenges in the learning process. These mismatches range from the use of desks and sitting positions to using instructional resources intrinsically meant for the right handed. When using such tools, a left-hander will either learn to use the tool right handed (awkward and inefficient at best) or somehow learns to hold the tool backwards so that it can be manipulated with the left hand (often clumsy). When undertaking activities that require precision and speed, left-handers are expected to perform at the same speed as their right-handed peers since Kenya, like many other countries in the world does not recognize left-handedness as a special learning need. This review paper seeks to establish that left-handedness is a special learning need that ought to be given a special consideration in line with other behavioral and physical impairments that influence learners’ ability to learn effectively.

Key words: handedness, left-handers, right-handers, mismatch between physiology and learning resources
INTRODUCTION

Left-handedness is a phenomenon that accounts for approximately 10% of any population (Bishop, 1990; Denny & O’Sullivan, 2007). This 9:1 ratio of right- to left-handers is widely cited, but it does not appear generalizable to all populations (Michael, 2007). This is because the incidence of left-handedness varies across culture, sex and over time (Denny & O’Sullivan, 2007). In a study by Gilbert and Wysoski (1992) that sampled 1 177 507 people, data showed that men are more likely (12.6%) to be left-handed compared to women (9.9%), young people are more likely to be left-handed (14% for men and 12% for women) compared to the elderly (nearly 6% for both sexes). A more recent study by Johnston, Nicholls, Shah and Shields, (2010) also showed that males have a somewhat higher incidence of 11.9% of being left-handed compared to females at 8.9%. Collaborative studies have also revealed that there are more left-handers today compared to 20–30 years ago (Kula, 2004). These numbers have not increased because of a growing trend but it rather reflects a greater individual freedom that permits people to act in accordance to their preferences, individuality and in-born peculiarities (Kula, 2004).

Several explanations have been given for the varying incidences of left-handedness. On the one hand the varying percentages have partly been attributed to the diversity in tasks and tests used to test handedness which seem to introduce complications in the comparison of handedness across populations (Masud & Ajmal, 2012). On the other hand, investigations have disclosed that the frequency of left-handers is lower in eastern cultures, which may reflect greater cultural resistance to left-handedness (Masud & Ajmal, 2012; Denny & O’Sullivan, 2007; Mandal & Dutta, 2001; Medland, Perelle, De Monte & Ehrman, 2004; Raymond & Pontier, 2004; Perelle & Ehrman, 1994; Peters, Reimers & Manning, 2006). For instance, Singh and Bryden, (1994) reported lower incidences of left-handedness among nonwestern populations (India 5.4% and Japan 4.8%) compared to incidences established in western cultures (Bishop, 1990; Kula, 2008; McManus, 1991).

Major world religions are also strongly inclined towards right-handedness. For example, the devil has been linked with left-handedness and is normally depicted as being left-handed in pictures and other figures (Left-Handed Myths and Misunderstandings, 2000). In both the Quran and the Christian Bible, God’s chosen people sit on his right-hand side while the condemned sit on its left hand side (Pervert, 2006). In Mark 16:19, the Bible particularly indicates that Jesus sits at the right hand of God and is in fact God’s right hand. Since Christianity has had wide spread effect on millions of the world population through history, it therefore potentially strengthens the spread of right hand preference.

As far as the diversity of tasks used to test handedness are concerned, a review by Raymond and Pontier (2004) found a range of 5–25.9% in 81 studies that examined throwing or hammering in 14 countries in America, Africa, Europe, Asia and Australia. This finding suggests an important geographical variation in hand preference (Llaurens, Raymond & Faurie, 2008). Such geographical variations were also observed for unimanual tasks such as writing. A survey of 12 000 participants from 17 countries by Perelle and Ehrman (1994) found a 2.5–12.8% range for those who wrote with their left hand. Based on 255 100 answers to a BBC internet study, left-handers ranged between 7–11.8% among seven ethnic groups (Peters et al., 2006). The frequency of left-handedness thus appears to vary among human populations, with left-handedness always being at a lower frequency compared to right-handedness. Moreover, in most populations studied, male left-handers have been twice that of females left-handers (see Raymond & Pontier 2004 review), suggesting an important influence of sex in the determination of hand preference.

Left-handedness has been defined by Burt (2008) as a consistent tendency to undertake new dexterities with the left hand rather than with the right hand. In the general population, left-handedness appears to occur more frequently in identical
twins and several groups of individuals with neurological disorders (Rosebaum, 2000). A recent study showed that two right-handed parents had a 9.5% chance of having a left-handed child. The chances rose to 19.5% if one parent was left-handed and increased to 26.1% if both parents were left-handed (McManus & Bryden, 1992). This implies that hand preference could be transmitted by parents to their children; either at a genetic or a learning level (Llaurens et al., 2008).

Various theories have attempted to explain the origins of left-handedness. For example, Johnston, Nicholls, Shah & Shields (2009, 2010) broadly divide theories on the origins of handedness into: (a) genetic explanation, (b) exogenous factors and (c) the social environment.

