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The Effect of Color Use in Designing Instructional Aids on Learners' Academic Performance

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Abstract

As a result of the rapid development in educational technology, the design of instructional aids has been gaining a lot of significance. To date, researchers have studied the effect of using instructional aids on the learners' academic performance, and a positive effect has often been proven. This study reviews and analyses existing literature and empirical evidence in relation to color use in designing instructional aids. Two major areas reviewed in the study are the Color Theory and the psychological and physiological impacts of color on learners. The results show that using colors in designing instructional aids plays an important role in enabling learners to concretize concepts and relations. Results also indicate that the effects of using color reflect on both the learners' and the teachers' emotional experiences. The results of the study may benefit educators, teachers, and pre-service teachers in designing the right and favourable learning environments for their teaching strategies.

KEYWORDS: Color, Instructional Aids, Academic Performance, Color Theory.

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1. Introduction

It is a rule of thumb that learners construct increasingly complex knowledge through the active involvement with the instructional materials and aids (Dienes, 1973). And colors are acknowledged to have a powerful effect that produces profound physiological and psychological reactions. Several studies have shown that there is a strong relationship between color preferences and academic performance in the learning environment (Boyatzis & Varghese, 1993; Imhof, 2004; Karp & Karp, 2001; O'Connor, Sofo, Kendall, & Olson, 1990; Terwogt & Hoeksma, 2001; Wilkins, 2003). A student-centered approach has been adopted, and the integration of teaching materials in the learning environment has been strongly emphasized. Thus, teachers, within this framework, are requested to use instructional aids in their learning environments efficiently enough to produce the intended effects (Billstein, et al., 2009; Gürbüz, 2010).

Using instructional aids in classroom situations has, recently, gained special significance in concretizing concepts and relations; it is proven to be an effective instructional strategy used specially to increase the learners' successful understanding of the concepts included in the content or the skills being taught (Sherman & Bisanz, 2009). And, as indicated in (Carbonneau et al., 2013), for the abstract concepts to be successfully understood, it is important that models be used. With the help of instructional aids, learners usually develop positive attitudes towards learning and, hence, instructors can easily arouse their interest, ensure their active participation, and enhance their critical thinking skills (Apperson et al., 2006). Therefore, instructional aids have become one of the most important instructional elements that enable learners to develop good conceptual understanding of the content or skills taught and to represent abstract concepts. Generally, in classroom situations and learning environments where abstract concepts (e.g., mathematics) are represented by different models, students are enabled to construct abstract understanding (Moyer, 2001). Learners are also

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enabled to associate these abstract concepts with their previous knowledge and experiences. As learners interpret their accumulated experiences more easily, it is important for them to construct their own abstract knowledge. Instructional aids are of great help in offering learners all these opportunities in spite of the

> *"practical and pedagogical issues in relation to utilizing instructional aids in the classroom situations makes it difficult for teachers to implement them effectively" (Ünlü, 2017).*

2. What does Research Tell us about Using Instructional Aids in the Classroom?

In the last few decades, and in our increasingly visual world, the use of instructional aids in creative and meaningful ways that help enhance learners' understanding has been greatly capturing researchers' attention. The increase in the number of educational institutions adopting instructional aids, esp. the technological ones, in the classroom environment has urged educators and scholars to find out which designs and which colors of instructional aids are the best and the most engaging.

Eulho and colleagues (2019) study explores which instructional design components influence learner control. The study revealed that all course design factors, transactional interaction between student and content structure and assessment, were significant predictors of learner control and sense of progress.

Yufi (2018) investigated the importance of Teaching Aids, and their role in the teaching process in teaching Arabic language at the University of Education, Indonesia. He found out that using the Teaching Aids, in teaching Arabic language, has a big role to make the teaching useful for non-Arabic speakers; it helps the teacher to be an investigator and an executor, It also assists to present, perform, control and verify the course in the education situation.

Lorkpilgh and Adalikwu (2017) identified the effect of educational aids on academic performance of students in the secondary stage. They found out that students who were taught with educational aids performed much better than those who were taught without educational aids. They also found that the use of educational aids enhanced the student's understanding of the concepts and, hence, led to better achievement.

Hassan (2016) identified the colors that kindergarten teachers use in coloring the educational aids they produce for kindergarten children. The teachers used 9 colors in coloring the educational aids that they produce manually for the kindergarten child. He discovered a statistically significant difference between the use of parameters for red in coloring educational aids and children's preference for it in favour of children's preference. He also noticed the presence of statistically significant differences between the use of parameters for green, brown, white and black on the one hand and children's preference for these colors on the other hand in favor the teachers.

