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RESEARCH PAPER

Implementing Discussion and Predict-Observe-Explain teaching strategies for Promoting Argumentation in Science Education

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ABSTRACT

State of science is poor in Pakistan. Logical reasoning or argumentation is one of the aims of scince education. This study aimed to apply the strategies to promote argumentation among the students in Karachi, Pakistan. The practical action research methodology based on cyclic model by Kemmis et al., (2004) and Toulmin Argument Pattern (TAP) were used to attain the aim of the study. The data were collected from the students of Grade seven and a science teacher through classroom observations, interviews, field notes, reflective journal, audio-recording and document analysis. The data were analyzed in two steps; on-going and overall data analysis. The results revealed that the students could construct better level of arguments by using claim, data and warrant components of TAP, through the whole-class discussion based-on students' personal experiences along with teachers' and students' questioning, and Predict-Observe-Explain (POE) along with working model about the sun, earth and moon. The study recommends that argumentation should be part of all science teacher education programs, science textbooks need to have socio-scientific, health and environmental issues and a persuasive style to develop argumentation which will bring about both conceptual understanding and scientific thinking.

KEYWORDS Argumentation, Predict Observe Explain, Tolumin Argument Model (TAP)

Introduction

The Science and science education has fundamental importance in the world. It is widely accepted that advancement in science is the fountainhead of all scientific developments. In any society economic development is not possible without scientific improvement which embeds social, environmental, technological, political, and cultural developments. For example, a country like Japan having limited natural resources is highly developed due to expertise in scientific and technological developments. Unlike, the situation of science education is poor in developing world particularly it is poorer in Pakistan (Bhutta & Rizvi, 2022; Hali et al., 2021; Mullis et al., 2020). One of the reasons could be the prevalent science teaching and learning practices in schools based on transmission of knowledge and rote memorization. It could be due to current teaching and learning practices not only schools but also recognized public universities are not creating scientific-thinking among our prospective scientists to understand the phenomena. As a result, science education is getting poorer in the country and as per TIMMS report, Pakistan stands second lowest in the world (Mullis et al., 2020).

Having many scientific characteristics, argumentation has central importance in science and science education. And the pedagogies fostering arguments are at the centre of science education (Boettcher & Meisert, 2011; Giri & Paily, 2020; Magalhães, 2020). Although there is a realization of the usefulness of these strategies and there is little research undertaken in the area of argumentation in Pakistani schools. It is possible that the unavailability of contextually-relevant literature and practices could be the reason for practicing transmission mode of teaching in the country. In the absence of contextual examples, schools portray 'positivist perspective' in science which has clear right and wrong answers instead of promoting argumentation which results in scientific thinking.

However, the development of these skills needs opportunities where children can think, discuss, reason, debate, agree, disagree, and take decisions. Our experience and the studies from Pakistan reveal, both teachers and students are not experiencing these important opportunities which in my view are the basic requirements of the discipline of science. In Pakistani government schools, it was also found that there are some possibilities to implement student-centered approaches because these played important role in teachers' as well as students' conceptual understanding (Bhutta & Rizvi, 2022). Hence, identifying and understanding the ways to apply the strategies in teaching of science to initiate the process of change from transmission mode to student-centered constructive mode to promote students' argumentation emerges as researchable problem.

