Analogy in secondary physics teaching-learning: Teachers' views and practices in Bangladesh

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Abstract

Analogical reasoning is a basic learning mechanism. Analogy in teaching science is a very popular pedagogical approach in many countries. The use of analogy is not recognized as one of the formal teaching learning strategies to facilitate students' science learning in Bangladesh. In secondary science teaching, teachers' unconscious and unsystematic use of analogy cause misunderstanding for learners which is a barrier to promote scientific literacy among students. This study investigated secondary physics teachers' views and practices of analogy as a teaching learning strategy in the context of Bangladesh. It followed explanatory sequential

mixed method design. Quantitative data was collected through questionnaire (Likert scale) from 55 secondary school physics teachers. Case studies were conducted for qualitative data through lesson observations, interviews and document analysis. The findings reveal that teachers consider analogy to be an effective tool, but they have less idea as it was not embedded in any of their professional programs or in-service trainings. It is hard to find any quality source of analogies for seconday physics in Bangladesh. They even do not know about any models of using analogy yet which leads to inappropriate use of analogies. Teachers mostly think that analogy would be more suitable in the context of Bangladesh as we have shortage of instruments and teaching aids. This study will inform teacher educators about the deficiency of guideline for our teachers about using analogy in physics teaching. Textbook writers will also get guideline about which analogies are preferable. Further research can be conducted on which types of analogies in our science textbooks are suitable and which are not. Which models of using analogy are preferred by teachers can also be explored.

Keywords: Analogy, curriculum, secondary physics teaching, Bangladesh

Introduction

Analogies and models are excellent inquiry tools. Analogies use familiar, everyday situations that can be used to explain difficult and abstract ideas (Harrison, 2004). An analogy is a process of identifying similarities and dissimilarities between two concepts. The familiar, everyday object or concept is called the analogue and the unfamiliar, scientific idea or concept we are trying to explain is called the target (Harrison, 2004). The strength of an analogy lies less in the number of features the analogue and target domains have in common than in the overlap of relational structure between the two domains (Gentner, 1983). Harrison (2004) asserted that analogies are effective when the everyday object or event is familiar and the students can identify when the analogy is valid and when it breaks down. When the analogies are unfamiliar or the analogy breaks down, alternative conceptions often follow. Harrison (2004) also described the role of shared and unshared attributes when using analogy. Ways in which the analogue is like the target concept are called the analogy's shared attributes (or positive analogy). Ways in which the analogue seems to be like the target, but is not, are called unshared attributes (or negative analogy).

Context of Bangladesh

In Bangladesh we have three types of schooling systems at national level- General Education, Madrasah Education and Vocational Education System. In all system of secondary level we have three streams- Science group, Humanities group and

Business Education group. If we compare the students' enrollment group wise, we will find that the rate of science group's enrollment is decreasing year by year (BANBEIS, 2015). Science education in our country is failing to attract students due to lack of proper teaching learning activities, enough instruments and competent teachers.

Analogy is not a formally recognized science teaching learning strategy for science concepts in the curriculum of Bangladesh. Teachers use different analogies unconsciously but do not use it regularly (Tapan, 2010). Sometimes, when students do not understand the concepts and the content demands its use, they try to use analogy particularly as teaching aid but they do not know about the models of using analogies. Teachers do not have any guideline. Uncritical use of analogies may generate misconceptions, and this is the case, especially when unshared attributes are treated as valid, or when learners are unfamiliar with the analogy. In secondary science teaching, teachers' unconscious and unsystematic use of analogy cause misunderstanding for learners which act as a barrier to promote scientific literacy among students (Halder & Rahman, 2015). The past research only focused on secondary science teaching practice to promote scientific literacy by using analogy (Halder & Rahman, 2015). That study only focused on the enrichment of analogy to explore teachers' practice. In Bangladesh, research on physics teachers' views towards using analogy and their practice in teaching through a detailed classification system has not been conducted so far.

Purpose and Research Questions

The purpose of this study is to explore secondary physics teachers' views and current practice regarding analogy in teaching physics.

The following research questions are going to address the above purpose of the study.

1. What are the views of secondary teachers' on the use of analogies in teaching physics?
2. What type of analogies do secondary physics teachers use in their classroom practice?