Jennifer and colleagues (2015) explored the implications of technology transience on instructional design. They indicate that the impact on quality, currency, and effectiveness in the design of learning experiences needs to be considered in relationship to the ways technology changes the learning environment.

John and colleagues (2014) used the ratio of instructional theory and laboratory practice to define the learning context. They found that the use of the aid was not associated with any measurable gains for participants when used in year two.

Jan and colleagues (2013) examined design factors that may evoke positive emotions in learners and investigate the effects of these positive emotions on learning. They found out that well-designed materials induced positive emotions and facilitated comprehension, though transfer performance was not affected by emotional design. The study also found that warm colors alone did not affect learners' emotions.

Manthra and colleagues (2018) study investigated the effect of teaching aids on student's academic performance in professional courses. They found out that the majority of students are aware of teaching aids and that 94% of the students wanted teaching aids to be implemented in the lecture classes by professors.

Altakhaineh and colleagues (2020) examined the effectiveness of using colors and learner's intelligence quotient (IQ) in teaching new vocabulary in Arabic (L1) and English (L2) to children with autism spectrum disorder (henceforth, ASD). They discovered that the children's IQ played a crucial role in learning L1 and L2 vocabulary. They also found out that using colors had no significant impact on the children's performance in the test.

Ayoola and Adebule (2016) investigated the effectiveness of the use of educational aids on the academic performance of students in the subject of Alrabadia. The study showed that there was a difference of statistical significance in the performance between students who were taught using educational aids and those who were taught using traditional methods

Bakrawi and Husayn (2019) examined the introduction of teaching assets in teaching primary schoolchildren. They found out that Audio-based aids such as radio, cassette players, visual-based aids such as pictures, posters, maps and the globe were very effective. At the end of the study, the two students made a few recommendations, which may guide teachers and gain good results.

Apondi (2015) investigated the Impact of instructional materials on academic achievement in Mathematics in public primary schools in Sayaia County, Kenya. The study showed a statistically significant difference in children's performance between the control group and the experimental group.

3. The Role of Instructional Aids in Classroom Situations

Instructional aids help to reinforce and supplement the teacher's communication during the presentation of the lesson. In classroom situations, instructional aids can be presented in the form of physical objects or in a software form in a digital environment. So, instructional aids are classified into two forms: the physical form represented by solid materials, and the computer-produced form represented by digital materials (Burns & Hamm, 2011; Moyer, 2001). In classroom situations, manipulative materials are used for concretizing abstract concepts and relations being taught. Instructional aids, if used properly, help the teacher to communicate effectively by adding realism and substance to ideas, descriptions, and explanations being presented in the classroom situations. It should be pointed out that for an effective use of instructional aids in the classroom, a teacher must use appropriate procedures and techniques; i.e. the time as well as the method of introducing the aid in the lesson are very important factors.

Digital manipulations are computer-assisted instructions and web-based applications. And computer-based teaching can be accessed online. Hence, computer-assisted instruction is widespread in schools since materials are easy to access. Electronic aids enable teachers to integrate pictorial, verbal, and nonverbal representations of

Category	Findings	Source
Red	Connected with the base of the spine and motor skills	*Torrice & Logrippo, 1989* *Morton, 1998*
	Raised blood pressure Increased respiration	
	Fastened Heart beats Heightened sense of smell	*Engelbrecht, 2003*
	Associated with excitement and happiness Positive reaction - girls more positive than boys	
	High preference for 7-year-olds	*Terwogt, & Hoeksma 2001*
	Associated with anger, pain, happiness, and love in 4th graders	*Karp & Karp, 2001*
Blue	Favorite color for 7 and 11-year-olds	*Terwogt, & Hoeksma 2001*
	Correlates to eyes, ears, and nose – seeing, hearing, smelling	*Torrice & Logrippo, 1989*
	Favored by sight and hearing impaired children	*Torrice & Logrippo, 1989*
	Calming effect on heart rate and respiratory system	*Engelbrecht, 2003* *Torrice & Logrippo, 1989*
	Lower body temperature	*Morton, 1998*
	Reduced appetite	*Walker, 1991* *Morton, 1989*
	Positive reaction - girls more positive than boys	*Boyatzis & Varghese, 1993*
	Associated with sadness in 4th graders	*Karp & Karp, 2001*
Yellow	Chest, heart and lungs affected Favored by children with asthma and other breathing problems	*Torrice & Logrippo, 1989*
	Highly preferred by seven-year-olds Associated with honesty in 4th graders Most bright and shiny. In large quantities, irritating for the eye	*Terwogt,& Hoeksma, 2001* *Karp & Karp, 2001* *Morton, 1998*