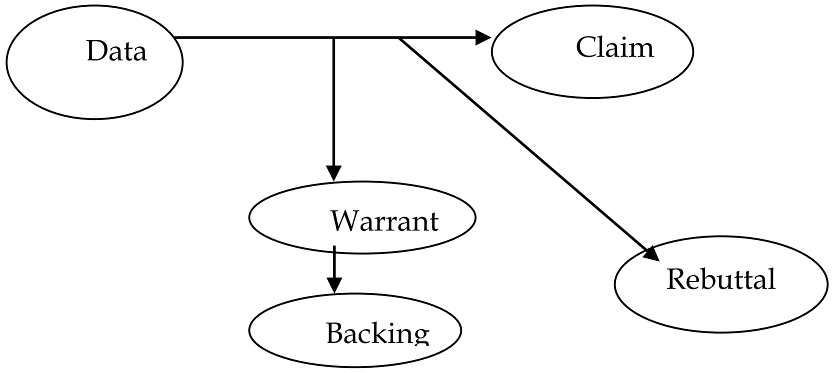
Literature Review

Argumentation is a process of constructing argument individually or collectively (Novaes, 2021). It involves a skill or combination of thinking skills like listening, thinking, questioning, analyzing, and convincing (Novaes, 2021; Zohar & Nemet, 2002). It could be argued that it is a verbal, social, and rational activity (Kim & Song, 2006), which involves students in classroom discourse based on logical claims and evidences to construct knowledge and to create a culture of argument. In addition, it is also a cognitive activity as it engages students in open classroom discourse in which they put forward their ideas on the basis of reasoning, analyzing, and questioning. A discourse of this nature assists in the promotion and development of both social setting and culture. If it is based in the content of science then it develops scientific-thinking based on logical reasoning. Such opportunities can be provided through several strategies following Toulmin's Argument Pattern (Erduran, 2018).

Toulmin's Argument Pattern (TAP)

Many researchers have advocated Tolumin's Argument Pattern or model (1958 updated in 2003) to foster learners' argumentation in general and particularly in science (Boettcher & Meisert, 2011; Erduran, 2018; Magalhães, 2020; Newton et al., 1999). The model consists of three main parts; claim, data, and warrant. The claim is statement or conclusion supported by data. It is also called the heart of argument because it engages students to think and provide data and warrant to support or reject the claim (Bulgren & Ellis, 2011; Metaxas et al., 2016). Data are the scientific facts, evidences, concepts, and reasons on which claims are based. Warrants are the reasons and explanations that provide connections to support claim based on data. In order to construct a good argument, Toulmin had also suggested backings and rebuttals. Backings are the basic assumptions which support the warrant and rebuttals are the extraordinary circumstances which undermine the support of arguments or backings and disqualify the claim through counter claim based on data and warrant.

Figure 1



TAP 1958 cited in Erduran et al., 2004

The Strategies to Promote Argumentation in Science

There are various strategies discussed in the literature which promote argumentation in science and help learners to construct knowledge. We practiced following two strategies.

Driver et al. (2000) have suggested small-group discussion and whole-class discussion to promote students' argumentation and " such practices, are the means of socializing young people into norms of scientific argument from which they may gain confidence in their use, and a deeper understanding of their function and value", (p. 288). Discussion might enable students to apply argumentation, persuade others in their daily life contexts, to solve their scientific problems. As Zohar and Nemet (2002) found through discussion 90% students were able to construct arguments and give and transfer reasons in and from the context (p. 51). However, in organizing discussion by following TAP teacher needs careful consideration to facilitate students to use contextual language to present, support, challenge, and question arguments.

Predict-Observe-Explain (POE)

This is a constructivist teaching learning approach because it helps students to link what they learned prior in different contexts (Bulgren & Ellis, 2011; Metaxas et al., 2016). Considering the prior experiences and context learner can predict what will happen. Then in observation it shows actual context where learner can see, hear, touch, smell or feel and evaluate his/her predictions. Newton et al. (1999) found that in POE students think, infer, predict, observe, compare and explain their predictions. It seems teacher would provide these learning opportunities to the students along with questions about predictions, observations and explanations which may represent real situations. In these situations it would explore students' ideas, reasons wherein students are required to provide the predictions about the consequences of particular change in a particular phenomenon, then description of their observation, change and an explanation (Bulgren & Ellis, 2011).

