Chapter 13
Correlating Universal Design of Learning and the Performance in Science at Elementary School Level

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Abstract Recently, we have been relying greatly on technology and scientific advancements in every filed of life, therefore, a science class must include scientific literacy regardless of gender, social circumstances, interests, learning styles or learning difficulties without any barriers. A barrier to learning is anything that hinders the way of a child being able to learn effectively. A learner may experience one or more barriers to learning throughout his or her education. A teacher needs to have a number of options for methods s/he can use to deliver the lesson to the pupils. If a single method is used to deliver the content to diverse learners it might create barriers and all pupils may not grasp the concept thoroughly. When teachers preplan their lessons with respect to three principles of Universal Design of Learning (UDL) framework, its guidelines, and network of brain associated with each principle using blended learning approach, it helps eradicate the barriers and provide inclusive learning environment to improve learner's academic performance. Science teachers need to preplan their lesson using multiple means of representation, assessment and engagement for inclusive educational environment. Therefore, the present study aims to investigate the impact on learner's academic performance when a teacher uses Universal Design of learning framework for planning Science lesson. The unit of food and health from the national curriculum for General Science of

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Pakistan was selected for experiment for the elementary grade pupils. UDL, a framework based on the constructivist theory, built on cognitive neuroscience emphasizes on engaging multiple brain networks by providing guidelines organized into three essential principles. This framework condemns the teacher-centered methodology where teacher's lesson plan does not cater the needs of all pupils and advocates the learner-centered approach, where pupils are provided with various ways to understand learning content, express what they have learnt and stay engaged during the learning process. To evaluate the effectiveness of the UDL based lesson implementation in science, a quasi-experimental pre-test post-test design was used in the study. The UDL compliant lesson plan was also mapped with UDL principles, guidelines or checkpoints. Participants of the study were fourth grade pupils (N = 60) of private school in capital of Pakistan with age ranges between 8 and 11 years. Through experimental study, it was found that elementary grade pupils perform better in science when taught using universal design of learning approach in contrast to those who have taught using traditional teaching method. The finding also discovered that there are similar check points within the UDL framework, therefore, during the mapping of pedagogical strategies (method, materials and assessments) with checkpoints, overlaps were observed.

Keywords Universal design of learning · Framework · Principles · Pre-test · Post-test · Elementary grade · Curriculum integrated

13.1 Introduction

A barrier to learning is anything that stands in the way of a child being able to learn effectively. A learner may experience one or more barriers to learning throughout his or her education. These barrier impact negatively on learners' interest in their studies and may lead to increase in dropout rate. Providing an engaging learning environment by cognizing and eradicating learning barriers is challenging for educators. When teacher defines goal and decide a single path to achieve the goal then it will not be possible to incorporate all kinds of learners with different needs. To achieve a defined goal, the teacher selects certain materials which will be used to deliver the content of lesson. The teacher needs to have several different flexible media in order to effectively deliver the lesson to the pupils. If a number of options are not provided in terms of materials all pupils might not grasp the concept thoroughly. Then it might create learning barriers and adversely influence learners' interests and academic performance. The teacher needs to have several different flexible media in order to effectively deliver the lesson to the pupils. All pupils have different needs, interest and different ways of expressing themselves so it's important for a teacher to have multiple ways for engaging and assessing the pupils.

Universal design for learning is an approach towards learning with the aim to design lessons, which are inclusive and effective for all. UDL is a framework based on the constructivist theory, built on cognitive neuroscience which emphasize on

engaging multiple brain networks by providing guidelines organized into three essential principles i.e., Multiple means of representation, engagement and assessment [2]. These principles advise the design of inclusive curriculum [23].

Most of the pupils in a classroom have gaps in their previous knowledge. When the concepts are built on a prior knowledge, it is more likely to be assimilated. Scaffolding like pre teaching the vocabulary [5], use videos or illustrations and explaining difficult concepts in small easy part can help pupils learn easily. For the proactive preparation of engaging, accessible instructions in a classroom with diverse learners, Universal Design of Learning (UDL) is a valued tool [48]. UDL principles help us to know an individual's strength rather than their learning difficulties by providing multiple means of representation, engagement and assessment. Inclusive practices in science classroom make pupils with learning difficulties more confident so that they can feel comfortable in sharing their ideas with peers and teachers and keeps them engaged in the class activities. Developing countries today are incorporating technology in their classrooms for better understanding of concepts through videos and internet resources which are used by pupils and teachers both [38]. Moreover, it provides more options to include all kinds of learners in a single classroom which is the basic goal of UDL. Learning barriers can also be identified with respect to three principles of UDL and network of brain associated with each principle i.e. (a) recognition network, (b) strategic network and (c) affective network.

13.1.1 Recognition Network

Recognition network is associated with principle of representation. This principle states that you have to provide multiple means of representation so that all the pupils with diverse backgrounds and needs can grasp the concept well. The representation of a particular content in the class in one particular way cannot deliver the content meaningfully or in an effective way. Pupils with diverse needs and backgrounds may face barriers which can make understanding of concepts difficult and result in poor learning outcomes.

Today we rely so much on technology and scientific advancements so a science class must include all the pupils to develop scientific literacy regardless of their gender, cultural background, social circumstances, learning styles or learning difficulties [4]. It is widely suggested that online technologies can help address issues of educational equity and social exclusion [22]. When teachers use UDL framework, they mostly incorporate technological assistance for multiple means of media and tools. For example, teachers can show video before reading and then use graphic organizers to categorize the new information. In this way though UDL principle of representation teacher provide various ways to explain and present new knowledge. This provides learners opportunity to interact with content in various ways, which help cater diverse learners in classroom.

13.1.2 Strategic Network

Strategic network is related to how the pupils will express what they have learned. If they are not provided with enough means of expression, it is quite possible that they end up failing to express the knowledge they have gained. While few learners are able to express and answer question successfully when traditional assessments techniques are used i.e., text book question or paper pencil assessment approach, but several learners answer haphazardly. Therefore, educators target needs to have learners express the understanding of main ideas identified in the learning objectives [48]. It is therefore extremely important for a teacher to provide the pupils with multiple means of action and expression. To express the knowledge, pupil can be given choices such as make a presentation using PowerPoint, write a poem, short story, slogans, make poster or painting, use tape recorder to record oral responses, essay or orally give answer themselves etc. this way learners will be able to express their knowledge successfully and participate despite their learning challenges [43]. This let learners to demonstrate the knowledge with respect to their learning preferences. Providing choices is not just about providing varieties of activity and differentiation, but most vital is that learner's metacognition evolved by focusing on their own learning assets [48]. The above-mentioned ideas for assessment can be used and adapted with respect to the content and rubric must be provided for communicating the expectations of teacher from learners. When learners are able to select form broad choices of authentic formats, they are able to express with respect to their strengths and feel more comfortable with assessment. Teachers also need to be prepared and have familiarity of the differentiated techniques required implement the framework effectively [13].