Contributory models for left-handedness linking a solitary gene with major effects have been proposed, most influentially by Annett’s (1985) ‘right shift theory’ which is based on a single hypothesized gene with two alleles. The genetic model, according to Annett (1985) suggested that handedness is determined by one gene with two alleles; the dominant allele (RS+) and the recessive allele (RS−). She theorized that the recessive trait is maintained because of a cognitive advantage for individuals with both alleles (RS+ RS−) relative to left-handers (RS− RS−) and individuals who are very strongly right-handed (RS+ RS+). A similar argument has been advanced by a number of authors, for example Bryden, Roy, McManus and Bulman (1997) and McKeever (2004). That means the probability of a child being left-handed is a significant function of the mother’s left-handedness.

There exists another line of research guided by the notion that the normal distribution of right- and left-handedness can be altered by pathological pre-natal or peri-natal events (Satz, 1972, 1973; Bakan, Dibb & Reed, 1973). Accordingly, many studies have assessed whether or not there is an increased rate of left-handedness among persons insulted during pre- or peri-natal development (for example, pre-natal exposure to neurotoxins, ultrasound, maternal smoking or alcohol use, severely premature birth and birth stress). Bakan et al. (1973) particularly propose that the fetal environment and more so the occurrence of birth related stress are important in the explanation of handedness. This argument has been supported by Coren and Halpern (1991) in the assertion that markers of any pathological factor, for example the utero environment, developmental instability in early fetal development, birth weight and birth stress can disrupt normal development by inducing a switch in hand preference. This is so regardless of mechanism and has been shown to manifest itself in a higher percentage of left-handers (Llaurens et al., 2008).

The existence of associations between left-handedness and various health problems have often led to a distinction being drawn between pathological left-handedness, arising from familial left-handedness genotype (Harris & Carlson, 1988). This hypothesis argued that some individuals are left-handed because they had suffered diverse types of pathology. The explanation for the increased frequency of left-handers in clinical populations with central nervous system disorders (e.g. schizophrenia, epilepsy, mental retardation or learning disabilities) was based on the claim that early brain insult may cause the individual to switch to the opposite hand for unimanual activities (Satz, Orsini, Saslow, & Henry, 1985; Bishop, 1990). Johnston, et al. (2010) saw no relationship between familial left-handedness and discernible socioeconomic characteristics such as family income or maternal education.

Social factors have also been shown to exert selection forces on hand preference depending on the culture and the geographical location of the individual. According to McManus (1991), it was generally felt that using the right hand improved efficiency among workers and so everybody was made to use their right hand. As such, changes were usually carried out in an atmosphere of psychological pressure and without the necessary knowledge of edifying ideology; they caused various disturbances in the functioning of the left-handed individual. Llaurens et al. (2008) contend that this change happens in three ways depending on different degrees and types of pressure: (i) changing the hand used for some activities (e.g. writing, eating), with no change for other unimanual activities, (ii) reducing the degree of hand
preference, when weak pressure applies to all hand actions, or (iii) changing the overall preferred hand, when strong pressure applies to all hand actions (pp.6). The consequences of such changing became a significant social problem (US Sports Academy, 2008).

In the recent past, different sections of the world population previously opposed to left-handedness are realizing that left-handedness can neither be ignored nor wished away and hence more left-handers can freely express themselves according to their in-born peculiarities and preferences (Kula, 2004; Salmaso, & Longoni, 1985; Bryden, Ardila, & Ardila, 1993). Despite this freedom of expression, left-handers still continue to face challenges today just like they did in the sixties and even earlier, when functioning with the left hand was strictly forbidden (Meyer, 1998). It has been hypothesized that this is so because generally, everyday use tools ranging from simple objects to dangerous machinery are solely designed for use by the right-handed, making them difficult, painful, and/or unsafe for left-handers’ use (McManus, 1991).

In the school context specifically, the challenges faced by left-handed individuals include school desks that are unworkable, scissors that are of no use, pens that spread ink and make handwriting unreadable and computer mouse that cause spasms of the hand (Flatt, 1999). Further, some of the instructional resources in use are ungraspable by left-handers because they have an inbuilt advantage for right-handers (McManus, 1991; Townsend, 2012). Yet instructors expect left-handers to function at the same precision and speed as their right-handed peers. This is so because learning institutions have no provision for left-handers’ preferences and the adaptations they have to make to comfortably fit in and with the operating systems (Malusi, 2014).

A theoretical case was advanced by Rouet (2009) that given a specific task and specific materials, cognitive load is obviously subject to variations as a function of learner characteristics, such as memory capacity and the interacting elements. For example, during learning, sometimes learners are faced with the task of learning, understanding and applying in situ some intellectually difficult material that require considerable time, effort and thought. It is expected that the learner engages certain mental processes and instructional procedures and designs that can best facilitate learning. These instructional methods which are intended to aid understanding tend to incorporate all the information elements necessary for understanding in the instructions (Pollock, Chandler & Sweller, 2002). Frequently, these types of instructions may overwhelm a learner’s limited working memory and hinder effective learning (Johnstone, 1997).

The purpose of this review paper is to show that left-handedness is a special learning need that affects the performance of tasks in daily life. It is hypothesized that mismatches in the teaching and learning environment negatively influence left-handers’ ability to interact with learning resources, process information effectively during learning and therefore hamper the effective attainment of their academic threshold. This may lead to an eventual departure from active participation and effective learning which consequently may result to decreased learner outcomes. The discussion will generally seek to highlight how left-handers fare in other areas of life and specifically in academics.

