



Effect of Combined Teaching Strategies on Higher Order Thinking Skills (HOTS) of Biology Students

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Abstract *In this age of globalization, learning priorities of the learners have been under dramatic changes and teachers have to develop combination of such strategies which can engage the learners of the 21st century. The objectives of this study were to examine the effect of combined teaching strategies on low and high achievers' higher order thinking skills in biology at secondary level, conducted in a public school of Punjab province. The researcher used the combined teaching strategies which comprised of KWLH charts, hands on activities, multimedia integration and cooperative learning to cover the contents from 10th grade text book of Biology, for a period of 8 weeks. In this experimental research posttest only, design was adopted. The HOTS of biology students were assessed through 50 multiple choice items. After the intervention, experimental group exhibited promotion in HOTS of the biology students as compared to their counterparts. The results of t-test showed that these combined teaching strategies not only promote the HOTS of high achievers but were effective for the low achievers as well.*

Key Words: Teaching Strategies, Multimedia, higher order Thinking Skills, KWLH Charts

Introduction

Learners of this era, often called the digital natives (Halton, 2019) or the millennials, seem to be very fluent in using technology as a mean to their everyday existence. Even the low-income families support the idea of providing their children with android phones not only for communication purposes but also for gaming, surfing, reading, and other personal, educational, or entertainment-influenced activities. Including computers, televisions, and other technologies, these millennials seem to be provided with an influx of information which decades ago could only be accessible in largely bound encyclopedias, almanacs, and dictionaries in libraries. With the vast amount of information available to students, better learning skills are imperative to properly manage and utilize this information to produce more worthwhile outcomes and become better citizens contributing to the country's growth. They need to be trained to attain learning skills necessary in the 21st century (NCREL and Metiri Group, 2003).

Twenty first century skills include the major goal of fostering the HOTS in students and peoples are trying to attain this goal (Scott, 2015) by reforming their teaching methods, approaches and teaching strategies to engage the digital learners of 21st century who have been attracted from multiple dimensions. Creemers (2005), Eison (2010) are of the view that combined teaching strategies are helpful to improve higher order thinking skills (hereafter cited as HOTS) of students thus promoting their learning skills. Regular use of combined teaching strategies effectively enhanced their higher order thinking skills by challenging learners to take lessons actively. Ramos and Morales (2016) have also found that combined teaching strategies have significant effect not only on HOTS of low achievers but also on the high achieving biology students and recommended in their research to replicate this within different contexts. In another study, Zohar and Dori (2003) found that low achievers had higher gains than high achievers after the use of combined teaching strategies. In Pakistan, National Curriculum for Biology (2006) has focused on promoting scientific and higher order thinking of students by using variety of teaching strategies as it has become a challenge not only for advanced countries but also for developing countries like Pakistan to draw the attention towards thinking skills of the students. For better performance, students need not only lower thinking skills but also higher-level thinking skills (Yuliaty, Siti & Lestari, Ika, 2018) so that they can survive in today's challenging world of learning (Merta, Rosidin, Abdurrahman & Suyatna, 2017). The cognitive aspect of the learners is an important constructs of the 21st century skills (Kamisah & Neelavany, 2010) in fact better cognition is attributed to students exhibiting

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higher order thinking skills (Heong, Yunos, Hassa, Othman & Kiong, 2011) leading to enhancing their ability of learning, better speed, and more effective assimilation and accommodation of information (Ramos, Dolipas & Villamor 2013).

HOTS are rooted in Bloom's taxonomy and has been passed through different discussions in varied contexts as it is thinking about content, critical-cum-creative aspects, problem solving, formulation of creativity and communicating effectively (Collins, 2014). For promoting the higher order thinking skills in classrooms learners must be needed to know and comprehend so that they may be able to use information. For promotion of HOTS in classroom learners are needed to know and comprehend lessons so that they may be able to use information as self-direction, self-monitoring, self-disciplined and self-correction in the thinking and it stimulate higher order thinking skills of learners (Crawford et al., 2002). Through use of higher order thinking students can clarify concepts with better reasoning, use their own view points, predict something, implement their inferences to evaluate their concepts. For development of thinking skills another concept is cognitive acceleration (CA) rooted in the cognitive psychology of Piaget and Vygotsky. Cognitive acceleration focused on teaching strategies that challenge students' thinking through cooperative work and metacognition reflecting students' own thinking and problem solving (Shayer & Adey 2000).