Theoretical Framework

This section represents the literature related to basic understanding of using analogy and the classification of analogies. Jonane (2015) focused on several aspects of analogies to understand teachers' views. In this current study, these aspects of analogies were included in the questionnaire for this study. Teachers' practice of using analogies were analyzed and divided into five categories according to the

classification system developed by Thiele and Treagust (1994) and Curtis and Reigeluth (1984). These categories were used to analyze the types of analogies teachers frequently use during their teaching.

Framework for teachers' view

Teachers' views were analyzed and presented as their belief and their understanding on analogy. To ensure teacher's purposeful use of analogy, teachers need positive belief and a sound understanding on analogy. Teachers' beliefs about the necessity of analogy in Bangladesh need to be revealed as they are the one who will use this pedagogical approach in their teaching. They need to know the proper manner of using analogy, appropriate time of using and an idea about required competency for both students and teachers.

Analogies help to understand complex and abstract concepts, but analogues need to be familiar to students. It is found in many studies that analogies can promote meaningful understanding of complex scientific concepts during science teaching and learning (Harrison, 1993; Gentner, 1983; Wong, 1993; Friedel, Gabel & Samuel, 1990). However, if the teacher uses an unfamiliar analogue to the learner, development of understanding through use of that particular analogy is constrained (Jonane, 2015).

Exploring prior knowledge and purposeful use of analogies are necessary. From the study of Jonane (2015), it is found that purposeful use of analogy develops students' ability to apply knowledge to new situations and assist development of transferred skills. According to Treagust and Duit (2012) when teachers use analogies, this creates an increased awareness in the teacher that they also need to take students' pre-instructional conceptions into consideration when teaching.

Analogies may create misconception among students. At some point, however, every analogy "breaks down" as there are always a number of similarities and dissimilarities between analogue and target. It is precisely at that point when misconception and misdirection can begin (Glynn, 1991). For this reason, Duit and Glynn (1996) have said that analogies are 'double edged swords'.

Stating both shared and unshared attributes is crucial. For understanding conceptual ideas, explaining the likes and unlike are important. Glynn (1991) and Harrison and Coll (2008) recommended that teachers discuss with their students the everyday aspects of the analogy, the ways in which the familiar instance or event teaches about a scientific concept along with where the analogy breaks down. For understanding conceptual ideas, explaining the likes and unlike are important. Clarifying analogies in this way enriches them and makes them more effective (Duit, Roth, Komorek, &

Wilbers, 2001; Glynn, Britton, Semrud-Clikeman & Muth, 1989; Harrison and Treagust, 2006; Iding, 1997).

Using analogy requires students' competency. Holyoak and Thagard (1995) posit that the very act of forming an analogy requires a kind of mental leap to visualize one thing as if it were another. Treagust and Duit (2012) claimed that if the students lack visual imagery, the value of analogies may be limited. Jonane (2015) claimed that famous analogies in science frequently induce mental leap among students. Cruz-Hastenreiter (2015) emphasized that analogies activate analogical reasoning, organize perception and develop cognitive skills like creativity and decision making. Analogies from life also inspire imagination.

Using analogy require teachers' competency. Treagust and Duit (2012) claimed that using analogy also requires planned strategy which demands competent teachers. Halder and Rahman (2015) found that teachers don't know about FAR guide, they do not conclude by summarizing analogy's outcome and they are not concerned about self-reflection. The study of Gess-Newsome (cited in Glynn, 2008) mentioned that using analogies without knowing the way of presenting it is risky. Most of the studies regarding analogy suggested following a model for teaching with analogies.

Teachers' views need to be evaluated through these aspects as teachers need competency and a proper understanding on using analogy for using these properly. In Bangladesh, on average about 15% schools and 31% madrasahs have no science laboratory. 13.5% rural and 20.3% urban high schools and 23.1% and 13.6% urban madrasahs purchase equipment regularly (BANBEIS, 2015). Conducting inquiry-based teaching is quite difficult without instruments. Analogy is a vital teaching pedagogy and an excellent inquiry tool. It is not a popular pedagogical approach in our country. Teachers' belief and understanding on analogy need to be explored and addressed in order to introduce this approach in our country. Jonane (2015) used the aspects discussed above for exploring teachers' view regarding analogy.