Table 1 - Outlines findings, issues, and associations related to specific colors.
Categories, Issues, and Findings Related to Color (adapted from Gaines, K. S., & Curry, Z. D. 2011).

problems more easily. The main difference between physical and digital aids (hard and soft copy) is that physical aids are touchable (Karakirik & Aydin, 2016). So, while digital instructional aids help learners develop their flexibility manipulating them, physical aids help learners develop their psychomotor skills as they address the sense of *touching* (Olkum, 2003).

Instructional aids in computer-based education provide various opportunities for interactivity; learners can rotate, flex and reshape the object easily in virtual environments. With this respect, it is important for learners to interpret the concepts through real and concrete experiences. Burns and Hamm (2011), however, found only a few studies in support of the idea that web materials should be used more than physical materials. Likewise, Reimer and Moyer (2005) stated a similar finding:

> *"the only advantage of implementing web materials rather than or tangible materials is that web-based materials are easily accessible and they associate visual images".*

Thompson (1992) went even further when he reported that using instructional aids in classroom situations does not significantly affect students' success. Similarly, other researchers found no positive or negative effect of using instructional aids on students' achievement in mathematics, for instance (McNeil & Jarvin, 2007; Moyer-Packenham & Suh, 2012). In my opinion, it must, however, be emphasized that instructional aids cannot solve all problems of teaching; they can only make the teaching learning process more effective.

4. The Color Theory and Color Perception

An explanation of the Color Theory and color perception is important for shaping a better understanding of the pedagogical responses to color.

When sunlight shines on an object, its surface reflects the colored light. The reflected color/s is/are received through the receptor cells of the eye retinal wall (Morton, 1995). These retinal receptor cells absorb the hues and send messages to the brain, which, in turn, sends impulses to the major endocrine-regulating glands, causing some emotional and psychological responses (Nielson & Taylor, 2007).

The standard Color-Wheel Theory (Morton, 1995) is based on the standard Color Wheel composed of twelve colors. Red, yellow, and blue are the three primary colors, which cannot be formed by the combination of other colors. There are also three secondary colors, usually formed by mixing the primary colors, and six tertiary colors, that emerge from mixing primary with secondary colors. An unlimited number of colors can be obtained by mixing the twelve colors of the wheel along with white and with black.

Color has three basic attributes: hue, value, and saturation (Morton, 1995). *Hue* is another word for *color* such as blue, red, or yellow. *Value* is the relative lightness or darkness of a color. A hue may be lightened (by adding white), or darkened (by adding black). *Saturation* (also intensity or chroma) is the purity of a hue. A decrease in the purity causes the hue to be muted or dull (Morton, 1995).

Color is also classified according to visual temperature; half of the colors on the wheel are classified as *warm*, and the other half as *cool*. Colors associated with red and yellow are described as warm because they remind us of things like the sun and fire evoking a warm feeling. Cool colors, which are associated with blue and green, remind us of things like grass and water evoking a cool feeling.

How the eye perceives the color is usually influenced by the physical characteristics of the color itself and by the physical environment surrounding the color. Color perception is influenced by the different wavelengths; warm colors tend to advance in a space whereas cool colors tend to recede affecting the perception of depth. This visual temperature (the relative warmth or coolness of the color) may also be affected by the intensity (saturation) of the color (Nielson & Taylor, 2007). In general, preschool and elementary children prefer warm colors, and secondary students prefer cool colors (Engelbrecht, 2003). Color perception is also influenced by lighting; placing a blue painting under a bluish light (such as a cool LED light) will heighten the blueness of the painting. However, a red painting under a blue light will become dull and grayish because no red color waves are being made by the light. A study by Styne (1990) showed that a space painted with cool colors under cool florescent lighting resulted in spaces that seemed larger, quieter, and cooler. A space with warm colors under warm incandescent lighting resulted in a more active space that seemed smaller, warmer and louder. Such information provides useful insights when designing instructional aids.