13.1.3 Affective Network

It is extremely important for a teacher to develop the interest of pupils in what they need to learn. If they will not be interested in the content of a lesson they will not be motivated to learn. This might result in poor concentration and learning outcomes. To avoid such kind of barriers a teacher needs to provide pupils with multiple means of engagement. These barriers are associated with affective network of brain. This is about how learners feel about the content they learn. One way that this principle suggest is to reduce threat that learners feel or may feel during work such as answering in front of peers, reading aloud, work in noisy or crowded environment when concentration is required for the work. To decrease these threats, teachers can allow them to take small breaks and allow learners to 'say no' to reading aloud or answering in front of class fellows, instead provide them chance to answer in a written form or to teacher during break time. Additionally, allowing learners choices such as to work alone, in pair or group of their own choice when feasible also motivate them and keep them comfortable. Furthermore, grading in detail such as grading for

expression of content knowledge and rewarding remarks for effort helps enhance engagement and motivation. In general education classroom for pupils with special needs, effective tool for successful inclusion is to grade for process and product distinctly [47].

The present work considers learning through UDL framework as a remedy to learning barriers that limits the provision of inclusive educational experience for learning science. The UDL compliant lesson plan was conducted with aim of investigating the research question of whether the UDL compliant Science lesson is more effective to have better learning gain in contrast to traditional Science learning. For this purpose, quantitative method, pretest posttest quasi experimental technique was used. The learning gain refers to the increase in academic performance of learners after experiencing UDL based educational environment as compared to conventional teacher-based methods of book and worksheets.

13.1.4 Research Question

The study was designed to focus on following research question:

RQ: Is there a positive impact of instructions strategy based on framework: Universal Design of Learning on pupil's academic achievement?

13.2 Literature Review

To enhance the accessibility, interests and engagement for science in classroom, it is critical that teacher recognize and address barriers that excludes learners from accessing the quality education. At elementary level, having a personal association to science is essential for both teacher and learners as they have fewer science exposure in daily life and also a dislike for it Roychoudhury [44]. Literature reviewed showed that there can be barriers related to goal setting in a science class i.e., pupils do not know why they are learning and what the role of science in their daily lives is Williams et al. [53]. This leads to rote memorization of the textbook where teacher comes to the class, reads book but this method of teaching is not effective especially in science class [24]. Williams, Papierno, Makel and Ceci, described that there must be a link between pupil's lives and the content they are studying so that they can think scientifically about their environment and this will keep them engaged [53].

A basic purpose of science is to construct representations that have analytical and investigative power, where such goals are supporting in daily knowledge growth. Roychoudhury advised that the science is required to be grounded in everyday experiences, so pupils develop the sense from their experience of learning science (2012). When pupils' needs are responded it helps to address learning barriers [14]. Therefore, teachers require professional training that promotes thinking, talking and doing science in classroom [29, 44]. Thinking in science advocates using commonly

accepted concepts which may be solved through collaborative group learning in which pupils will brainstorm ideas and discuss it with teacher. Pupils are often not being able to express scientific ideas. This can be overcome through collaborative talks and use of multiple media and tools to express ideas of science as promoted in idea of talking in science. Not being able to carry out experiments is the biggest concern of learning science and doing science. Provide pupils with multiple options of performance is the solution [29].

Another serious difficulty, which pupils might face in science is misconceptions that needs to be treated very seriously. Misconceptions are those early perceptions based on personal experiences, that are not in line with the scientific theories [8]. Pupil's naïve theories may interfere with their capability to understand Science concepts adequately [37] and if clarification is not provided it stays in pupil's minds. There are diverse pupils in science class with different preconceptions and a teacher must consider those pupils who have misconceptions about the lesson and without clearing them, pupils cannot build new knowledge on those misconceptions [19]. Wahyuningsih, Rusilowati and Hindarto, mentioned that teachers are often unable to identify that pupil's academic performance in science is adversely impacted because of pupil's misconception or misunderstanding [52]. According to Pine, Messer and Jhon teachers rated one third of science topics as abstract and difficult, also identified more than hundred misconceptions that pupils have in primary Science curriculum (2010). Teaching approaches that provide well scaffolded instructions and constant formative assessment takes account of learner's prior knowledge and misconceptions [14]. While representation of knowledge, teacher needs to identify misconception and address them timely through query-based technique, discussion or preassessment in classroom [52]. Franke, Scharfenberg and Bogner, suggests that constructivist pedagogical approach can help change the pupil's misconceptions in favor of scientific conception [19].

Lemke states that leaners are not taught how to talk in science, which is required to discuss, explore, investigate or express science in writing [29]. Pupil have difficulties to describe or use the scientific terms when explaining scientific concepts, thus poor Science vocabulary is another barrier mentioned in literature [6, 19, 31, 41]. Learning science means learning complex vocabulary meaning some words are unfamiliar to pupils and some are used specifically in science, which can be a barrier for many pupils [41] because thinking and talking in science is very important and thinking requires language [53]. Franke, Scharfenberg and Bogner found that 52.8% pupils failed to deliver appropriate concept for the scientific term e.g., enzymes [19]. Pupils are often not being able to express scientific ideas. Moreover, Science vocabulary is challenging for both native English speakers and English language learners because several terminologies are uncommon [21]. This can be overcome through collaborative talks and use of multiple media and tools to express ideas of science using scientific vocabulary [1]. Lemke advised that to learn Science language, one needs to speak it with those who mastered it and use it during learning process [29]. Therefore, they advised that teachers need to use suitable strategy by introducing and describing the scientific terms clearly with emphasis so pupil use them appropriately [19]. For example, text book reading sessions [21], discussion-based approach with

emphasis on science terms [1], use of collaborative work with scaffolding i.e., visual aids, flash cards, graphic organizers [21]. However, it is not merely using the vocabulary but to learn how to associate the meanings of diverse terminologies with respect to accepted ways of talking science [29]. Brown and Concannon advised the literacy strategies to support Science learning including learner's perceptions of vocabulary knowledge and associate it with significant content achievement [6].