Punjab School Education Department has been supporting the concept of e-learning by installing books of science and math on the website (<http://elearn.punjab.gov.pk/>). The use of relevant videos, audios, animations and simulations to support innovative strategies which can enhance the learning (Liaw, Wong, Chan, Ho, Mordiffi, Ang, & Ang, 2015), entrenched in the concept of blended learning and multimodal learning (combination of teaching strategies) which are useful to engage the digital learners of the 21st century (Eady & Lockyer, 2013). This concept of teaching with physical presence of teachers supported by videos, audios, animations, simulations and e-presentations was not commonly used in the past but it is gaining attraction and popularity in the present. It is being used for training of prospective and in-service teachers so that they may teach well and can improve cognitive skills of learners, who are being affected and attracted vigorously by social media in this global context (Bravo, Mosqueda, Solís, & Stoddart, 2014). In this regard throughout the globe, teachers have been using different teaching strategies which can enhance the higher order thinking with different perspectives and contexts (Creemers, 2005; Eison, 2010). These teaching strategies include using; "what we know, what we want to learn, what we learn, how we can learn (KWLH) charts, using multimedia, cooperative and collaborative learning strategies, encouraging questioning, developing concept maps, enabling students to infer by graphic organizers, for problem solving, inspiring for creative thinking, using minds on movies, teaching students to elaborate their answers, and teaching question-answer relationships (Cox, 2016). Literature has supported the use of multimedia for watching related videos, animations, simulations and e-presentations, hands on minds on activities, cooperative learning with the support of teachers in biology classes at secondary level (Ramos et al., 2016; Zohar et al., 2003). As Ramos et al. (2016) and Zohar et al. (2003) have also recommended to conduct research about effect of combined teaching strategies to promote HOTS of science students with different contexts.

Numerous teaching strategies had been reported in literature and Brookhart (2010), Collins (2014) and Ramos et al. (2013) had found varied teaching strategies and pedagogies that improve students' higher order thinking skill. These strategies include the use of graphic organizers, concept connections, use of minds on movies, problem solving (Cox, 2016), and web quest (Polly et al., 2009) and it was found that these strategies have increased the level of motivation and critical thinking capabilities of the students (Zohar et al., 2003). According to Creemers (2005) and Eison, (2010), different teaching strategies infused in a class may bring about combined effects leading to a holistic approach to enhancing HOTS, hence, the current research will use the following teaching strategies i.e. KWLH charts, Hands-on activities, and Multimedia integration through cooperative learning for fostering the higher order thinking of students.

KWLH Chart is an instructional tool for activating students' prior knowledge before teaching. KWLH chart is about a topic or a subject which encourages active learning and acquisition of knowledge. It acts as important as pre reading strategies before reading and expository text, or some time may be used for a topic as assessment as what students have learnt in a topic or a unit. These abbreviations are explained as; K represents for previous knowledge; W represents want to learn, L for what students learn, and H stands for how students can learn. These are helpful for students to be active thinkers (as cited by Ogle, 1986). KWLH charts are helpful for self-reflection about specific thinking, and regulation of cognitive thinking of the learners. Flavell (1979) has described it as self-awareness and thinking about thinking. Researchers like Hershberger, Zembal-Saul and Starr (2006) concluded that these are useful for engagement of students during science lessons and are helpful for triggering the HOTS not only of high achievers but also for low achievers (Ramos et al., 2016). In this way KWLH charts are helpful to develop questions about the topic which they are going to learn and hands on, mind on activities are tasks that engage students' physical as well as mental skills for problem solving. It enables students to solve the problem through prediction of the results.

Hands on activities are helpful for students' better understanding to construct their own meaning by improving growth of mind and learning which takes place on personal experience. During hands on activities learning occurs through discovering, creating or interaction and discussion. Students become able for decision making and more interactive learning takes place through personal experience (Cooperstein, Kocovar & Weidinger, 2004). For the completion of hands on

experiences, they have to access for their local library, print and electronic media to create and generate new ideas through brain storming. By doing such activities learners always feel comfortable to do and improve mistakes time and again. Jodl and Eckert (1998) are of view that low cost gadgets are used for hand on activities. It leads to their suitability while mind on activities tasks are turned on minds on activities help and encourage thinking process and ability to create questions (Ramos, et al. 2016).