Material and Methods

We implemented Kemmis, McTaggart and Retallick (2004) model of action research. The model includes identifying general idea, reconnaissance, planning for action, implementation, monitoring and reflecting. In this research study, classroom was the social context wherein five students of class VII and a science teacher as our critical friend voluntarily participated. The Class was selected due to the interest shown by the critical friend in participation in the study and the selection criterion for the number of students is given in the sampling part. The participants' participation in planning was limited, but their suggestions were considered in planning the action, topic selection and in making changes to the plan. For example, the inclusion of socio-scientific issues was based on their suggestions. We gathered data through classroom observation checklist, note-taking, interviews, audio-recording, reflections, field-notes and document analysis. We have analyzed the data in two steps: on-going data analysis and summative data analysis during and after the reconnaissance stage and implementation stages.

Findings

We started with reconnaissance stage followed by two cycles of action research. The detailed findings comprising various sub-themes are categorized under three stages (Reconnaissance stage, Planning stage, Cycle one and Cycle two). Here we discuss glimpses of Cycle One and Two summarised in Figure 2 and Figure 3, respectively.

Cycle One

In cycle one, we practiced discussion strategy for promoting students' arguments. Following Figure 2 shows how the cycle was implemented followed by Table 1 informs level of argument and counter argument through various discussion strategies.