5. Psychological and Physiological Reactions to Color

There are two types reaction to color: a scientific (physiological) reaction, and an emotional (psychological) reaction. Studies (Engelbrecht, 2003; Morton, 1998) conducted to investigate the physiological responses to color have reported changes

Category	Findings	Source
Physiological Differences	Color discrimination: Distorted along blue-yellow system with ADHD	*Banachewsk et al., 2006*
Physiological Reactions	Eye fatigue relieved Changes in blood pressure and brain development observed	*Engelbrecht, 2003*
	Color rays detected by eyes and skin Autonomic nervous system stimulated by bright war colors, but retarded by soft cool colors	*Morton, 1998*
Psychological Reactions	Colors can have an adverse effect on the behaviour of students with ASD Monotone environments create restlessness	*Shabha, 2006* *Gaines, 2008*
	Warm, neutral colors prevent overstimulation	*Engelbrecht, 2003* *Clay, 2004*
	Both blind and sighted children react to color	*Myler et al., 2003*
	Color preferences change with age	*Engelbrecht, 2003* *Terwogt & Hoeksma, 2001*
Mood	Subjects unable to screen environmental stimuli were angrier in an office painted white and depressed in the office painted red	*Morton, 1998*
Attention	Improved with colored paper Use of color improves attention Workers in offices with saturated colors reported more vigor – blue and green highest scores Easily distracted subjects scored lower in proofreading in a red office Subjects not easily distracted scored lower in a blue offic	*Imhof, 2004* *Zentall & Dwyer, 1989* *Engelbrecht, 2003* *Morton, 1998*
Productivity	Improved academic performance White and off-white environment less efficient	*Engelbrecht, 2003* *Morton, 1998*
Accuracy	Improved academic performance Improved in reading with colored lenses and overlays	*Engelbrecht, 2003* *O'Conner, 1990* *Imhof, 2004* *Wikins, 1996*
	Drop in accidents with the introduction of color	*Engelbrecht, 2003*

Table 2 - Summarizes physiological and psychological reactions to color.
Categories, Issues, and Findings Related to Physiological and Psychological Reactions to Color
(adapted from Gaines, K. S., & Curry, Z. D. 2011)

in blood pressure, eye strain, and brain development. For example, exposure to red causes the heart to beat faster, the blood pressure to increase, and the sense of smell to become stronger. In contrast, blue causes a slower pulse rate, a lower body temperature, and a reduced appetite (Engelbrecht, 2003). Psychological responses to color include changes in mood and attention span (Engelbrecht, 2003; Shabha, 2006). The brain releases a hormone which affects the mood, mental clarity, and energy level when color is perceived through the eyes (Engelbrecht, 2003). For example, pink may suppress aggressive behaviour in prisoners (Walker, 1991). Interestingly, color's impact is not limited to visual aspects since color wavelengths are also absorbed by the skin (Torice & Logrippo, 1989). Wohlforth and Sam (1982) also supported this claim in their study. Their findings show that changes in the color of the environment result in a drop of blood pressure and, hence, reduction of aggressive behaviour in both blind and sighted children.

6. Color and the Learning Environment

Some learners' responses to color are temporary while others' responses may last for a long period of time. In addition, many reactions are immediate (Morton, 1998). A number of studies have addressed the impact of color on the classroom environment (Engelbrecht, 2003; Grangaard, 1995; Imhof, 2004; O'Connor et al., 1990; Wilkins, 2003). But the findings of these studies are not consistent enough for determining the color choices to opt for in the learning environment.

Therefore, the following information serves to provide functional guidelines and explains the importance of color in the classroom.

The research conducted by Torice and Logrippo (1989) has shown that active children prefer cool colors, but passive ones are more comfortable surrounded by warm colors. Morton, 1995 concluded that color purity and contrast are more important than color temperature. In other words, a strong green may stimulate an individual as much as a strong red (Morton, 1998). Additionally,

color quantity should be considered in the physical learning environment; large amounts of color over-stimulate individuals regardless of the color temperature or preference. Verghese (2001) discusses the process of visual search and the attention span in regard to the Signal Detection Theory. This theory states that the human mind continuously strives to organize visual information. Too much color, motion, or pattern functions as distracters making this process of visual search more difficult. Thus, a stressful learning environment will result from excessive use of color. Studies by Shabha (2006) and Gaines (2008) explored the impact of visual environmental stimuli for students with special needs and in general education schools. Teachers were surveyed, and they determined that visual triggers (including lighting color) in classrooms have an adverse effect on the behaviour of students with disabilities. Some observed behaviours included staring at light sources, repetitive blinking, moving fingers in front of the eyes, and hand flapping. The outcome of these behaviours may lead to poor concentration, communication, and social interaction.