Multimedia is the combination of videos, animation, simulations, text, images and sounds which is being used as educational technology. It helps the learners for linkage, navigation, retrieve information store in a infuse form of a text video graphic (Lambert & Cuper, 2008). It can be used as an instrument in more a creative way. Within our brains transformation of data into information takes place through the multimedia (by reading a text, by listening in conjunction). As there is an odd saying, "a picture is worth than a thousand words" which is best depicted in case of using multimedia (videos, audios, animations).

In the educational process cooperative learning is a systematic pedagogical strategy which is useful for the achievement of objectives more efficiently (Vijayratnam & Phawani, 2009). Proponents of cooperative learning strategies, Paul, Richard, Elder and Linda (2006) argued that cooperative learning develops interpersonal and communication skills besides with effective learning. According to Vijayratnam and Phawani (2009), learning cooperatively in small groups is an efficient instructional method and active learning pedagogy of teaching in solving scientific problems. Education is a social and informal process by which learners exchange their ideas through individual participation and activities (Kagan, 2009) and cooperative working in teams are interactions that improve deep learning of concepts. Cooperative learning techniques are known as more reliable, acceptable and most general for learning. Teacher can play a key role as a facilitator in the process of learning. Cooperative learning increases self-esteem and interactions with each other through high communication skills and decreases anxiety and stress (Erdem, 2009). In implementation of cooperative learning incentives, praise, reward and appreciation are given to the best teams, and moreover helpful or unhelpful activities and pleasant or unpleasant experiences are identified by self-reflection. Implementation of cooperative learning direct the learning activities for future planning. Therefore, the use of cooperative learning engages learners for making deeper connections among facts, concepts, and ideas which can enhance the HOTS of students (Jayaprabha, 2013).

According to meta-analysis by Higgins, Hall, Baumfield and Moseley (2005) one study was conducted for development of thinking skills in Pakistani scenario by Iqbal and Shyer (2000) at secondary level. After that Siddiquah (2009) focused on promoting thinking skills in science at early childhood level. In Pakistan passing percentage of students at secondary level is high in science subjects but they are performing low in national assessment and in competitive exams (PMS & CSS, reports 2014 to 2018 in Pakistan) in which mostly questions are based on HOTS which are being ignored in traditional classrooms with chalk and talk methods (Pakistan National Curriculum for Secondary School Biology, 2006). Rote memorization is being promoted only for number games and the process of thinking with application analysis, synthesis and evaluation (HOTs) has been ignored. In Pakistani scenario the age of secondary school students is approximately between 13-16 years which is logical reasoning stage (12 years to onward as cited by Piaget in his age stage model). At this stage HOTS should be promoted through combined teaching strategies not simply by using chalk-talk methods as Ramos et. al. (2016) and Zohar et. al. (2003) found that regular use of combined teaching strategies (KWLH Charts, Hands-on, activities, and multimedia integration) in secondary school science class rooms, have effectively developed their HOTS by challenging them to learn science lessons effectively and recommended to study the effect of combined teaching strategies on endorsing these skills with different contexts. Brookhart (2010), Collins (2014), Polly and Ausband (2009), Ramos, Dolipas and Villamor (2013) and Thomas and Thorne (2009) are also of the view that higher order thinking skills can be improved and promoted by a variety of pedagogy and innovative teaching strategies like use of graphic organizer, concept mind, hands-on, minds-on activities, mind on movies and problem solving (Cox, 2016), and web quests (Polly & Ausband, 2009). Zohar et al. (2003) and Ramos et al. (2016) have found that effective teaching strategies not only benefit the high achievers but also improve the low achievers by motivating and developing higher order thinking skills.