FIGURE 2

Visual version of Cycle One adapted from Kemmis et al. (2004) model

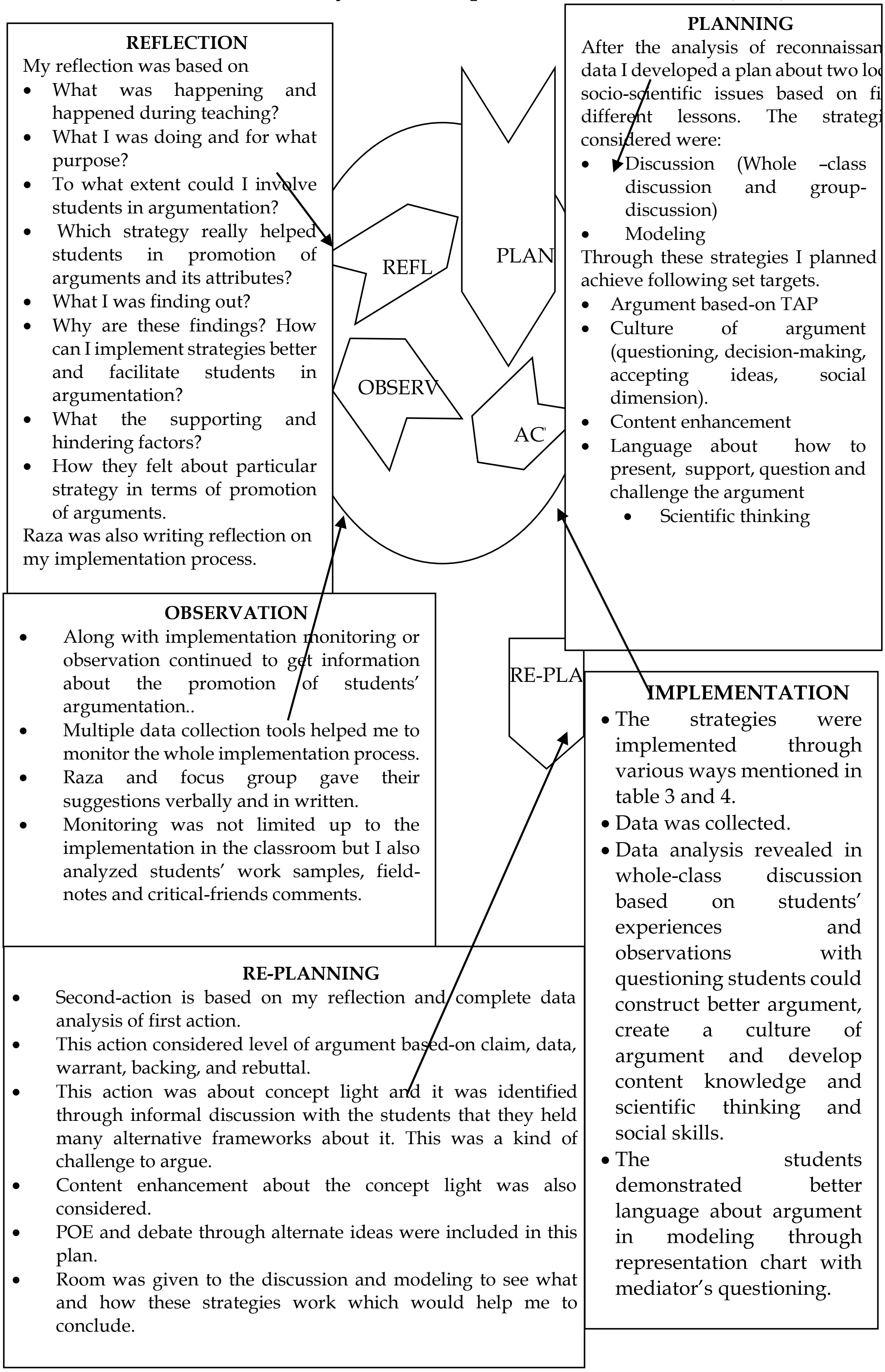


Table 1: Table key: C=claim, CC= counter claim, D= data, WD=weak data, W=warrant, WW=weak warrant, B=backing, R=rebuttal