To eradicate all the barriers to learning, teacher tries its best to make the course accessible for varying needs and strengths. Universal Design for Learning is an effective framework and provide distinct set of guidelines that support teachers to plan lessons that is accessible for all pupils in the classroom [10]. Literature suggests that when teacher plans the lessons using the framework, it helps to eradicate the persisting barriers in curriculum and allow learners to access and engage in curriculum [16, 24]. UDL popularity in recent years as pedagogical approach to fulfil the learning need of all the pupils with diverse abilities is substantial [25]. UDL is a framework based on the constructivist theory and built on cognitive neuroscience which emphasize on engaging multiple brain networks [2]. UDL framework is based on three main principles to eradicate learning barriers i.e. (1) Multiple means of representation, (2) Multiple means of action and expression and (3) Multiple means of engagement [35]. Science is all about concepts and constructing new knowledge over prior knowledge with experiences or experiments. According to Singh and Yaduvanshi, learners actively construct knowledge in the science classroom by actively participating in the classroom, brainstorming, group discussions and experiments, [46]. Clearly stating the purpose of the undertaking Science problem is vital [53] which is one of the basic guidelines of recognition network. UDL principles help us to know an individual's strength rather than their learning difficulties by providing multiple means of representation and assessment [4].

Schreffler, Vasquez, Chini and James synthesizes the UDL based literature for STEM education of postsecondary pupils and suggested that UDL based lesson planning is very beneficial in term of accessibility, self-regulation and enhancing attention in classroom [45]. According to McPherson, learner takes responsibility of their work and develop sufficient self-reliance when flexibility in learning processes is offered with respect to the framework [31]. Baurhoo and Asghar, stated that pupils with a learning disability or any physical disability in primary and secondary grades are not performing well in their science class as compared to their peers and 56% of the teacher accepted that they use the term "Disability" as a reason of the failure of these pupils [4]. Moore, Holterman, Simone and Huggett recommended that team-based learning applied with UDL guidelines can be very advantageous for pupils and it does not have any disadvantages such as noise because 90% pupils find these sessions more successful to improve learning in classroom [32]. McPherson found the evident positive influence of instructional planning in learner's performance when based on neurological networks for Pre-K-4 Science education [31]. Narkon and Wells designed instructions with evidence-based story mapping technique using

UDL guidelines to improve comprehension for reading primary grade pupils and found it very effective [35]. When a case study and participatory action research as methodology was used to evaluate the process of redesigning the Science curriculum for high school learners with and without disabilities using UDL framework, most positive outcome was observed in term of teamwork, empathy development and academic performance [16].

It is challenging to evaluate the UDL impact on learning because of its design, flexibility and iterative nature [3]. Murphy states that, effectiveness of UDL frame work is yet to be proven before applying the framework in educational institutes [33]. The application of UDL framework for improvement of learner's performance is not reported much, however, variability of learners and lesson planning are addressed [40].

13.3 Methodology

To evaluate the effectiveness of the UDL based lesson implementation in science, a quasi-experimental pre-test post-test design was used in the study.

13.3.1 Participants

The study was conducted in a private school situated in the city of Islamabad, the capital of Pakistan. The school was selected on the basis of convenient sampling, because technological equipment was required for the intervention, which was easily accessible in the selected school.

Research participants were fourth grade pupils (N = 60) with age ranges of 8 to 11 years. Participants were divided in two comparison groups named as control group (N = 30) and experimented group (N = 30). For comparative analysis, control group was taught in traditional instruction (teacher-centered lecture based with very little involvement of pupils) conversely, experimental group received UDL compliant instructions (pupil-centered with technological incorporation, where teacher acts a facilitator). The structure of classes was kept intact, as the school administration wanted to keep the class structure intact and did not allow to create partitions within the class. However, the school had two sections for grade four, thus, the groups were assigned between two sections of grade four. It was also ensured that the previous academic records of the two groups did not contain any inherent bias that may affect the study. Both groups were assigned the same instructor for any particular subject, and each group demonstrated similar grades and learning achievements, prior to this study.

13.3.2 Intervention: Time, Resources and Space

Learner profiles were created using the Felder Silverman's tool to diagnose learner's preferences and learner interest and technological accessibility and preference was also identified through questionnaire. After understanding learner's interests, technological and learning preferences, lesson was planned using the learner's information with respect to UDL guidelines and checkpoints. Afterwards, pre-test was conducted for both the control and the experimented group. The intervention was then continued for three weeks, based on the span of 12 sessions of 30 min each. The intervention span of three weeks was suitable for the experiment as it has been practiced by Khan et al. [27]. Experimented group received instructions in the computer lab because technological tools required for interventions were not available in the classroom, however, the control group received traditional teaching (lecture-based teacher centered approach) in their own classroom.

13.3.3 Instructional Objective

The typical curriculum is usually based on written material and devised for uniform group of pupils, ignoring the needs of diverse learner needs. Thus, traditional curriculum puts a burden on educators to create modified materials that will support various learner needs [39]. As indicated before, blended learning approach are more viable to attain the required instructional objectives when UDL framework is linked to curriculum. Heterogenous group of pupils in a classroom can engage in appropriately challenging learning environment when curriculum objectives are attained using multiple means of expression, assessment and engagement [39]. Thus, the UDL framework implementation is based on the following learning goals as proposed in the Pakistan National Curriculum of Science for Grade four.

- To identify the sources of common food
- To explain the properties of major food groups
- To classify different food into their basic groups
- To differentiate between balanced and unbalanced diet
- To suggest the balanced meal from given list of foods and to explain why each food was chosen
- Explain the effects of unbalanced diet on health
- Explain hygiene and its basic principles.

After understanding the learning goals and expected learning outcome from the unit's curriculum, commonly used lecture based and teacher centered-traditional approach was used for control group. However, the UDL based lesson plan was developed to teach the experimental group. Both the pedagogical approaches are discussed and compared below.

13.3.4 Traditional Instructional Design for Control Group

According to traditionally planned lesson provided to teacher by the school for teaching the unit food and health did not require any technological resource. Thus, the control group received the instructions in their own classroom. After greeting the class, the teacher prepared the whiteboard, and there she mentioned the unit title and number form the text book i.e., Unit 4: Food and Health. Then she asked the pupils to open their books and look at the pictures of different foods and asked about their favorite food items from the picture. Next, she started to explain why food is important for human body and then linked it to the first topic i.e., food group and sources. She opened the book and showed the pupils pictures of different food items and explained the groups they belonged. Afterwards she asked the pupils to read the explained topic form the book. If the pupils faced any difficulty reading any word, the teacher read it for them and asked them to read again. Teacher used only the English language as mode of instruction in class. After the reading session, pupils were asked to take out their science note books while the teacher wrote True and False statements based on the discussed topic on the white board and asked pupils to copy the work on their notebooks. Answers were not provided and the pupils were only asked to copy the statements first. Once all the pupils copied the statements, teacher gave them fifteen minutes to use the book and write whether each statement is true or false. After fifteen minutes, the teacher wrote the answers on the bord and asked the pupils to copy them or make necessary corrections. Additionally, the activity in the book was given as homework. Afterwards, the teacher checked their notebooks to make sure that all the pupils copied the work correctly from the white board.