Framework for teachers' practice

Analogies were classified into five categories according to the classification system developed by Thiele and Treagust (1994) and Curtis and Reigeluth (1984). This classification system was used to identify teachers' frequently used analogies' classification and therefore, teachers' practice.

Table I. The analogical relationship between analogue and a target

Types	Definition

Structural	The analogue and target concepts in the analogy share attributes of shape and size
Functional	The analogue and target concepts in the analogy share attributes of function, behavior.
Structural-functional	The analogue and target concepts in the analogy share both structural and functional attributes.

Table II. The presentational format

Types	Definition
Verbal	The analogy is presented in the text in a verbal format only
Pictorial-verbal	The analogy is presented in a verbal format along with a picture, drawing or visual model of the analogue.

Table III. The level of abstraction of the analogue and target concepts

Types	Definition
Concrete-concrete	Both the analogue and the target concepts are of a concrete nature
Concrete-abstract	The analogue concept is of a concrete nature but the target concept is an abstract
Abstract-abstract	Both the analogue and the target concepts are of an abstract nature.

Table IV. The position of the analogue relative to the target

Types	Definition
Advance the organizer	The analogue concept is presented before the target concept in the text
Embedded activator	The analogue concept is presented with the target concept in the text
Post-synthesizer	The analogue concept is presented after the target concept in the text.

Table V. The level of enrichment

Types	Definition
Simple	In this type of analogy, only one similarity is underlined between the analogue and the target concepts. The analogy is formed of a simple sentence with no details. Analogue ↔ Target
Enriched	It tells the student that the analogy is about processes, about dynamic functions and not limited to superficial structures. Indeed, the difference between a simple structural analogy and an enriched functional analogy is the addition of some form of causation; that is, a simple analogy is descriptive whereas an enriched analogy is more explanatory Analogue ← grounds (limitations) → Target
Extended	Two or more similarity dimensions between the analogue and target concepts are underlined. Extended analogies contain a mix of simple and enriched mappings or all the mappings are enriched analogies. The "eye is like a camera" analogy is an extended analogy. The grounds on which an "eye is like a camera" are stated in each case and there are multiple shared attributes in the analogy (and some limitations or unshared attributes) (Harrison & Treagust, 2006) Single analogue: Analogue ← Grounds (limitations) → Target Analogue ← Grounds (limitations) → Target Analogue ← Grounds (limitations) → Target Multiple analogues: Analogue ← Grounds (limitations) → Target Analogue ← Grounds (limitations) → Target Analogue ← Grounds (limitations) → Target

Five aspects for classification of analogies are presented here. These aspects have been used to explore physics teachers' current practice in secondary level.

Methods

The method of data collection followed explanatory sequential mixed method. Quantitative data (survey) was collected to select the cases and then qualitative data (case studies) was collected. The study was conducted on 55 secondary physics teachers to determine the teachers with better understanding of analogy. The questionnaire used for this determination process also explored their views on using analogy. Three teachers were chosen from them and selected as three cases for lesson observations to understand their practice and interviews to explore their views furthermore. Classwork copies of students from those three cases were also analyzed.

The teachers at the first phase (55 teachers) were selected through convenient sampling and at the second phase, three of them were selected purposefully with better understanding of analogy. Students (3 from each case) for analyzing classwork copies (document analysis) were also selected purposefully and these were the students who are most attentive ones in the classes, who take notes regularly.

Data analysis

For the quantitative part of the study, a five-point likert scale with 16 statements was used. Here, scale 5= strongly agree, 4= agree, 3=uncertain, 2= disagree and 1= strongly disagree. Negatively worded questions were counted oppositely. There were 16 statements in the questionnaire and score of all the statements for each teacher was counted and summed up to determine high scoring teachers. Three teachers with high scores were chosen as they have better understanding of analogy. After choosing those teachers as cases, lessons were observed, interviews were conducted and classwork copies were analyzed. Views of teachers were presented as two categories- their belief and their understanding. Descriptive analysis was used for types of analogies teachers use in their practice and presented through graphical representation. Analogies were analyzed and divided into five categories according to the classification system developed by Thiele and Treagust (1994) and Curtis and Reigeluth (1984). These categories were used to analyze the types of analogies teachers frequently use during their teaching.