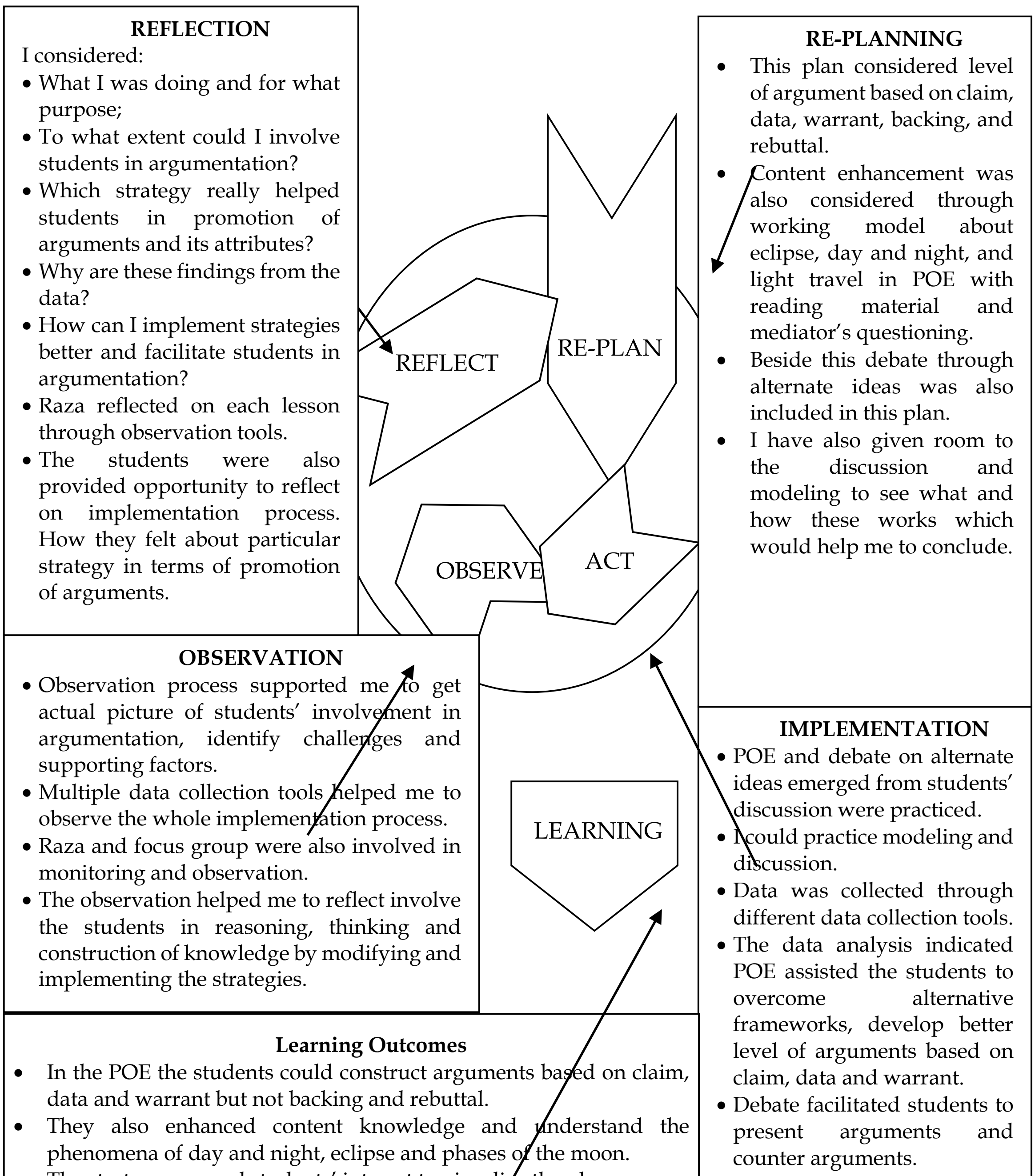
Strategy	Implementation and Arguments based on students responses	Counter Arguments
Whole-class sharing and brainstorming	I asked them: What are the socio-scientific problems in and around the school and how they influence you?. Unhygienic water is problem **C**. It causes diseases **WD**. *Paan* chewing is problem **C**. It creates mouth infection **D**. It creates diseases. February 12, 2021.	No counter claim or argument
Discussion through Showing Pictures	I pasted paan users' pictures and also distributed them among the students and asked them to observe and share their responses. They responses are "We should not use *pann* or *gutka* **C**.Because of using *paan* the tongue becomes thick and gets cut **W**. These pictures show that the tongue gets thick by using *chalia*. Its *pati* [leaves] may cause cancer **WD**" (Focus group February 10, 2021).	Chewing paan is necessary **CC** Because it is natural, so it is beneficial and we should use paan. **WD**
Think-Pair-Share TPS	I asked them to think, discuss and share how the issues are affecting you and what could be the problems? "Using *paan* is our problem **C**. People are using it as food. It should be solved, because it pollutes environment **B**. The benefit of this solution is that we can save ourselves from diseases from mouth cancer. There will be no paan/gutka spitting or pollution. Government should ban on this. **B** It is a problem of science, because it has *choona* ($CaCo_3$) **D**. It creates cancer, (misconception) because of using it, the tongue becomes thick **DW**". February, 12, 2021	We should use paan-parag. **CC.** It saves us from smoking. **WD** Chewing paan is good for toothache. (misconception)
Student-student, and student-teacher questioning	Why do people chew paan? It creates diseases like mouth infections, which may create diseases like cancer **WD**. But people said it strengthen teeth **B**. Teacher: How do you feel chewing about *paan* in the society? It is dangerous **C**. Two people died and they had blood vomiting **D**. We have to make others understand not to use *paan*. So we have to ask them daily not to use *paan-parag,* because it creates diseases **DWB**. Feb 15, 2021	Barkat: Paan-parag is necessary **CC** because without it my mind does not work. **B**
Sharing group work	Eating *paan* and *gutka* is dangerous **C**. Because of chewing *paan,* doctor cut the esophagus of a 65 years old person **D**. February 14, 2021.	*Paan* saves us from smoking and it cures some heart diseases. **CC** Shahid: My mother used to it during toothache. **D**
Whole-class discussion based on students' experiences and observations with questioning	Khalid: Then why do people go to the doctor? Actually it does not strengthen teeth, but it weakens teeth, because *supari* particles get stuck in the teeth **CW**. People chew *paan* in friendship. Majid said: How can we convince people not to use *paan-parag*? Barkat: I work as a dispenser in the clinic. Doctor examined the *paan* chewers and told some of them that their kidneys are affected **D**. First time when we see other we become enthusiastic. It is haram [prohibited] in religion **B**. It affects trachea and teeth **W**. Khalid: Actually there are germs in *gutka*. Have you seen germs in gutka? Barkat: Yes I have seen. Tayab: If you put *gutka* in hot water you can see germs in it which causes different diseases and people die due to it **D**. February 12, 2021.	People chew paan because it strengthens teeth, so paan should be used but some time not daily. **B**.
Discussion through	Focus-group: Story was about water and we should not pollute water, it causes diseases **CWD**.	Human do not pollute water. **CC** If human