In the global scenario, the major issue of 21st century is the engagement of the learners in a meaningful way (Scott, 2015). The teachers have to adopt such interesting strategies like use of KWLH Charts, hands-on, minds-on activities, multimedia (e-presentations, audios, videos, animations and simulations) and cooperative learning which can engage the modalities of the digital generation for the promotion of their higher order thinking skills. Since in the past, the promotion of learners' higher order thinking skills through innovative teaching strategies was not taken into consideration especially for science students in a developing country like Pakistan, despite of emphasis in the National Curriculum (2006) of Biology, quality education in National Educational Policy (Government of Pakistan, 2009). So far no substantial studies have been done in Pakistan for the fostering these thinking skills in science among students at any level, regardless of the fact much emphasis in the national documents (NEAP, 2009 and National Curriculum, 2006) it is still being neglected in Pakistani class rooms. It seems to be very promising and sensitive to do research on the importance of these thinking skills, recognition of its needs at crucial age (secondary level) generated the strong rationale of the present study. Thus, by finding the gap in the existing

literature the present study focused on “Effect of Combined Teaching Strategies on 10th grade Students’ Higher Order Thinking Skills in Biology.”

Research Objectives

The objectives of this study were to;

- (i) examine the effect of combined teaching strategies on students' higher order thinking skills.
- (ii) investigate the effect of combined teaching strategies on the higher order thinking skills of low achiever biology students.
- (iii) determine the effect of combined teaching strategies on the higher order thinking skills of high achiever biology students.

Null Hypotheses

1. There is no significant difference between the mean scores of experimental and control groups on post-test.
2. There is no significant difference between the mean scores of low achievers of experimental and control groups on post-test.
3. There is no significant difference between the mean scores of high achievers of experimental and control groups on post-test.

Research Method

This experimental research investigated the use of combined teaching strategies to enhance students’ higher order thinking in Biology at secondary level. The dependent variable was students’ higher order thinking skills while combined teaching strategies were the independent variable and quantitative method for data collection was used. The population in this research comprised of the male students enrolled in 10th class of public schools and one public school was selected through convenient sampling (Gay, 2000) for this study. A sample of sixty 10th grade, biology group students were randomly selected. Prior permission was taken from principal of the institution to conduct the study. Students were randomly assigned to experimental and control groups. These groups were equated on the basis of their scores in 9th grade Biology in Board annual examination. Each group consisted of thirty (30) students. Combined teaching strategies (KWLH charts, Hands on Minds on activities, multimedia and cooperative learning) were used in experimental group while other group used traditional teaching strategies (chalk and talk).

Research instrument

Different types of rubrics can be used to assess the HOTS of students which are available in different forms of essay and MCQs type items. According to Bloom, the items consist of questions of low cognitive level which form the understanding level and questions of high cognitive level which form the application, analysis, synthesis and evaluation level. In social science research, multiple choice items can be used to evaluate HOTS (and lower order thinking skills in various ways (Zheng, Lawhorn, Lumley & Freeman, 2008). Students need to master at least the understanding level of the relevant concepts to answer questions of high cognitive level. Hence, for assessing the subjects’ HOT skills of the sample the researcher used MCQS type items for the post-test. The researcher constructed the test based on content from three units of 10th grade Biology due to their major role for linkage to previous grades (Science Textbook for Grades IV & VII) and next grades (Biology XI-XII) as cited in Biology National curriculum 2006 and their weightage in external exams by BISE Lahore. The question paper was validated through experts’ opinion. For the validation of the test, experts (from the field of biology, experts of biology education and two paper setters) were approached and the test was finalized after their suggestions. Its pilot testing was done before its use as post-test. The test consisted of 50 MCQS type items to assess HOTS (Gronlund & Linn, 1998) having fifty marks. Sabu (2018), Ramos et al. (2016), and Zohar et al. (2003) have also used MCQS items for the assessment of HOTS of biology students. Moreover, the researcher conducted the post-test on the same day and time to the control and experimental group.