To teach the topic: balanced diet, its importance and food pyramid, the teacher pasted a chart showing a food pyramid and connected the previously taught topic by explaining importance of each group for the human body. She pointed at each group of food shown in the pyramid and explained how the amounts of different food groups make a balanced diet. Teacher read the topic and then explained again. After that the teacher wrote 20 statements with blanks for the pupils to solve. Pupils were given 20 min to copy and write the answers. When given time was over, the teacher wrote the answers and checked the notebooks to ensure all the pupils completed the written task correctly.

In the next session, the teacher pointed at the mounted chart and revised the importance of a balanced diet. She asked the pupils to raise their hands to answer questions such as, how can they make sure they eat balance diet? What does food pyramid show? Why vitamins and minerals are important? What does fat provide us? If the pupils did not provide expected answer, the teacher provided the answer and asked them to repeat after her so that they may learn it by heart. Then she linked it with topic: unbalanced diet and its harms. After explanation of topic, the teacher wrote short questions on white board from the text book and left some space for answers between each question. Pupils were given 25 min to copy the work and answer the questions. Later, the teacher wrote the answers on board and made rounds to ensure

each pupil completed his or her written task in given time. Multiple choice questions provided in the text book exercise were given as homework.

To teach the last topic of the unit, the teacher read the topic and explained the meaning and significance of personal hygiene. Then she asked all the pupils to open their books and one by one each pupil was asked to read the topic at their turn. After the reading session, the teacher asked the pupils to copy the exercise of match-the-columns from the white board and gave them ten minutes to do the work on their own. When the ten minutes passed, the teacher mentioned the answers and checked whether all the pupils completed the work or not. A quiz from the work done on the notebook was assigned for the next session.

13.3.5 Instructional Design Based on UDL Framework for Experimental Group

A unit, Food and Health, from national curriculum for general science of Pakistan was selected for experiment. After understanding the learning goal and expected learning outcome from the unit's curriculum, the UDL based lesson plan was developed. Barriers in material, method and assessment was cognized and it was ensured that these barriers are removed. Technology was incorporated for representation and assessment of content through power point slides, videos with audio and subtitle, PDF files of exercises question with images and games. The non-technological pedagogical approaches for representation and assessment were also incorporated in the lesson, such as, inquiry-based class discussions, class activities, outdoor games, role playing and group project. Three topics of selected unit (i.e., food group and sources, balanced diet and its importance, unbalanced diet and its harms) were taught in two weeks and two topics (i.e., food pyramid, and personal hygiene) were taught in one-week period.

Teacher used both English and Urdu language as medium of instruction. Mostly English language was used, but since Urdu is the first language of the pupils, therefore, the teacher also explained in Urdu but used the specific vocabulary of Science in English. Science vocabulary required for the unit topic discussion was provided on paper with pictorial representation and it was pasted on the board. Also, the second chart was displayed which presented the nutritional value of several food items along with the pictures. The vocabulary of the taught content is vital and needs to be presented to comprehend the text and it is one of the fundamental checkpoints provided to implement UDL framework [5]. Learning science vocabulary from someone who masters it and then use it appropriately in class discussions, arguments and during analyzing or writing, is essential for science education [29].

It is vital to support and work on authentic scientific thinking of learners that can help them to make better decisions to improve daily life [53]. Thus, the goal of the unit was not only to teach the textbook-based content but also help the learners internalize the habit required for leading healthy life so they can practice the learnt

concept of science in daily life. Therefore, first lesson started with a short video which showed the impact of eating habits on a person's health. The goals of the topic were discussed by posing questions from the video, such as, what was the difference in eating habit of boy and girl shown in the video, why the boy got tiered and felt unwell. Using technological medium like the video can provide alternative input for learners who require it King-Sears [28].

To enhance engagement, learners' own eating habits were discussed in the classroom by posing several questions, such as, what is your favorite food? When you go to market? Do your parents allow to pick food items of your own choice? Which food would you prefer in the given list and why? What kind of food is available in school cafeteria? Do you buy from school cafeteria? What kind of food do you prefer to buy form your pocket money? What kind of food your parents persist to consume in daily life? Afterwards, the pupils were asked to write down the list of their favorite food items and mention which of them are healthy. Then the misconceptions were cleared and new knowledge was presented by relating it to prior knowledge in a discussion session.

Subsequently**, food group and sources, balanced diet and its importance, unbalanced diet** and its harms were demonstrated using video composed of images related to the text given in the book with background audio and subtitles as suggested by Spencer [48]. Facilitator paused the video several times and asked questions from the video to keep the learners engaged. Next, the facilitator read the mentioned topics from e-book shown through multimedia projector, and learners looked at the chapter in their books. The colorful images of the food groups and its sources are provided in the textbook. Worksheet based on questions related to the topics discussed through video and explained in reading session was provided to the pupils, which comprised the book exercise. Pupils worked in pairs to do the exercise provided in the book. Pupils were more motivated and engaged to participate in pairs or groups of their choice [48]. Facilitator also provided the option of working alone, but all the pupils preferred to work in pairs. After discussing the worksheet with each other, one pupil was required to write the answers and one was required to share the answer with class. As an option, the pupils were allowed to use the audacity software in computer using their headsets to record their responses in case they did not wish to present in the class themselves. This was opted only by a single group. For support during formative assessment, the video was provided to the pupils on their computer systems, if pupils required, they could watch the video again on their pace using earphones or use the text book for support. Additionally, pupils were given a choice to use their text book to look for answer as well. Facilitator provided feedback and support continuously during class activities and group work.

Afterwards, the pupils were asked to make groups of their own choice and through power point presentation labelled images were shown to the class to connect the acquired knowledge of **balanced diet and its impact on our health**. For this purpose, images were displayed on multimedia comprising different meals which included balanced or unbalanced diet. Facilitator asked the pupils to choose the 3 meals for themselves and prepare their healthy diet plan for one day. Pupils were also required to discuss the effect of their chosen meal on their health and describe if it is based

on balanced diet or not. Groups were allowed to express their work either by writing their answer, drawing pictures, explaining verbally or preparing a short presentation.

An activity was performed to internalize the concept of learnt topics. In the group activity, each group was provided two baskets and bag of food. Each group was required to add food in the basket for a healthy and balanced diet meal and also write the name of food group on the sticker and paste it on the food item or explain verbally to demonstrate the group of the food item. Pupil were also provided with the nutritional value chart to make the meal balanced for support.

For homework, pupils were asked to record what they eat daily and categorize the foods into groups in order to monitor whether a balanced diet is being taken or not. For support, worksheet was given to them but the pupils were provided choices to represent their work in different ways such as, use audio recording, a small video, a presentation, drawing, a short essay or a chart.