story-telling with questioning like what was the story about, how do you know, reasons	Tayab: How do you know?. Because water is a thing that we use water for drinking, washing, and bathing. In all these things, we use water. In all these, water is being use, so it was about water. Majid: if we drink impure water our eyes will be started close **WD**. I would also listen from someone. February 14, 2021	pollute water then how they will drink. **B**

Second Cycle

This action was based on seven lessons about light, day and night, eclipse and the phases of the moon to address their identified alternative frameworks such as "light comes from eyes, day and night happen because the sun rises, eclipse happens, GOD rotates earth and sun" (focus group conversation, February 17, 2021). In these action lessons like day and night, eclipse and phases of the moon came from students sharing and discussion particularly they shared alternative frameworks about these topics. As a teacher it was one my responsibility to provide opportunities to the students to address their alternative frameworks. Following Figure 3 tells overall representation of the cycle.

Figure 3. Visual version of Cycle two adapted from Kemmis et al., 2004 model



Predict-Observe-Explain (POE) through Working Model and Teacher's Sequential Questioning (Mediator)

The purpose of implementation of this approach was to engage students to construct arguments based on claim, data, warrant, backing, and rebuttal. It also aimed at overcoming students' alternative frameworks and constructing scientific knowledge. In order to achieve the well-thought out aims, POE was implemented through the use of a working model about the sun, earth, and moon, represented with the help of bulb, a large and a small ball. In the model, a ball signifying earth was placed in between a bulb signifying the sun and another ball signifying the moon.

This model helped the students to concretize their experiences, which helped them to understand and argue about day and night, eclipse, and phases of the moon. Prior to engaging students in POE through a working model, I asked a question from them: "After looking at the model, recall your daily observations and share how do day and night occur?" To respond to the question, the students not only shared ideas about day and night but phases of the moon and eclipse. Perhaps the recent news of the eclipse on the media helped them to relate to the model to eclipse. The question not only engaged students in presenting their ideas but also supported them with reasons and make explicit many alternative frameworks, such as:

The sun changes its place, and day and night happens. The earth is round and moves behind the sun and the sun also changes its place, but we do not feel. Day and night happen because the sun rises. The sun moves like it rises from the east and sets in the west. If the sun does not change its place, then how day and night come. (Focus group, audio-recorded conversation, March 2, 2021)

The data show students' weak content knowledge and lack of conceptual understanding, which I faced in the beginning of each lesson about the new concept and it hindered students in terms of argumentation. In this process, I realized the important role of the science teacher that she/he can create or strengthen the students' alternative frameworks and also overcome. As the students shared the earth is round and in ball of the model earth was also round. However, I clearly explained that the earth is in elliptical in shape and not round like this ball. Hence, I would say teacher should be very careful at any stage not to create or propagate alternative frameworks.