**EFFECTS OF HANDEDNESS ON AN INDIVIDUAL’S LIFE**

Handedness apparently affects nearly all facets of an individual’s life. Numerous studies that vary in focus and level of functioning of the participants have been carried out in the context of handedness. Such studies include creative arts (Preti & Vellante, 2007), interactive sports (Loffing, Hagemann & Strauss, 2012; Gursory, 2008) and music, (Aggleton, Kentridge & Good, 1994).

**HANDEDNESS AND CREATIVITY**

Contrary to scientific and popular literature which has reported an over-representation of left-handers among populations of creative artists (Preti & Vellante, 2007) and architects (Peterson & Lansky, 1977), Kula (2008) established that left-handed children experience more learning difficulties in script techniques, handicrafts and art at primary school level.
compared to their right-handed peers. There was evidence that left-handed children in general classes succeeded in learning foreign languages, music, art and have good results in sports. However, left-handers who experienced persistent learning difficulties were often sent to remedial classes (Kula, 2008).

Learning to write the Roman alphabet which typically runs left to right is perceived as a very threatening task for left-handers. This has been explained by Paul (2002), a researcher of left-handedness that most of the difficulties experienced by left-handed children stalk from their having to write with the left-hand and sight with the right eye. Primary school children have been shown to experience challenges attributed to picking up and responding to ideas expressing spatial directions, for example, left and right, up and down, which makes it more difficult learning to read, write, developing mathematical skills and orientating in the environment (Paul, 2002). For this reason, left-handed children in primary school have difficulties in comprehension and they might read backwards, have difficulties finding the correct direction when moving their hand and creating reflected image of letters (Kove, 1997) a common practice in lower primary school.

But despite these challenges left-handers are characteristically more creative, more likely to notice the size, shape and form of things and are also more likely to see the whole picture or concept compared to right-handers (Kula, 2004). All these aspects in an amalgamated form show that left-handers have more power of perception compared to right-handers (Rice, 1998). Enhanced mathematical ability, which involves a high level of visuo-spatial ability (Hermelin & O’Connor, 1986), may also show an effect of hand preference in favor of older left-handers.

The disproportionately demonstrated greater creativity by left-handers compared to right-handers has been explained as emanating from having to learn from an early age to navigate in a right handed world (Townsend, 2012). This could be the reason left-handers are somewhat seen as more flexible than right-handers. It has been claimed that they appear to be capable of switching over their hands for performing tasks more easily than right-handers and that they think faster when playing computer games or some selected sports (Pawlik-Kienlen, 2008). However, even though life has become slightly better for left-handers in the recent past, living in a world planned and particularly designed to match the needs of advantaged right-handers it is still tricky (Masud & Ajmal, 2012).

**IMPACT OF HANDEDNESS ON SPORTS**

The world has been designed up-down by the right-handed for the right-handed (Masud & Ajmal, 2012) and the minority population (left-handed) has to make adaptations in order to fit in. In yesteryears, democracy and tolerance has widely spread (US Sports Academy, 2008) and hence the probability of maintaining the left-handedness peculiarity is higher. In sport like in other spheres of life, tolerance is an achievement. Left-handers have to take part in training prepared for right-handers or its special version for the left-handed. That means they have to adjust to the training. For a left-hander to realize a certain portion of the training prepared for the right-handed is a great achievement which is entirely a left-hander’s initiative (ibid).

But despite tolerance and adaptation being a left-handers greatest achievement in sport, there has been tremendous success for them. Cross-sectional studies have found significantly enhanced left-hander frequencies among elite athletes exclusively in interactive sports such as baseball, cricket, fencing, tennis (Loffing, Hagemann & Strauss, 2012) and boxing (Gursoy, 2008).

In their study, Loffing et al., (2012) longitudinally tracked left-hander frequencies in professional tennis singles and contrasted these data with left-hander frequencies in a more recent sample of non-professionals. The findings supported the surprise effect advantage hypothesis insofar as the left-handers’ advantage in tennis seemed modifiable, probably through the professionals’ more sophisticated match preparation opportunities, extensive domain-specific learning and adaptation processes.
Further, in order to find the effect of left- or right-hand preference on the success of boxers in Turkey, Gursory (2008) did a study to evaluate the role of left- or right-handedness on the success of a boxer. Participants were 22 active, semi-professional or amateur male boxers. The boxers had actively been boxing for between 4 and 15 years (mean 9.87), were aged between 17 and 46 years (mean 32.25) and weighed between 65 and 101 kg (mean 81.06). They were divided into left- and right-handed boxers. Handedness was determined using the Oldfield Index. Further, the boxers were categorized into win and defeat cases. Data from both groups were compared statistically using t test.

Collected data showed that left-handed boxers were involved in between 75 and 800 fights (mean 120.6) with between 5 and 79 losses (mean 19.32). Right-handed boxers were involved in between 50 and 820 fights (mean 127.8) with between 23 and 78 losses (mean 42.25). Findings showed that left-handed boxers were significantly more successful than right-handed boxers (p<0.01). According to Gursory (2008) left-handers should never be forced to convert to right-handedness; they should be supported both verbally and in terms of equipment and they should be motivated, because obtained data proved that left-handedness translates to success, especially in boxing.