The topics i.e., **Food Pyramid and Personal Hygiene** needed to be connected to the previous lessons, therefore, facilitator showed a short-curated video to pupils which connected the new topics to the previously taught topic and asked few questions at the end of the video as advised in literature [28, 48]. Then a worksheet based on textbook was given to the pupils and it was also displayed through multimedia projector. Facilitator asked the pupils to fill at least three food items for each group of food and then afterwards the teacher explained what is food pyramid and how can we make a balanced meal using guidelines from the food pyramid. Afterwards, teacher displayed the concept map chart on the soft board and explained in which described the topic food pyramid and then a small video was shown how to develop a concept map. Pupils were asked to develop a concept map in a group activity and facilitator provided the support when required. Pupils were also provided with the video on their computer to revisit the idea of how to develop concept map on their own. Facilitator read the topic form the book aloud for recognition of science vocabulary. Next, the pupils were asked to read the topic form text book. Pupils were also provided the e-book, the text to speech feature of e-book helped them to read the difficult words. Important vocabulary items were emphasized as advised by Lemke [29].

After the reading session, pupils were provided with a worksheet comprising two types of fun questions. To do this formative assessment, pupils were given a choice between match the column exercise or play the cross-word puzzle in groups of three. This helped them to combine science terminologies and meanings and supported in understanding and comprehension.

Literature suggests that video games are an effective way to offer pupils multiple means of representation and expression [17, 30]. The group who completed their work in given time and showed discipline in their work were recognized by a reward. Then the pupils played the digital game: healthy eating kids food game where they prepared the meal for the character i.e., a Panda. The pupils prepared the meal for the panda and then facilitator asked questions regarding the choice of food items for the meal with respect to the food pyramid. Khan, Ahmad and Malik recommended game-based learning for science in comparison to conventional science lesson for significant impact on learner's engagement [26].

Science homework was a small project from the text book that was given to the pupils where they were required to make a booklet of the different food items used by their family during breakfast, lunch and dinner and then describe whether the meals were balanced with respect to the food pyramid guidelines or not. For providing multiple ways of expression, learners were allowed to write, paste or draw pictures for the booklet. Rubric for the project was provided in the form of a printed copy and attached in pupils' notebooks to clearly communicate the expectations of the work.

Next, the unit topic i.e., **personal hygiene** was also demonstrated using video composed of images related to the text given in the book with background audio and subtitles as advised by King-Sears [28]. Teacher asked questions afterwards to explore learner's understanding related the topic as suggested by Darling-Hammond, that when instructions are thoughtfully interwoven with inquiry, it helps understand learner's engagement, and provide timely feedback [14]. Teacher then explained the topic showing the images provided in the book through multimedia projector. For formative assessment, pupils worked on the class activity based on role playing to show how to take care of their personal hygiene in a group of their choice. Pupils had a choice to present in the class or record a video of their role play. Only two groups opted the option of video recording. Rubric was provided to each group in form of a hard copy. When all learners presented their work, similarity and differences in the role play was discussed. Also, the most compelling reasons for prioritizing personal hygiene in daily lives mentioned by the groups in their role play were highlighted in the discussion.

Reinforcement-based-homework was given where learners were required to build projects from the given choices such as taboo card game based on Unit topics, a short story book on Unit: Food and health, a puppet show for the unit topic, poems for each topic in the unit. Rubric for each kind of representation was provided to pupils so that they have clarity of expected performance. Pupil picked projects of their choices and in next class presented their work and shared the learnt knowledge with their classmates. All of the above-mentioned assessment techniques used in classwork and homework were considered as formative assessment. After the completion of the unit, a post-test was conducted.

13.3.6 Instructional Design with Respect to UDL Checkpoints

The following Tables 13.1, 13.2, and 13.3 provide the details of the pedagogical strategies of UDL compliant lesson mapped with the standard recognition, strategic, and affective network checkpoints, respectively.

In Table 13.1, the check points related to the recognition network are described. The recognition network deals with the 'what' of learning. The table includes all the check points belonging to the categories of perception, language and symbol, and the comprehension. Each of these categories are further divided in to several check points as shown in the table. For each of the checkpoints, the corresponding pedagogical methods, supplementary material, and the modes of assessments are

Table 13.1 Pedagogical strategies of UDL compliant lesson mapped with recognition network's checkpoints

UDL network	Recognition network The 'WHAT' of learning			
UDL principle	Provide multiple means of representation			
Check point no	Guideline for check points	Methods	Materials	Assessment
1	Perception			
1.1	Suggest modes to customize the presentation of information	– Teacher explains video and plays it twice – Large font and images used on Chart and – E-book provided to pupils – Discussion through questions	– Video – Chart paper – E-book – Verbal questions – Paper pencil – Multi-media projector	– Verbal questions – Worksheet – List down asked information
1.2	Suggest substitutes for audio information	– Chart for vocabulary – Use of underline and bold feature in E-book – Video of text book content with large images and subtitles with clear and large fonts	– E-book – Video with images form text book and background audio	NA
1.3	Suggest substitutes for ocular information	– Text to speech feature provided in the book	– E-book	NA
2	Language & Symbol			
2.1	Clarify terminology and symbols	– Pre-teach science vocabulary – Highlight complex terms	– Chart paper with pictorial representation on soft board – E. book – Multi-media projector	– Questions related to science vocabulary during reading session – Underline the words and write down description
2.2	Clarify composition and assembly	– Link between ideas and concepts	– Verbal explanation	Underline the words and write down description
2.3	Help interpreting text, mathematical representations	– Access to e-book on their computer system	– E-book's text to speech feature	NA

(continued)

Table 13.1 (continued)

UDL network	Recognition network The 'WHAT' of learning			
UDL principle	Provide multiple means of representation			
Check point no	Guideline for check points	Methods	Materials	Assessment
2.4	Support understanding across languages	– Explained book content in and video on both English and Urdu language	– Verbal explanation	– Questions during reading sessions
2.5	Illustrate through multiple media	– Explained concepts and made links between information	– Chart paper with pictorial representation on soft board – Video – Text book – E book – Multi-media projector	– Questions
3	Comprehension			
3.1	Stimulate background knowledge	– Pre-teach critical prerequisites—explains video and play it twice – Chart explained – Connection between information through discussion and questions	– Video – Chart paper – Verbal questions – Paper pencil	– Verbal questions – Worksheet – List down asked information
3.2	Emphasize patterns, critical features, big viewpoints and associations	Use of cues and prompts to draw attention to critical features	– Video – Verbal questions	– Verbal questions – Worksheet – List down asked information
3.3	Guide information processing and visualization	Introduce gradual scaffolds to support information processing – Chunk information into smaller elements – Progressing release of information	– Verbal feedback – Chart paper – Video – Verbal questions	
3.4	Increase transfer and generality	– Revisit the idea and opportunity to revisit ideas – Questions based on learner's real-life experience and practices – Provide template to create concept maps	– Chart on softboard – Video	– List down asked information – Create concept map