After getting the students' responses, I moved towards the approach POE. During the approach, the students were engaged in predictions through my sequence questioning such as, 'what will happen' and 'why' if we switch on the model and move a ball representing the earth or moon. To respond to the questions, the students only shared with the class that "bulb will be lightened", but did not share predictions about the concepts. This was amusing for me, because my previous experiences and literature about POE inform that students' share their predictions in response of what will happen. Perhaps these students were not used to predictions; and hence, could not give a complete prediction. Or maybe my question should have been framed alternatively. In this situation, my sequential questioning such as if we lighten the bulb then what will happen with the earth ball and moon ball? The questions helped students to present their predictions, such as: "Half earth ball will be lightened; shadow will form; both balls will lighten; light will spread" (focus group, March 02, 2021). The students' predictions were about the model. At this stage, I could not follow the proper step of POE as mentioned in the lesson plan due to students' unfamiliarity with the approach and their weak content knowledge.

However, for the reinforcement, the students were asked about the model and they shared the bulb, the large, and that small ball to represent the sun, earth and the moon respectively. Then I asked students put a dot on the ball signifying the earth and visualize how we are on that part of the earth. Next the students were engaged from the switch-on the bulb up to the spinning of the earth ball and rotating the moon ball around the earth ball. During this, I was questioning the students, such as: "What is happening with the ball (earth) when you are spinning it? What about the dot? These kinds of questioning forced the students to think and visualize the phenomena about day and night, phases of the moon and the eclipse. After the observation of the working model and my sequential questioning, the students' responses and their level of argument and content knowledge emerged, and this is presented below:

Earth is spinning [claim]. Day and night happen because the earth is spinning. Because now we can see that part of the earth is facing towards the sun in brightened [warrant]. It means in this part is day and back is night. The earth blocks the light of other side [data]. Why does the earth block the light? [Culture] Because it is an opaque body. What reasons do you have? [Language] Let us spin the earth-ball and see what happens. Now I understand why morning, noon, night comes because earth is spinning and sun is not moving [data and warrant]. (March 2, 2021)

The data reveal that the students could construct arguments based on claim, data, and warrant but not by backing and rebuttal, which were also expected to achieve. There could be different reasons, but the most important was students' weak content knowledge. The above data also show that in POE the students could enhance their content knowledge, promote a culture of argument and demonstrated the language of argument to question or challenge each other's ideas. In the culture, I could see the maximum use of 'why' and 'how' with 'what' but here 'what' was not representing close-ended questions. However, the students took more time to respond to the questions and influenced the development and quality of argumentation. Hence, in the argumentation, POE was one of the key approaches to initiate the discussion of reasons and develop scientific thinking because in this approach through the model students visualized the science phenomena.

Conclusion

The study was conducted in the background of the current situation of the level of argumentation in the science classrooms to determine the usefulness of argumentative strategies for the promotion of argumentation by using TAP. The findings of the study indicate the promotion of students' argumentation through the implementation of argumentative strategies. The analysis also shows that the students could develop a better level of arguments, following TAP having claim, data, and warrant and its other aspects. These aspects and argument were observed well in whole-class discussion, based on students' personal experiences and POE through working model about the sun, earth and moon with teacher's sequential questioning. Additionally, the language aspect was improved in modeling through questioning the students' claims. Following are the major conclusions drawn from the findings discussed above.

Prevalent Science Teaching is a Limited Transmission Approach

The prevalent mode of teaching and learning of science included notebook preparation and the telling of factual information to the students, written in the textbook based on jug and mug concept, in which the teacher's role was to pour textbook information and students had to receive and memorize it. In this examination oriented teaching and learning approach, the students could not see the relevance and applicability of science in their everyday lives. The students and the teacher also realized the importance of argumentation, but had a limited view about argumentation. They considered it as a situation, in which students were supposed to share ideas and teacher had to tell the students what is right and wrong.