To explain left-handers achievement in interactive sports, Starosta (1975) suggested that a higher efficiency level of one upper limb is shifted to the lower limb thereby limiting the direction of turns in sporting exercises. Right-handers perform this type of exercise into the left considering their right leg as dominant. Only particularly talented people may achieve success in complex movements involving the whole body. In order for left-handers to achieve a certain level of efficiency, the claim that compared to right-handers they might benefit more from long and intense training appears plausible (Holtzen, 2000).

It has also been argued by Wood and Aggleton (1991) that left-handers’ advantage in many sports can be explained tactically without any hypothetical additional neurological advantage. Accordingly, right-handers are more frequent and it is therefore more likely to be confronted by a fellow right-handed opponent than a left-handed one. When confrontation comes from an opposite handed opponent, it catches the right-hander off guard. Left-handers are used to right handed confrontations, so it does not come as a surprise for them when confronted by right-handed opponents. Hence, left-handed players have a surprise advantage which increases when their frequency is lower (Raymond, Pontier, Dufour & Moller, 1996).

Given that sports training manuals are almost always written in favor of right handers; left-handed sports trainees have to first turn around instructions before embarking on undertaking any task (Silverman, 2009). In golf, Silverman argues that learning how to stand correctly is not a major issue for any golfer because it is a relatively simple and straightforward task. However, left handers have to turn things around and that’s where it gets complicated. Instead of thinking about their posture and swing, left-handed golfers first think about turning around the instructions. The overall effect is that this takes both time and effort. Further to having to turn instructions around during training, the golf course is designed for the right-handed golfer, the most common golfer, while being uninviting to the left-handed (Jamison, 2002). Many left-handed golfers play right-handed. Therefore if the golf course designers recognized that there is a difference between performances, those who naturally prefer to be left-handed but train to be right-handed could have one fewer obstacle to overcome (Jamison, 2002).

In conclusion, left-handers are well represented among elite athletes especially in interactive sports. They are said to benefit from the surprise effect due to their biological predisposition. Left-handed sports men and women have to take part in training prepared for right-handers or its special version for the left-handed. That means the left-handed trainees have to adjust to the training at their own initiative and cost. Due to the adaptations they have to make it has also been shown that left-handers benefit more from long and intense training.
LEFT-HANDERS IN MUSIC

In music as in sports, studies have shown that left-handers enjoy a good representation in the upper end of the performance spectrum (Aggleton, Kentridge & Good, 1994). The effect of handedness on the performance skills in string players and pianists was investigated by Kopiez, Jabusch, Galley, Homann and Lehmann (2011). In their first experiment, the researchers asked piano and string players and a group of teachers and students at a professional conservatory questions about bodily discomfort while playing and any history of injuries, their own feelings regarding their level of skill and expressivity on their chosen instrument. Findings indicated that there was no association between being left-handed and having increased physical discomfort or having negative feelings while playing their preferred instrument. There was a slight tendency for left-handed musicians to rate their playing position as more beneficial than did the right-handers. It was evident that left-handed string players tended to be more positive about their expressive skills than were their right-handed peers.

While self reports are subjective, in their second experiment with the music pianists, Kopiez et al., (2011) tested the players’ sensorimotor skills as they played. Each pianist played sequences of between 10 and 15 repetitions of a 2-octave C major scale on a digital piano. Findings indicated that being left-handed presented no disadvantages. For both right- and left-handed pianists, the performance of the right hand always displayed a higher degree of evenness between notes, and hence a higher degree of motor control, compared to the left hand. The more practice time a left-hander had accumulated, the better the right hand performance. The researchers concluded that a temporal sensorimotor precision in the right hand was superior to that of the left hand in both right- and left-handed pianists.

Professional musicians adapt to the standard playing position regardless of their handedness (Kopiez, et al., 2011). These findings were in agreement with other studies that left handers adapt to right handed instruments in order to fit in a world conveniently made by the right-handed for the right-handed (McManus, 1997). Evidently therefore, left-handers have to learn to adapt to the available resources in almost all spheres of their life.

The US Sports Academy (2008) concurs that the problem of individual sports training for left-handed sports people has not been addressed although it affects a greater part of the population. The academy carried out a study to establish the types and effects of adaptations (transformations) left-handed people have to make during training. According to the Academy, the then system of sports training had been prepared for right-handed sports people. The system lacked a suitable program for individualized training for left-handers. With no other option, left-handed sports persons must adapt to existing systems. An analysis of the progress in sports careers of the best competitors indicated significant difficulties of the left-handed in adapting to right-handers’ schema of training, and simultaneously showed incredible human adaptational possibilities. It also pointed to the existence of unsolved problem of distinct feature of sports training for left-handers.

This section has shown that in sports like in any other field of life, left-handed players are faced with challenges that they ought to overcome in order to succeed. Left-handers have the advantage of the surprise effect in interactive sports, an advantage that gives them an edge against their right-handed opponents. However, in both sports and music, left-handed individuals have to benefit from intensive and prolonged training. A lot of effort and time has to be invested, not to mention the discomfort that left-handers experience because of having to uncomfortably contort the body during training. In golf, left-handers not only have to turn around instructions around, they have to play in golf courses designed for right-handed users. Such adaptations are not only time consuming, they are costly.