Research Design and Procedure

Researcher used the posttest only equivalent group design which seemed appropriate for this research. Experimental and control groups were randomly selected from the total available sample. Students were randomly assigned to these groups. The groups were equated through previous achievement in 9th grade Biology through paired random sampling. Moreover, the treatment duration was 60 days (2 months) which control the mortality. Control group was taught with the help of white board, text book, blue and red markers and exercises from the text book. They were given home task from the exercises of

the text book in a traditional way and their work was also checked and discussed regularly. Experimental group was given treatment of independent variable (use of combined teaching strategies). For every start of the lesson, they were asked to fill the first two columns of KWLH charts as practiced in the orientation session. The purpose was to take warm up activity of prior knowledge of the students with respect to lesson taught. They were taught through multimedia (videos, simulations and animations), hands on minds on activities by dividing them in small groups (cooperative learning). The researcher made the concept of the students from the text book watching videos, animations, simulations and getting firsthand knowledge through the hands-on minds on activities with in small groups (cooperative learning). At the end they were asked to fill the last two columns of the KWLH charts. The students were asked oral, written challenging questions for practice. The KWLH charts were checked for formative assessments and feedback to get the follow up of the students.

Analysis of Data

Table 1. Post test scores difference between Experimental group and Control group

Group	N	Mean	SD	t	p	Effect Size
Experimental	30	41.47	5.716	7.187	0.546	1.86
Control	30	30.40	6.201			

*p<0.05

Table 1 showed that there was a significant difference in the posttest scores of experimental group (M=41.47, SD=5.716) and control group (M=30.40, SD=6.201) at p<0.05 with effect size 1.86. The value of effect size was more than 0.2 which is not negligible (Cohen, 1988) thus leading to conclusion that students in experimental group taught with combined teaching strategies have higher level of higher order thinking skills as compared to those taught traditionally. It shows that students' higher order thinking skills in experimental group were high as compared to students' higher order thinking in control group. So, there was significant difference in the mean scores of experimental and control group students on posttest.

Table 2. Post test scores difference between low achievers of Experimental group and Control group

Group	N	Mean	SD	t	p	Effect Size
Experimental	6	33.83	3.545	6.690	0.507	3.56
Control	8	22.38	2.875			

*p<0.05

Table 2 showed that there was a significant difference in the posttest scores of low achievers of experimental group (M=33.83, SD=3.545) and control group (M=22.38, SD=2.875) at p<0.05 with effect size 3.56. The value of effect size was more than 0.2 which is not negligible (Cohen, 1988) thus leading to conclusion that low achievers' students in experimental group taught with combined teaching strategies have higher level of higher order thinking skills as compared to those taught traditionally. It shows that students' higher order thinking skills of low achievers in experimental group were high as compared to low achievers' students' higher order thinking in control group. So, there is significant difference in the mean scores of low achievers of experimental group and control group students on posttest.

Table 3. Post test scores difference between high achievers of Experimental group and Control group

Group	N	Mean	SD	t	p	Effect Size
Experimental	11	46.91	2.625	10.388	0.781	4.429
Control	11	35.55	2.505			

*p<0.05

Table 3 showed that there was a significant difference in the posttest scores of high achievers of experimental group (M=46.91, SD=2.625) and control group (M=35.55, SD=2.505) at p<0.05 with effect size 4.29. The value of effect size was more than 0.2 which is not negligible (Cohen, 1988) thus leading to conclusion that high achievers' students in experimental group taught with combined teaching strategies have higher level of higher order thinking skills as compared to those taught traditionally. It shows that students' higher order thinking skills of high achievers in experimental group were high as compared to high achievers' students' higher order thinking in control group. So, there is significant difference in the mean scores of high achievers of experimental group and control group students on posttest.

Conclusion and Discussion

It was concluded (from the table1) that experimental group have higher level of HOTS as compared to control group which is in alignment with previous results of Zohar et al., (2003) and Ramos et al., (2016) who used combined teaching strategies and found their significant effects on students' higher order thinking skills. This means that positive change in the performance of the participants seemed to be propelled by the intervention provided. Apparently, positive change in the