Result and Discussions

Findings of the two research questions are presented here sequentially and discussed to serve the purpose of this study with the support of relevant literature.

Teachers' views

Teachers' views were collected through both questionnaire and interviews. The interviews were conducted to explain or elaborate on the data collected through questionnaire. This portion presented as two themes which are teachers' belief and teachers' understanding.

Teachers' belief: Statement 1, 2 and 3 of the survey questionnaire represent teachers' belief about their own teaching regarding analogy.

Table VI. Teachers' belief about their own teaching regarding analogy

Statement	SD	D	UN	A	SA	Mean Score	Indication of Mean
1. During physics lessons, I sometimes use analogies consciously	0	0	0	33	22	4.4	Teachers have claimed that they sometimes use analogies consciously during Physics lessons.
2. More frequently I use analogies consciously rather than when they arise spontaneously	0	2	1	32	20	4.27	Teachers have agreed that they use analogies consciously rather than they arise spontaneously.
3. I encourage students to analyze analogies contained in textbooks	1	1	0	34	19	4.25	Teachers have agreed that they encourage their students to analyze analogies from the textbooks.

N.B: SD- Strongly Disagree, D- Disagree, UN- Uncertain, A- Agree, SA- Strongly Agree

The results represent that all the teachers (100%) claimed that they use analogies during physics teaching learning. Almost all (94.6%) of the teachers use analogies consciously rather than they arises spontaneously and encourage (94.5%) their students to analyze analogies contained in textbook.

Statement 13 and 16 represented teachers' belief about the effects of analogy on students.

Table VII. Teachers belief of the effect of analogies on students

Statement	SD	D	UN	A	SA	Mean Score	Indication of Mean
13. If the teacher uses analogy in an explanation,	1	6	5	40	3	3.69	Teachers have agreed that if they use analogy during teaching

the students reiterate it in their answers or discussions							learning, students use it in their answer scripts too.
16. At the end of secondary education, most students have sufficiently developed analogical reasoning	0	2	3	37	13	4.11	Teachers agreed that most students develop the analogical reasoning skill by the end of their secondary education.

N.B: SD- Strongly Disagree, D- Disagree, UN- Uncertain, A- Agree, SA- Strongly Agree

Majority (78.2%) of the respondents agreed that students reiterate the analogy they learn in the classroom in their answers during a test. Majority (91%) of the respondents agreed that most students sufficiently develop analogical reasoning at the end of secondary education.

Participant teachers have positive belief about their own teaching regarding analogy. They think that they use analogies consciously and they encourage their students to analyze analogies contained in textbooks. Teachers' belief on the effect of analogy on students is positive but they think that students reiterate the analogies used in the classroom in their tests. Teachers also think that using analogy is more suitable for Bangladesh as we have lack of instruments and other teaching aids and also financial constrain in educational sector. We have time constrain and the number of students is also high and it creates difficulty in conducting inquiry-based teaching in science class.

Brown and Salter (2010) suggest that it is extremely important that due caution be exercised to be sure that students remember the content and not just the analogy. In Bangladesh, on average about 15% schools and 31% madrasahs have no science laboratory (though there is a small store of a little amount of equipment in a self or in a drawer of head master's / principal's room or in teachers room). 13.5% rural and 20.3% urban high schools and 23.1% and 13.6% urban madrasahs purchase equipment regularly. More than 50% schools and Madrasahs have no provision for annual budget for laboratory fund (BANBEIS, 2015). Due to this situation, using analogy is more preferable for science teaching in Bangladesh.

Teachers' understanding: Statement 4, 5, 6, 7, 8, 9, 10, 11, 12, 14 and 15 referred to teachers understanding on the effectiveness of analogy.