EFFECT OF HANDEDNESS ON ACADEMICS

The preceding section showed how handedness affects an individual’s life specifically in the areas of creativity, interactive sport and music. In the following section, this paper attempts to show how handedness may affect a learner’s
academic life. The discussion will include how mismatches that occur in the classroom as well as during the dynamics of teaching and learning may influence left-handers’ academic achievements.

GENERAL PERFORMANCE OF THE LEFT-HANDED IN SCHOOL
A study of the UK national curriculum results by Gregg, Propper and Janke (2008) found that left-handed children perform worse at school compared to right-handed children. More than 10,000 children participated in the study that showed left-handers performing less in IQ tests and tests for 11 to 14 year olds. In cognitive outcomes at ages 8, 11 and 14, left-handers performed worse than right-handers with the gap between right-handed girls and left-handed girls being bigger than that between right-handed boys and left-handed boys. On average, left-handers’ test scores were 1% below those of right-handers. The research indicated that there were more boy geniuses amongst left-handers than right-handers. Left-handed boys dominated the top and bottom of the ability charts. The study concluded that while left-handers from both sexes start off performing worse, left-handed girls fail to catch up with their peers during later school life.

The findings in this study can be collaborated by findings in a study by Kula (2004) which found that left-handers experience more learning difficulties (related to reading, writing and comprehension of other school subjects) compared to right-handers, more than half of whom are boys. Lance (2005) also suggests that handwriting puts forward a special obstruction for left-handers. The functions of cerebral hemispheres may develop later in left-handed children and therefore handedness in such children develops later due to their physiological peculiarities (Johnston et al., 2010). Consequently, there is confusion in using the left hand and motion perception is bad; which explains why acquisition of notions expressing motion perception and responding to them renders it more difficult to learn reading, writing and the disturbance of the development of mathematical skill, hence the reason left-handers more frequently compared to right-handers have learning difficulties (Johnston et al., 2010).

EFFECT OF MISMATCHES IN THE CLASSROOM
Studies have established that left-handers are adversely affected in the classroom (Kula, 2008; Malusi, 2014). Since learning is determined by learners’ characteristics among which prior domain specific knowledge, learners’ physiology, more general cognitive abilities and their level of expertise, effective learning is a result of the interplay between these aspects (Rouet, 2009). A mismatch between any of these variables will consequently cause challenges in the learning process. Such mismatches range from using pencil sharpeners, spiral note books, scissors, rulers and sports equipment designed for right-handed people (McManus, 1997). When using such tools, left-handers either learn to use the tool right-handed (awkward and inefficient at best) or somehow learn to hold the tool backwards so that it can be manipulated with the left hand (often clumsy) (Coren, 1997).

Numerous studies concur that left-handers have to put in great effort even for simple tasks of life contrary to their natural tendencies and face problems in the use of tools for routine chores (Misom, 1995; Coren, 1997). Some of the evident challenges for left-handed individuals in school include desks that are unworkable, pens that spread ink and make writing unreadable and computer mouse that cause spasms of hand (Flatt, 1999). Writing left-to-right is one other complex activity a left-hander has to do (Paul, 2002). Due to poor paper-pen control which causes them to tire more easily (Misom, 1995), left-handers tend to write slowly, which sometimes makes them fail to complete timed tasks.

The classroom, where left-handed learners spend most of their school life fronts challenges. Some of the challenges include; sitting on desks that have the arm rest on the wrong side, sitting next to a right-hander which results in knocking elbows during writing, using pens that spread ink making freshly written work smudged and messy, and sometimes having to write for lengthy periods which makes the hand tire because of flexing the hand muscle wrongly. Adapting to these conditions in order to fit is costly for left-handed learners.
Participants were required to draw 45° and 135° lines by turning at an equal rate the left and the right knobs. For 22.5° and 157.5° angles, the left hand had to be turned twice as fast as the right hand. For 67.5° and 112.5° angles, the right hand had to be turned faster than the left hand. For the leftward oriented lines (x>90°), the left hand had to be turned counterclockwise and the right hand clockwise. For the rightward oriented lines (x<90°) both hands had to be turned clockwise. Each participant had two trials for each angle. In one trial, participants could see the line as it was drawn while for the other trial, a barrier was placed over the screen after half of the line had been drawn. Participants were then required to continue drawing without seeing the line. In-sight trials always preceded out-of-sight trials.

Findings indicated that there was a main effect of handedness. For lines that were not within the guidelines, left-handers made more errors than right-handers (left-handers’ mean=0.86 inches, right-handers’ mean=0.41 inches). Left-handers were slower than right-handers for lines oriented at 22.5°, 45° and 67.5°. These were the lines which required clockwise turning by both hands. The 67.5° line also required that the right hand turned faster than the left hand.

The conclusion was that left-handers have trouble coordinating the movement of both right and left hands. The researchers suggested that the anterior callosum found in left-handed people may reflect the additional processing load required in some left-handers when motor programming does not take place in the hemisphere controlling the movement. Due to this predisposition of left-handers, the struggle with teaching/learning instructional resources during the manipulation of the same while undertaking timed tasks may result in frustrations and a probable negative attitude towards the task and/or the subject.

The study by Ruecker and Brinkman had a small non-representative sample that did not control for any socioeconomic characteristics. It had a further limitation of using only one measure of coordination and so there was no breakdown of the different aspects of performance for
in their study, Johnston et al., (2007) tested whether handedness affects early child development for a nationally-representative sample of children. In their study, eight wide ranging and comprehensive measures of child development covering learning, social, cognitive and language aspects were used. The researchers also estimated models of child development that controlled for differences in socio-economic and parental characteristics. The study found robust evidence that left-handed children perform significantly worse in nearly all measures of development, with the relative disadvantage being larger for boys compared to that of girls.