Discussion as Progressive Argumentative Strategy

Whole-class discussion, based on the students' personal and prior experiences along with the teacher's questioning promoted arguments that were better constructed, and based on claim, data, warrant, and backing. Discussions also helped to enhance students' content knowledge for promote scientific-thinking skills, such as: identifying, relating ideas with the claim, creating personal claims, convincing claims, weighing the ideas, and justifying the claims. The broad scope of discussion in promotion of students' arguments and its related aspects suggests that this strategy could be considered as a progressive argumentative strategy to promote students' argumentation in a science classroom. It also promoted necessary scientific thinking skills such as: reasoning, convincing, justifying, and drawing conclusion.

POE to Visualize Science and Develop Scientific Thinking

The approach POE with the use of working model about the sun, earth and moon along with teacher's sequential questioning was implemented. In addition, role-play about the phases of the moon, and hands-on activity such as three card-board activity, were also implemented to promote arguments, scientific thinking, and understanding of the concepts. In this approach, the expected level of argument could not be realized, but students were thinking, questioning, reasoning, predicting, observing, interpreting, explaining, justifying, and convincing each other through arguments. This shows that the students developed scientific-thinking skills. They also addressed their alternative frameworks about the concepts; light rays, day and night, and the phases of the moon by visualizing the phenomena. However, in this approach expected level of argument was not observed, which does not mean that this approach failed to facilitate the students in promoting argumentation. The reason is in POE through working model their arguments were based on claim, data, warrant, and weak rebuttal. However, backing and rebuttal were also included in set objectives, but only weak rebuttals were obtained. It is likely that the students' weak content knowledge with strong alternative frameworks hindered to achieve expected level of arguments, but their interest and eagerness to learn supported it. The reason is POE provided an opportunity to the students, to express their predictions and the observation about the phenomenon and also created cognitive conflicts. These conflicts seemed to be the sources of argumentation and conceptual understanding, which embedded thinking skills. This seems relevant approach for promoting a culture of scientific thinking in the class, in which the members of scientific community can think and discuss in a scientific manner.

References

Bhutta, S. M., & Rizvi, N. F. (2022). Assessing teachers' pedagogical practices and students' learning outcomes in science and mathematics across primary and secondary school level: A nationwide study (2018-21). Aga Khan University, Institute for Educational Development, Karachi,.

Boettcher, F., & Meisert, A. (2011). Argumentation in science education: A model-based framework. Science & Education, 20, 103–140.

Bulgren, J. A., & Ellis, J. D. (2011). Argumentation and evaluation intervention in science classes: Teaching and learning with Toulmin. In (pp. 135-154). In Perspectives on scientific argumentation: Theory, practice and research (pp. 135–154). Springer.

Erduran, S. (2018). Toulmin's argument pattern as a "horizon of possibilities" in the study of argumentation in science education. Cultural Studies of Science Education, 13(4), 1091–1099.

Giri, V., & Paily, M. U. (2020). Effect of scientific argumentation on the development of critical thinking. Science & Education, 29(3), 673–690.

Hali, A. U., Aslam, S., Zhang, B., & Saleem, A. (2021). An overview on STEM education in Pakistan: Situation and challenges. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 12(1), 1–9.

Kemmis, S., McTaggart, R., & Retallick, J. (2004). The action research planner (2nd ed.). Aga Khan University Institute for Educational Development.

Magalhães, A. L. (2020). Teaching how to develop an argument using the Toulmin model. International Journal of Multidisciplinary and Current Educational Research (IJMCER), 2(3), 1–7.

Metaxas, N., Potari, D., & Zachariades, T. (2016). Analysis of a teacher's pedagogical arguments using Toulmin's model and argumentation schemes. , 93, 383-397. Educational Studies in Mathematics, 93, 383–397.

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). TIMSS 2019 International Results in Mathematics and Science (ISBN-978-1-889938-54-7). TIMSS & PIRLS International Study Center, Lynch School of Education and Human Development, Boston College andInternational Association for the Evaluation of Educational Achievement (IEA).

Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in the pedagogy of school science. International Journal of Science Education, 21(5), 553–676.

Novaes, C. D. (2021). Argument and argumentation.

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 39(1), 35–62.