Table 13.2 Pedagogical strategies of UDL compliant lesson mapped with strategic network's checkpoints

UDL network	Strategic network The 'HOW' of learning			
UDL principle	Provide multiple means of action and expression			
Check point no	Guideline for checkpoints	Methods	Materials	Assessment
4	Physical Action			
4.1	Adapt the ways for answer and navigation	Provided alternatives for physical responses, technologies, range of motor action required to interact with content	– Audio recording, a small video, power point presentation, drawing, write a short essay or make a chart – Paste picture, write or drawn with paper pencil – Present or record video of role play – Make card game, paper pencil to write story or poem. Puppet show	– Worksheet was given to categorize food items – Worksheet comprised of fun question with choice – Project: make a booklet – Role play – Project
4.2	Optimize provision of instruments and assistive technologies	Teacher provided technological assistance for the class work	– Head phones—Computer – Text to speech feature	For reading and worksheets
5	Expression and Communication			
5.1	Use several methods for interaction	– Allowed to use several media for responses – Answer questions using a variety of strategies	– Audio recording, a small video, power point presentation, drawing, write a short essay or make a chart – Past picture, write or drawn with paper pencil – Present or record video of role play – Make card game, paper pencil to write story or poem. Puppet show	– Worksheet was given to categorize food items – Worksheet comprised of fun question with choice – Project: make a booklet – Role play – Project

(continued)

Table 13.2 (continued)

UDL network	Strategic network The 'HOW' of learning			
UDL principle	Provide multiple means of action and expression			
Check point no	Guideline for checkpoints	Methods	Materials	Assessment
5.2	Use several tools for creation and arrangement	Provided and allowed to use the several tools for answering questions	– Text to speech feature of e-book – Voice recorder, -Audacity software – Headphone set and mic A chart paper with Science vocabulary and related images	Answer the worksheet
5.3	Build fluencies with progressed levels of help for exercise and implementation	– Read topic using text book with support of e-book – Provide differentiated feed – Started with worksheets and then projects were given	Text to speech feature of e-book – Verbal support by facilitator	Varied types of assessment methods were used
6	Executive Functions			
6.1	Guide appropriate goal-setting	– Objectives were discussed in the beginning – Provision of rubric – Time of tasks were provided	– Printed hard copy – Classroom wall clock	NA
6.2	Support planning and strategy development	– Provision of rubric with time to submit the project and checklist that shows expectations – Provision of support to achieve the goal	– Printed hard copy – Video links	Project: make a booklet – Role play – Project on all topics
6.3	Facilitate managing information and resources	Guided pupils for note-taking	– Note book – Worksheet	Assessment given in text book
6.4	Enhance capacity for monitoring progress	Provision of scoring rubrics Concept map example	– Printed hard copy – Video links	Rubrics were provided for assessments

Table 13.3 Pedagogical strategies of UDL compliant lesson mapped with affective network's checkpoints

UDL network	Affective network The 'WHY' of learning			
UDL principle	Provide multiple means of engagement			
Check point no	Guideline for checkpoints	Methods	Materials	Assessment
7	Recruiting Interest			
7.1	Optimizing individual choice and autonomy	– Choice between reward was given – Choices were provided to express their work	– Smiley sticker or start sticker – Audio recording, a small video, power point presentation, drawing, write a short essay or make a chart – Past picture, write or drawn with paper pencil – Present or record video of role play – Make card game, paper pencil to write story or poem. Puppet show	– Work sheets and Projects
7.2	Optimize relevance, value and authenticity	Activities were age appropriate and examples were taken from real life context – Activities that allow to practice the content – Activities included to promote the use of creativity	– Make card game, drawing, write a short essay or make a chart paper pencil to write story or poem. Puppet show	Project and experiment based on content knowledge
7.3	Minimizing Threats and distractions	– Continuous reminder to complete task in time – Allow extra time to complete the task – Use of equipment that help control noise in environment – Provided choices to perform the tasks	Class room wall clock – Headphones – Recording, a small video, power point presentation, drawing, write a short essay or make a chart – Paste picture, write or drawn with paper pencil – Present or record video of role play – Make card game, paper pencil to write story or poem. Puppet show	– Work-sheet, experiment and project

(continued)

Table 13.3 (continued)

UDL network	Affective network The 'WHY' of learning			
UDL principle	Provide multiple means of engagement			
Check point no	Guideline for checkpoints	Methods	Materials	Assessment
8	Sustaining Effort and Persistence			
8.1	Heighten salience of goals and objectives	– Teacher demonstrated how to use given application on computer – Discuss the content using real life example from pupil's life	– Audacity software – E book – power point – Verbal discussion	– Work-sheet and experiment
8.2	Vary demands and resources to optimize challenge	– To perform the given tasks, choices were provided with differentiated degree of difficulty	– Audio recording, a small video, power point presentation, drawing, write a short essay or make a chart – Past picture, write or drawn with paper pencil – Present or record video of role play – Make card game, paper pencil to write story or poem. Puppet show	– Work-sheet, experiment and project
8.3	Foster collaboration and community	Promoted group work in class with division of assignment of roles and responsibilities – Asked pupils to take help form facilitator in specific activities – Expectations for the work was communicated – Learners were also allowed to choose to work in group, pair or alone	– Worksheet – Multimedia projector – Computers – Printed rubric – Basket and food items	– Work sheets – Class activity – Experiment

(continued)

Table 13.3 (continued)

UDL network	Affective network The 'WHY' of learning			
UDL principle	Provide multiple means of engagement			
Check point no	Guideline for checkpoints	Methods	Materials	Assessment
8.4	Increase mastery-oriented feedback	– Timely feedback was provided after each activity and assessment – Mistakes and misconceptions were discussed without specifying any pupil	NA	For all kind of assessment techniques mentioned in lesson plan
9	Self-Regulation			
9.1	Promote expectations and beliefs that optimize motivation	– Teacher modelled and explained the process – Provided reminders to complete task in time and rubrics with guidelines so that pupils complete the tasks themselves	– Basket and food items – Multimedia Projectors – Computer	– Experiment – Concept map activity
9.2	Facilitate personal coping skills and strategies	– Teacher provided support to the pupils in a group's activity and individual tasks were also given in group so peers can also help each other when required – For homework, ample practice was done during formative assessments and rubrics were also given	– Computers – Paper – Card board – Pencils	– Game – Worksheet – Home assignments
9.3	Develop self-assessment and reflection	– Provided support for self-assessment through rubric – Feedback was provided	– Paper – Verbal feedback	For all kind of formative assessments

mentioned. Similarly, Table 13.2 describe the strategic network which is related to the 'how' of learning. All the checkpoints and the associated pedagogical methods, materials and the assessments are listed in this table. Lastly, Table 13.3 contains the checkpoints related to the affective network which deals with the 'why' of learning. Against each individual checkpoint, the associated methods, supplementary materials and assessments are mentioned.