The study by Johnston et al. (2009) found strong evidence that left-handed children perform significantly worse in nearly all measures of development, except for reading. Boys compared to girls performed worse. It has also been established that left-handers have trouble coordinating the movement of both right and left hands. Given that in most high school science classrooms there is a lot of hands-on minds-on activities that involve the manipulation of instructional resources, left-handed learners are therefore at a disadvantage because there is no allocation for extra time for them to make the necessary adaptations when using the said instructional resources.

**HAND PREFERENCE AND COGNITIVE DEVELOPMENT**

Although the studies on bimanual manipulation (Ruecker & Brinkman, 2001) and measures of child development (Johnston et al., 2007) established a disadvantage for the left-handed learner, none of the studies looked at the participants’ cognitive skills. Johnston, et al. (2009) provided a unique opportunity to examine the relationship between hand preference and cognitive development in young children. Previous studies investigating the impact of hand preference on cognitive ability either focused on older children (e.g., Faurie, Vianey-Liaud & Raymond, 2006) or on adults (e.g., Halpern, Haviland & Killian 1998; Resch, Haffner, Parzer, Pfueller, Strehlow, & Zerahn-Hartung, 1997). The data for the Johnston et al. (2009) study was drawn from approximately 5,000 children aged between 4 and 5 years. It was hypothesized that testing children at a relatively young age would allow the researchers to examine the relationship between hand preference and cognitive ability before the beginning of extensive schooling therefore providing an index of the relationship that is relatively free of social conditioning.

A broad range of skills were assessed in this study. These included vocabulary, reading, writing, copying, social development, gross and fine motor skills. More than half the sampled children were enrolled in an educational program and had a teacher willing to complete a questionnaire. The study findings indicated that left-handed children were 4.6% points more likely to be classified as “less competent” compared to right-handed children in social/emotional skills, gross and fine motor skills and receptive English skills. Further, left-handed children’s scores were approximately 2.6% lower than those of right-handed children.

The study concluded that since a disadvantage was observed for social/emotional development approaches to learning and receptive skills which did not require written responses, this was a clear demonstration that left-handedness deficit extended far beyond measures that required fine motor skills. It also appeared that despite being disadvantaged in most areas of cognitive achievement, left-handed children had the same ability for verbal expression as their right-handed peers. In conclusion therefore, it appears that failure to complete tasks and probably lowered academic outcomes as a result should not be taken to mean an inability to effectively retrieve information from the memory stores (Malusi, 2014). This could be due to the use of mismatched instructional resources that increase extrinsic load for left-handed users.

While using data from the US National Longitudinal Survey of Youth (NLSY), and fitting family fixed-effects models of child health and cognitive development, Johnston et al. (2010) tested if left-handed children performed significantly worse than their right-handed peers. Health measures covered both physical and mental health while the cognitive development test scores spanned constructs such as memory, vocabulary, mathematics, reading and comprehension. There were 12,686 participants aged between 14 and 21 years as of January 1979. Participants were first interviewed in 1979, re-interviewed
every year from 1979 to 1994 and every two years from 1994 to 2006.

Findings indicated consistent evidence that left-handed children performed worse than right-handed children in all areas of development except in reading. Quantitatively, the differences in development were large, with left-handed children scoring about 13% of a standard deviation lower test scores in the memory test, 11% lower in comprehension, 9% lower in mathematics and 7% lower in vocabulary. The size of the handedness differentials was about the same as found by comparing children who were born prematurely to those born with a normal gestation length. This effect of hand preference on general cognitive ability confirmed the results of studies such as Johnston et al. (2009), which also used a large, representative sample of Australian children.

Another study by Kula (2008) on skills and knowledge in teaching left-handed children sampled 28 classroom teachers from five schools, teaching children aged between 7 and 11 years in grades 1 to 4 in regular and remedial classes where English was taught more extensively and classes where music and dance were more advanced. Twenty two (22) of the teachers had classroom teacher certification while the rest had the special education teacher and speech therapist qualifications and taught remedial classes as well. Questionnaire were used to find out how much teachers noticed left-handed pupils at school, what help was needed and how they supported such children.

Findings indicated that 40% of left-handed children in general manage on their own, though 60% of left-handers and 45% of right-handers need teachers’ help. Data also showed that script technique is one school subject that causes the most difficulties for left-handers: 40% of left-handers in grade 1 (one) had difficulties with this, and so did 38% in grade 2, 82% in grade 3 and 27% in grade 4. Generally, 49% of the participants showed some degree of difficulty, proving that writing is the most difficult subject (skill) for left-handed children. Kula suggested that this phenomenon was because when children are taught how to write, teachers proceed from

the methodology of teaching writing to right-handers leaving the left-handers with no option but to cope on their own. This is significant because difficulties in learning script technique might contribute to learning difficulties in general.

Mathematics caused difficulties for 26% of the left-handers in the given sample. This was perceived as being because primary schoolers have problems with spatial perception. One of the main difficulties was given as picking up and responding to notions expressing spatial perception such as “left-right” and “up-down”. In manual training, 23% of left-handed children exhibited difficulties that could be explained by teachers showing the main techniques from a right-handed perspective.