Grangaard (1995) explored the effects of color and light on learning for 6 – year old students. Off-task behaviour and blood pressure were measured in two environmental conditions. One classroom had white walls and cool-white fluorescent lights. Another classroom was modified with light blue walls and full-spectrum lights. Findings showed that off-task behaviours decreased by 22 percent in the modified room. Additionally, blood pressure readings showed a nine percent reduction in the second classroom. A study at Texas University in Austin (Kwallek, Lewis, Lin-Hsiao, & Woodson, 1996) was conducted using 675 college students. Test offices (the four walls and the door) were painted 9 colors; including red, white, green, orange, yellow, blue, beige, grey, and purple. Students were evaluated on the basis of task performance, mood, and color performance. Findings showed gender differences in color preferences; males preferred white, green, blue, and grey work environments and did not like yellow, orange, and purple spaces. Whereas females preferred green, red, and beige offices and did not like the grey and orange spaces. Overall, white, blue and green offices received the highest scores; purple and orange work environments were the least preferred. Gender differences regarding mood in different colored environments were also observed. More depression, confusion, and anger were experienced by females in spaces with low-saturated colors of white, grey, and beige. Males experienced negative emotions in high-saturated environments of green, blue, purple, red, yellow, and orange (Kwallek et al. 1996). Most participants stated they prefer to work in beige or white offices. However, more errors occurred in task performance in white offices than in blue and red workplaces. Characteristics should be taken into consideration while designing them in classroom learning situations.

7. Conclusion

In conclusion, the use of color can have a significant impact on the learners' mood, attention, productivity, accuracy, communication, classroom performance and their overall achievement. As the reviewed studies indicate, color affects our emotions and moods and stimulates our feelings either positively or negatively. Thus, learners' feelings about their learning tasks can be positively or negatively influenced by the introduction of color in the learning environment. Instructional aids are definitely an important element in an active learning environment. The proper use of color in designing these instructional aids has recently been gaining greater importance due to its educational value reflected in attracting learners' attention, stimulating their participation, and helping them to concretize abstract concepts. When choosing color in instructional aids, the functional aspects of color (i.e. the psychological impact of the color on the students' reaction), rather than the aesthetic ones, should be emphasized. The key to a proper and functional use of color in designing instructional aids is to take into consideration the learners' age and gender; the color's visual temperature and the surrounding environment; and the effect each color has on the mood and feelings. A study by Benjamin et al., (2000) concludes that, people subjectively feel that colors other than white and black are more pleasing and exciting; they are able to tell us so in their self-reports. This feeling, which is not reflected in the underlying meaning of emotion, may stem from some inherent quality of color. For instance, color could increase the iconicity of photographic representations and, thereby, elicit more powerful and positive emotional responses (Messaris, 1997). In light of the results of the previous literature, instructional aids

8. Recommendations

8.1 In designing their instructional aids, teachers should choose colors that promote comfort and inspire a good learning environment.

8.2 Since color is an integral part of children's positive perception of life, it is a good idea to use bright colors that stimulate them and motivate learning.

8.3 It has been proven that light colors such as yellow and blue elicit positive, lively and energetic feelings while dark colors such as black or grey elicit negative feelings of boredom, depression, and sadness.

8.4 The colors green and blue are usually associated with relaxation, calmness, peace, and comfort. So, they are great options for overactive or hyperactive children.

8.5 The colors red and orange have been known to cause anxiety in some children, so they must be used in small quantities for attracting learners' attention to some details.

8.6 The color pink is known to be a feminine and calming color; it promotes warm and comfortable feelings. So, it is a perfect choice for children with aggressive behaviour. But, like the red color, it must be used in small quantities because of its calming effect on the nerves, which may lead to physical weakness.

8.7 For certain children, the teacher is the best judge on what colors motivate learning. And in some cases, it would be fun to allow them to vote on it, or even take part in designing and producing the instructional aids.

8.8 When a combination of colors is used in one instructional aid, these should complement each other in a way that stimulates learning and not cause a distraction.

8.9 The key to creating a learning environment that is conductive to learning is to make sure that learners are not over-stimulated by the use of large quantities of bright colors, or over-tranquilized by the use dark or calming colors.

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