13.4 Results

13.4.1 Pre-test and Post-test Design

The content of the pre-test and post-test was formulated carefully from selected units of science from the text book exercise. The pre and post-test consisted of ten multiple choice questions, which were used to check the understanding of the concept in contrast to memorization.

The content validity of the pre-test and post-test were ensured by obtaining the approval of several teachers through moderation, as practiced by Khan et al. [27] and suggested by Gay et al. [20]. Pupils were familiar and comfortable with paper worksheet method; thus, tests were conducted on paper worksheets. This specifically helped to keep the conductance method same [27]. The concepts, time period, level of difficulty and conductance method, for pre-test and post-test were kept same as advised by Creswell [12]. The test took 10 to 25 min depending on learner's pace. The knowledge in the assessment was covered in the lesson delivered during twelve sessions (each of 30 min span). Teacher remained in the classroom for providing support to the pupils during the tests. The support included helping pupil understand question and reading the question statements if required. Post-test was conducted in the fourth week. After marking all the tests, the scores were recorded using Statistical Package for Social Sciences (SPSS).

13.4.2 Data Analysis

The data of independent variables were evaluated by conducting descriptive analysis with certain assumptions i.e., normal distribution, because the parametric tests were based on normal distribution [18]. Shapiro–Wilk test was employed to test the normality of data because the sample was less than 100. A non-significant result i.e., $p > 0.05$, shows normality. In Table 13.4, the results of Shapiro–Wilk tests are provided which show that for both pre-test and post-test we get $p > 0.05$, which suggests that the assumption for normality is satisfied and therefore the inferential statistics t-test can be employed.

Table 13.4 Test for normality

	Shapiro–Wilk		
	Statistics	DF	P
Pre-test	0.96	60	0.075
Post-test	0.968	60	0.119

Table 13.5 Similarity of groups based on pre-test data

Group		Descriptive statistics		Independent sample t-test		
	N	M	SD	T	DF	P
Control	30	12.8	3.51	0.269	58	0.7
Experimental	30	12.5	5.00			

Similarity of groups based on pre-intervention data

The equal variance independent sample t-test was conducted, by setting a confidence interval of 95% to compare the means of experimental and control groups before applying intervention. The purpose was to check whether the learners of the two groups were at similar learning level in terms of their pre-test score before the intervention. As shown in Table 13.5, both the groups i.e., control and experimental, consisted of 30 learners. The mean (M) and standard deviation (SD) of the pre-test scores for both the groups came out to be similar. The subsequent inferential statistics results i.e., $T(60) = 0.269$, $p = 0.7$, show that both the control and the treatment group were at similar level of learning as presented in Table 13.5.

Evaluation of learning outcomes between the groups

To analyze the impact of UDL based lesson intervention, comparison of post-test scores of learners between experimental and control group was done. For this purpose, independent sample t-test was employed after testing the data for certain assumption i.e., data for the parametric tests is normally distributed which was calculated using Shapiro–Wilk test resulted in $p > 0.05$ to be exact $p = 0.119$ as shown in Table 13.4. The mean score for the experimental group was significantly higher 14.8 ± 4.34 as compared to the control group 12.8 ± 3.97. The learning outcomes calculated through independent sample t-test shows the statistically significant difference between experimental and control group in favor of experimental group (Table 13.6).

Table 13.6 Difference in learning outcome after intervention (post-test)

Group		Descriptive statistics		Independent sample t-test		
	N	M	SD	T	DF	P
Control	30	12.8	3.97	1.996	58	0.03
Experimental	30	14.8	4.34			

This indicates that when science lessons were taught using the UDL approach, the academic performance of learners improved significantly.

Evaluation of learner's pre-test and post-test within the group

The pair sample t-test was employed to evaluate the mean ranks of pre-test and post-test scores with in the experimental groups. The quantitative analysis showed that there was a statistical difference in the scores of pre-tests and post-test. For pre-tests ($M = 12.5$, $SD = 5.005$) to post-test ($M = 14.766$, $SD = 4.344$), $t(30) = 4.365$, $p = 0.000$, which is $p < 0.05$ (two-tailed), and $d = 29$. This test shows that the learners performed significantly better on post-test (after receiving UDL compliant instructions) as compared to their performance on the pre-test (after receiving UDL compliant instructions) in experimental group with a 95% confidence interval. The guidelines proposed the effect size larger that 0.014 as large [9], therefore eta squared statistics (0.39) indicated a large effect size.

13.5 Discussion

According to Supple and Abgenyenga, UDL is extremely beneficial to accommodate for diversity in learner where learners do not need to adapt with respect to the curriculum rather constraint of the curriculum are eliminated by teacher, [49]. Ok, Rao, Bryant and McDougall also agree that UDL based lesson plans has the potential to enhance improves academic performance, engagement and access to curriculum for pupils with special abilities, [36]. But through systematic review of thirteen studies, significant inconsistency was found in UDL based research when recording connection between UDL guidelines and its intervention in classroom [36]. Stolz states the critique that it is noticed in the literature of UDL that there is inconsistency in the research specifically lack of empirical evidence [50]. The present work investigated the extent to which he UDL based lesson implementation improved the learner's academic performance of Primary grade pupils in science classroom in Pakistan. The UDL based lesson planning had positive impact on learning outcome of science pupils of primary grade.

In response to the research question: "Does the proposed method based on UDL lesson planning improve the learning of science learners? the independent sample t-test shows the significant difference among the experiment and control group, indicating the learning of pupils were improved and learning benefits were attained via UDL based lesson plan. The difference in learning outcome between the groups in favor of experimental group in the present study can be associated to the several reasons. The way a teacher pre-plans the lesson and implements in the classroom has great impact on learning outcome of learners. Teachers are required to be prepared in accordance with the strategies of teaching for reaching diverse learners. When lesson

is planned efficiently using UDL guidelines, it allows educators to more successfully meet their learners' needs [11]. In traditional classrooms usually a teacher is involved in catering many pupils at a time and single medium of communication is encouraged and this hinders learning because of pupils' passive role. Use of technology to support the lesson plan not only enhances the engagement in learning of science, but also plays an important role in the improvement of learning outcome. To make specific UDL strategies that are essential to deliver complete accessibility and success in meeting the lesson objectives, a thorough analysis of pupil's needs is fundamental [35].