The findings further revealed that reading skills are relatively low in grades 1 and 2 and they caused difficulties to 21% of the sampled left-handed children. Sometimes left-handed children start reading words backwards or from the end of the line. So they acquire reading skills indirectly using spatial knowledge and feeling their own body (left-right/up-down). Reading skills for the left-handed improved in grade 4 where almost no difficulties occurred.

The data further showed that left-handed children experienced more learning difficulties at primary level than their right-handed peers. These difficulties are mostly connected with perception of directions and handedness, which requires accuracy and coordination skills. The researcher, Kula (2008) concluded that in these areas, left-handed children need individually adapted guidance. Similar research by Gaddes (1985) and Paul (2002) confirmed that left-handers have more learning difficulties because their brain hemisphere functions might develop later, which also explains their slower progress in elementary school (Paul, 2002).

Left-handed children have difficulties cutting with scissors. Approximately 46% of sampled teachers thought that they were unable to teach the most important manual techniques to left-handed children while 21% of them knew that when teaching left-handed children, it was wise to sit facing them because when left-handed children see the reflection of an
activity it makes it easier for them to follow (Malusi, 2014). Unlike their right-handed peers, left-handed teachers usually know the relevant techniques for instructing left-handed children (Kula, 2008; Milsom, 2006).

The deficits of the left-handed extend beyond challenges in the manipulation of instructional resources. They have been shown to perform below their right-handed peers in nearly all measures of development. Difficulties are mostly connected with perception of directions and handedness, which requires accuracy and coordination skills. Script technique is one school subject that causes the most difficulties for left-handers which was attributed to teachers instructing left-handed children using techniques meant for teaching the right-handed.

**IMPACT OF HANDEDNESS ON PRACTICAL LESSONS AND CLASSROOM DEMONSTRATIONS**

Demonstration as a teaching methodology and as it applies to the acquisition of gross motor skills has become a central teaching template for instruction, especially in physical education. It has also found its place in the classroom particularly in the high school science laboratory. In so far as watching an opposite handed demonstration is concerned, Malusi (2014) established that during a demonstration, left-handers in high school preferred watching classroom demonstration from the same side as their right-handed teacher. The learners argued that it made them ‘understand and follow the demonstration with ease’. Findings from the study by Parish (2011) argued for left-handed college students gaining more from opposite handed demonstrations.

In order to determine the categorical differences inherent between right- and left-handed individuals and how these differences affect the way in which learners learn, Parish (2011) sought to determine whether left-and right-handers can learn a skill effectively when seeing a demonstration from either a right or a left-handed instructor. It was hypothesized that performance and form scores of left-handers that see a right-handed demonstration would be significantly higher than those of right-handers that see a left-handed demonstration. In the study, a lacrosse\(^1\) shot was demonstrated to a group of 69 college-aged participants, equally split in numbers between male and female, left- and right-handed. Half of each group saw a left-handed demonstration while the other half saw a right-handed demonstration.

Participants were assessed on target accuracy and four components of shot form. Results showed that left-handers performed significantly better than right-handers on target accuracy (F (3, 68) =4.38, p=.007), shot form (F (3, 68) =2.87, p=.043) and body positioning (F (3, 68) =4.51, p=.006). It was concluded that left-handed college students appeared better able to collect important information from an opposite-handed demonstration, an attribute the right-handers did not seem to possess.

In a cross-sectional study that purported to compare the acceptance rate of left- and right-handers in college entrance examinations for national universities in Iran, Noroozian, Lofti, Gassemzadeh, Emami and Mehrabi (2002) randomly sampled and investigated 50 000 students in college entrance examination successfully for 5 years. The relationship between acceptance rate and hand preference, sex, college admission entrance examination scores and study areas, i.e., Mathematics, Natural Science, Humanities and Art were examined. Over the 5 year period, acceptance rate of left-handers was significantly higher than that of right-handers (27.3% compared to 24.3%, P<0.0001). The mean score obtained as attained on the examination by left-handers was significantly higher than the difference reached in statistical significance in Art at only P<0.01. It was concluded that left-handers may be regarded as a heterogeneous large group able to compete for college entrance examination scores even more successfully that right-handers in terms of average examination entry scores and rate of college acceptance.

\(^1\) goal game in which players use a long-handled stick that has a triangular head with a mesh pouch for catching, carrying and throwing the ball.
Numerous studies have been carried out in the context of attitudes and mismatches in the learning of science. It has been established that students subsequently develop negative attitudes towards science because of mismatches in the learning environment. Studies by Dhara, Khaspuri and Sau (2008), Parish (2011) and Malusi (2014) show that mismatches in learning environments have negative effects on learning outcomes. Ruecker and Brinkman (2001) found that left-handers have difficulties coordinating the movement of right and left hands simultaneously, especially in tasks that require clockwise turning by both hands. During the handling and manipulation of instructional resources in the practical classrooms, instead of deploying cognitive resources to consciously process information that is supposed to be learned, the effort of left-handed learners is directed to processing extrinsic load generated by consciously processing what ought to be unconsciously executed. As a result, the intended learning content is not effectively processed for storage and future retrieval in the LTM (Sweller, 1988; Baddeley, 1992). The failure to process and retrieve the required information effectively may lead to the development of negative attitudes about their abilities.