students' performance may be attributed to the improvement in their thinking skills as evidenced by the fact that all items fall in the cognitive learning domains (applying, analyzing, evaluating, and synthesis) classified under the higher order thinking level. Pogrow (2005) develop a program for students in grades 4-8 with low achievements that was based on a set of thought-provoking approaches for disadvantaged students. In this program combine use of Socratic method, role playing, and multimedia resulted in gains of scores for HOTS of low and high achievers. Veselinovska, Gudeva, and Djokic (2011) used 3 teaching methods (Laboratory method, multimedia and lecture method) to promote the cognitive skills in biology and found positive effects of these sequential teaching methods. Similarly, the findings showed that low achievers of experimental group have gained higher level of HOT skills with respect to low achieving students of control group. It was also alike to the results of Ramos et al. (2016) who also found that combined teaching strategies not only benefit the high achievers in biology but also improve the low achievers by motivating and developing higher order thinking skills. In another study, Zohar et al. (2003) also found that low achievers in biology benefit more than higher achievers to foster their HOTS during a Thinking in Science Classrooms (TSC) project in which combined teaching strategies. Likewise, that high achievers of experimental group have higher gains in HOT skills as compared to control group which was like the findings of Zohar et al. (2003). Brookhart (2010), Collins (2014), Polly et al. (2009) and Ramos et al. (2013) found varied teaching strategies and pedagogies that improve students' HOT skills. These strategies include the use of graphic organizers, concept connections, use of mind movies, problem solving (Cox, 2016), and web quest (Polly et al., 2009). Researchers found that these strategies assisted the disadvantaged students and have increased the level of motivation and critical thinking capabilities of most students. Students having different academic achievement in biology received significantly from these interventions. In contrast to the previous findings, empirical evidence showed students are more likely to benefit equally from instructions used for HOTS.

Zohar et al (2003), in 4 projects designed for promotion of HOT skills, concluded that higher academic achievers achieved higher gains in HOTS than their lower achiever peers. But in both groups students showed significant improvement in their initial scores. Further, results in one study of the project lower achievers' net gains were significantly higher than their counter parts. In a Biotechnology class Dori et al. (2003) found that students categorized as low achievers scored higher than higher achievers. These findings agree with the findings of Raudenbush et al. (1993). In other subjects, the use of combined teaching strategies have also showed positive effect on thinking skills of students as Arpacioğlu (2007) revealed that combined strategy instruction had a positive impact on thinking skills of students in seeking second language and recommended that it must be replicated for low proficiency students. But commonly, teachers believe that high-thinking task is only relevant to high-achievers while low-achievers who rarely pass the basics may not be able to cope with such tasks (Zohar, Degani & Vaaknin, 2001). These conclusions emphasized that teachers should inspire all academic-level learners to engage in highly complex thinking tasks equally.

The KWLH charts have developed the HOTS of students as the K component of the chart allowed the student to critically recall their prior knowledge and connect it to the current topics discussed in the classroom. Additionally, the W component enhanced the students' ability to formulate higher order thinking skills questions as most of their questions were on the how's and why's which Cox (2016) considered as an effective strategy to enhance students' higher order thinking skills. The L and H components of the chart helped the students to reorganize their ideas about the topics and gave them options on how the lessons they had in the classroom would be used in their daily lives. The last two components provided means for the students to exhibit the skills in cognitive learning domains such as applying, analyzing, and evaluating—constructs in the learning domain classified as higher order thinking skills (Anderson, et al., 2001). Accordingly, teaching strategies used in this research matched the strategies specified by Cox (2016) that effectively enhanced HOTS of students: teach to infer, teach to elaborate students' answers, encourage questioning, connecting concepts, investigating, and using graphic organizers, such as tables. Additionally, the students perceived the intervention to be enjoyable, engaging, and memorable because they were challenged, and they are encouraged to be cooperative in finishing the tasks (minds-on hands-on). Agreeably, these positive emotions generated while using the interventions lead to a fear-free environment (Caine et al., 2005).

The results of this research may contribute to the growing needs to enhance thinking skills through combined strategies, especially among grade 9 low performing students. For the entire duration of the experiment, the teacher-researcher utilized the combined strategies and gathered data using the different forms of assessment to detect how these strategies enhanced the thinking skills of the students. As discussed, the regular use of combined teaching strategies has effectively developed the students' higher order thinking skills in biology. Additionally, the combined strategies helped the students to organize their thoughts and make meaning of the lessons they are learning in the classroom. Finally, the utilization of various strategies, especially when they are being used at the same time bring excitement and challenge to the students to learn the lesson, thus, making them on task all the time. These positive outcomes of the intervention may be benchmarked and emulated by other teachers to develop better thinking skills and more student engagements. However, it may not be enough for teachers to depend on the process used in this study, since the intervention was found to be successful only in this study. It is recommended that teachers check on the learning styles and attributes of their respective students to determine which combined strategies best fit their classes.

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