Murphy, criticizes the evidence provided that supports the effectiveness of UDL framework and mentioned that only providing the sample lesson plans is not sufficient because it is impossible to investigate the specific impact of UDL [33]. Therefore, the present study provided the complete lesson plan and additionally mapped the lesson plan to the checkpoints of UDL framework given in the official website (https://udlguidelines.cast.org) of the CAST. These checkpoints or guidelines are the tools and specific suggestions that educators, researchers, curriculum developers even parents can use to apply the framework. Table 13.1, 13.2, and 13.3 showed the methods, material and assessment with respect to the UDL guidelines. However, Table 13.1 represents the lesson plan mapping on check-points for recognition network (i.e., multiple means representation), Table-2 for strategic network (i.e., multiple means of action and expression) and Table-3 for affective network (i.e., multiple means of engagement). The numbering of the checkpoints is kept same as provided in the CAST website (https://udlguidelines.cast.org).

All the guidelines have been followed to develop and implement the lesson plan in a way that learners could be able to comprehend the content, able to set goals, to achieve their goals and monitor their progress and able to self-regulate and engage in activities with intrinsic motivation. For this purpose, variety of pedagogical strategies were incorporated stepwise so they can achieve these goals. The teacher started with eradicating the misconceptions while activating prior knowledge, connecting the new knowledge to learner's own life experiences through discussion. Then gradually, with incorporation of technological resources teachers used several kinds of knowledge representation and formative assessment techniques so that the learners would be intrinsically motivated to take command as much as possible. In the lesson plan, it can be seen that at the start scaffoldings and support was very high but gradually there was release of support and learners were provided with rubrics to assess themselves and provided the tasks that they were able to perform alone on their own. At the beginning pair or group work helped learners to work with each other and get support with peers or facilitator but by the end of the lesson, learners were able to work alone on the class activities and project. Moreover, range of choices were also provided with assessments so learners could learn and perform with respect to their learning styles. Thus, the positive impact of the intervention is noticeable through the quasi-experimental pre-test and post-test design.

The similarity in the level of knowledge was determined by independent sample t-test of pretest results and it is observed that both control and experimental group were at same learning level as mentioned in Table 13.5. In the lesson plan, it is seen that there is overlap of planned strategies and UDL checkpoints. Boxtel and Sugita's finding also mentioned that there are similar check points within the UDL framework [51], thus overlapping of pedagogical strategies can be observed in the Tables 13.1, 13.2 and 13.3. For example, nine different check points, such as, 1.3, 3.3, 3.4, 6.1, 6.2, 6.4, 8.1, 8.3, and 9.1 suggest to signal/cue pupils to apply strategy [51].

When the statistical differences between groups were examined using independent sample t-test, the finding indicated a positive impact of UDL intervention on learner's academic performance in favor of experimental group. These findings are in line with UDL based research [41]. When the pair sample t-test was used to examine the mean ranks, statistical difference among pretest and post-test between experimental group was noticeable. The improvement in the academic performance of experimental group in contrast to control group can be related to number of factors. In order to eliminate most of these factors, it was ensured that there is not inherent difference in the learning abilities of the two groups. This was also validated through the t-test during the pre-assessment. The timing of the lectures was also consistent and both groups were taught during similar time of the day. The same teacher was assigned to both the groups so that there is no difference in the communication and inter-personal skills. With all these checks in place, the difference in the learning achievement among the control and experimental group is correlated with confidence to the traditional and the UDL based teaching approach.

The universally designed pre-planned lesson that addresses the diverse learners in classroom plays a vital role to heighten the motivation and increase the academic performance [24]. It is crucial to plan lesson using UDL principles, guidelines and checkpoints to eradicate the impediments that are essential for successful UDL implementation [23]. Therefore, to understand learner's, information was gathered through questionnaires and learner profiles was gathered at early stage before lesson planning. According to Dykes and Green, to facilitate the diverse group of learners in a classroom, it is fundamental to have knowledge of who these learners are and what are their preferences and interests [15]. This information included learner's preferences and learner interest and technological accessibility and preference. Thus, lesson plan included all kind of learner identified by the learner profile and it was made sure that diverse learning styles can be addressed for representation and assessment. Learning styles or preferences play important role in lesson planning of teachers who taught primary graders [34]. Chik and Abdullah also suggested identification of learning styles and incorporation of learning strategies that addresses diverse learner's preferences motivate and impact academic performance positively [7]. Keeping the interest of learners in mind while lesson planning, enhances the engagement and boost motivation and academic achievement [42]. Therefore, several options were provided to express knowledge with respect to learner's interests such as poetry, drawing, role playing etc.

The use of different technological methods also plays an effective role to enhance learner's engagement and performance. Rappolt-Schlichtmann et al. also agreed that

UDL is a method that attempts to influence the science learning in the user-experience design of educational environment [41]. When digital reading environment uses the assistive technology features such as text to speech, highlighting and hardware such as headphones at independent station, teacher is able to modify the level of support required by pupils as suggested by UDL check point 4.2 [51].

Limitations and implication for future research and practice

Some limitations were noticed in the design and implementation of the present study. Detailed demographics of representation sample is provided but variability with respect to ethnicity was not available in the sample. The study does not employ full curriculum of a course subject but the experiment was conducted on only one unit. Therefore, future study can by conducted using more units of science courses. The study is limited for the primary grade pupil for only science subject. It can also be employed for the secondary grade pupils and the effectiveness of UDL checkpoints applied to the instructions can be investigated. To have internal and external validity, experimental research with random selection and assignment to condition from population was not achieved because of the time and resources constraints. This work can be extended over a long period of time, with random grouping of the total population for each individual topic. This will eliminate any bias that could arise from mis-matched groups based on their learning abilities. Lastly, the present study is based on the quantitative method only, qualitative aspect of the intervention can be examined in further studies.

13.6 Conclusion

The goal of this study was to investigate the impact of UDL compliant Science lesson plan on learning outcome of elementary grade pupils. This study also explained that how UDL based preplanned lesson help engage pupils and boost their motivation and impact learner's academic performance. The data analysis revealed that when Science lesson is taught using UDL principles (i.e., multiple means of representation, multiple means of action and expression and multiple means of engagements), it had positive influence on learner's learning experience in comparison to those who are taught with traditional teaching approaches. Additionally, the UDL compliant lesson plan was also mapped with UDL principles (Tables 13.1, 13.2 and 13.3), guidelines or checkpoints, which reveals that there are similar check points within the UDL framework thus overlapping of pedagogical strategies (method, materials and assessments) can be observed.

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