On the other hand, the persistent failure to effectively manipulate instructional resources that front challenges to left-handers because they are mismatched to their physiology can lead to a ripple effect that changes the way in which the learners interact with some selected laboratory apparatus. This also causes lowered self esteem which may lead to the development of negative attitude toward laboratory tasks and the subject, eventually making the learner to harbour unfavorable attitudes towards the subject. Such unfavourable attitudes affect students’ academic achievement in a negatively.

To this end, it can be concluded that problems in reading, writing and arithmetic coupled with over-activity may not necessarily be caused by any mental disorder (Máki 2000). It has been shown that people link motor fluency with graspable objects when the orientations of the handles of the objects make them easy to grasp (Casasanto & Chrysikou, 2011). Faced with this reality and the bulk of everyday use instructional resources including laboratory apparatus oriented for right-handed users, left-handed learners have to adapt to use these apparatus. This adaptation is costly as it not only takes time but may be seen to decrease left-handers’ academic achievements.

According to Paul (2002), there are no standard systems to help left-handers and statistics shows that left-handers have more problems in the classroom than right-handers of the same age. Left-handed children might have problems in behavior if their difficulties are not noticed and they get no help. It is important that teachers notice situations where problems occur at an early stage. This is because solving these difficulties helps avoid learning difficulties later. This sequentially helps children to feel more protected at school and in everyday life and support their future academic development.

**CONCLUSION AND RECOMMENDATIONS**

A persistent theme in popular accounts of left-handedness is that left-handers are comparably more creative than right-handers. Various web sites have catalogs of well-known left-handers which demonstrate the popularity of this view. The intrinsic nature of left-handedness has made it draw minimal attention today. This has perhaps rendered it to naturally be accepted and integrated into the society. Despite this, left-handers have achieved immensity in numerous walks of life particularly in the political, entertainment, sporting and artistic fields where their natural aptitude for imaginative thinking and originality have made an enormous input to all our lives.

It can therefore be concluded that left-handedness is not an obstacle for cognitive development and not all left-handers experience difficulties (Paul, 2002). Nevertheless, learning difficulties are more recurrent in left-handers compared to right-handers. Left-handed children experience difficulties fundamentally in acquiring ideas expressing spatial discernment as well as responding to such discernments (Paul, 2002; Kove, 1997). Sequentially, learning to read and write is made more difficult just like the development of mathematical...
ability is distressed. Such disorientation in learning environment tends to draw the children to write from right to left, sometimes with mirror writing, reversed letters, numbers and symbols (Paul 2002). The fact that left-handers write in unnatural way means they cannot see what they are writing. They pull the hand over freshly written work, smudging it and often making it illegible and messy. Instead of pulling, a left-hander pushes a ball point as they write. That means the ball point pen stops up more because the ink does not flow as well. Left-handers will also more often lift their hand to see what they are writing. During timed tasks, this phenomena is not only tedious it also takes time and may result in the learners failing to complete tasks within the stipulated time.

Altogether the results indicate that left-handed people have been faced by more than their share of challenges in almost all spheres of life. It has been established that left-handers in comparison to right-handers benefit from long and intense training in sports because of being biologically predisposed. In professional music left-handers have to adapt to standard playing positions regardless of their objective handedness. In academics, mismatches resulting from sitting on awkward desks and sometimes on the wrong side of the classroom, to using tools that are intrinsically prejudiced as well as having to write left-to-right weigh heavily on left-handers. The adjustments left-handers have to make in order to fit more often than not cause back, neck and shoulder pains mainly because of the strange posture. A combination of all these have negative impacts on academic performance.

Left-handedness needs to be considered as a special learning need. Awareness on the existence of left-handed learners in the classroom ought to be highlighted at initial teacher training institutions as well as in-service teachers to bridge the already existing knowledge gap on left-handedness. Left-handers that are registered in subjects that require the manipulation of instructional resources meant for right handed users are particularly disadvantaged because these tasks are timed, especially during end of course examinations. When taking such tasks, left-handers ought to be allowed an additional few minutes so as to acclimatize themselves with the task environment. This essentially reduces anxiety during task taking. Further, every effort should be made to ensure that left-handers are as comfortable as can be generally in school and specifically in the classroom. This will ensure that any additional cognitive load is lowered to the minimum for effective learning to take place.

Present civilization is in favor of the right-handed. Left-handers demand modifications in ways that would take into consideration their functional diverse trait and expression of a more considerable tolerance. This is because handedness impacts learner outcomes and attitudes. However, being right- or left-handed should not be considered as superior or inferior, but rather merely different.

Needless to say, during teaching and learning, all individual differences need to be understood and factored in because in most classrooms, they not only exist, they affect learning. In tandem with the Education For All (EFA) goals and the Convention for the Rights of the Child Article 3 (1) which reads in part “… the best interests of the child shall be of primary consideration” (p. 2), it is the right of every child (left- or right-handed) to be treated fairly in educational settings despite their exceptional needs.

This literature review has highlighted some aspects associated with left-handedness for young learners in primary school to adults at college level. More longitudinal studies ought to be done to establish the progress from childhood to adulthood for left-handed individuals. This would help with testimony reliability and better assessment of the phenomenon.

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