Table VIII. Teachers' understanding on the effectiveness of analogy

Statement	SD	D	UN	A	SA	Mean Score	Indication of Mean

4. I think that analogies help students to imagine and understand directly perceived objects or processes	7	13	2	20	13	2.65	Teachers' view about this item is uncertain. Some think that analogies help students to understand objects or processes even if it can be perceived directly while others have a total opposite point of view. Due to the variety of perspectives, teachers' view is uncertain.
5. I think that analogy contributes to development of imagination	0	2	0	19	34	4.55	Teachers have strongly agreed that analogy contributes to the development of imagination of the students.
6. I think that analogy contributes to understanding of abstract concepts	0	1	0	37	17	4.27	Teachers have agreed that analogy contributes to understand abstract concepts.
8. Analogy sometimes diverts attention from the main concept which misleads students	10	19	11	12	3	2.62	Teachers' view about this item cannot be generalized. They have various perspectives and as a whole, their thinking about the negative feature of analogy is uncertain. They are not sure if analogy can mislead students or not.

N.B: SD- Strongly Disagree, D- Disagree, UN- Uncertain, A- Agree, SA- Strongly Agree

Only one third (36.3%) of the respondents think using analogy won't be effective when students get the chance of direct experience. Almost all (96.3%) of the respondents think analogies can develop imagination among students. 98.2% respondents think that analogy contributes to understanding of abstract concepts. Only 27.3% respondents think that analogy can mislead students and 20% are uncertain about it.

Statement 7, 9, 10, 11, 12, 14 and 15 referred to the understanding of teachers about how to use analogy.

Table IX. Teachers' understanding on using analogy

Statement	SD	D	UN	A	SA	Mean Score	Indication of Mean
7. Even if the analogue is unfamiliar to the learners, using	6	16	1	30	2	2.89	Teachers are uncertain about the fact that if the analogue used during using analogy

analogy can be effective for teaching learning							should be familiar to the students or not.
9. Using analogies do not require information about students' prior knowledge	7	28	0	19	1	3.38	Teachers are uncertain if students' prior knowledge should be explored before using analogy or not.
10. Analogy is effective without drawing similarities and dissimilarities between analogue and target	5	27	5	15	2	3.27	Teachers are uncertain if drawing similarities and dissimilarities between analogue and target should be drawn or not during using analogies.
11. Visualization of analogy is more effective than just the process of negotiation	7	21	8	16	2	2.67	Teachers are uncertain if visualization of analogy is more effective than just negotiation process.
12. When the teacher provides verbal analogy in class, the students are left to work out comparisons and conclusions about the target	4	16	3	25	7	3.27	Teachers are uncertain about the fact if only verbal analogy is sufficient for students or not.
14. Purposeful use of analogies develops the ability to apply knowledge to new situations, develops transfer skills	4	10	7	19	15	3.56	Teachers have agreed that purposeful use of analogies develops students' ability to apply knowledge to new situations.
15. Learning with analogies requires a mental "leap" because it involves imagining one thing as another	3	12	3	27	10	3.53	Teachers agreed that students need a mental leap for learning with analogies.

N.B: SD- Strongly Disagree, D- Disagree, UN- Uncertain, A- Agree, SA- Strongly Agree

Only 40% of the respondents think that analogue need to be familiar to the students for analogy to be effective in teaching learning while others think there is no need of using analogues familiar to the students. More than half (63.7%) of the respondents think that there is no need of students' prior knowledge exploration before using analogy and 58.2% think that analogies can be effective even without drawing similarities and dissimilarities between analogue and target. Only 32.7% respondents think that visualization of analogy is more effective than just the process of negotiation while 14.5% are uncertain about this. 58.2% respondents think that students are left to work out comparisons and conclusions about the target if it is

presented only verbally. Purposeful use of analogies is thought as effective to develop the ability to apply knowledge to new situations and to develop transfer skills by more than half (61.8%) of the respondents. 67.3% respondents agreed that students need a mental leap for learning with analogies.

Teachers have just a little idea about this pedagogy and not confident about using it in teaching learning. From interview, it was found that they have no guideline of using analogies and they are not aware about using it. They use it unsystematically. Teachers need to be informed about the effectiveness of analogy so that they can use it effectively more often during teaching-learning. The main sources of teachers' used analogies are textbook, internet and natural environment and they think they need more sources for ensuring quality teaching.

The mean values of each statement delineate a better understanding of teachers view about the statements. Total mean of these 16 items is 3.6 which indicates that teachers have some idea but do not have sufficient knowledge about analogy. Analogies' positive and negative features are not clear to them and they are uncertain about some vital items related to analogy. They have a little experience with analogies and they are not confident about this pedagogy.

According to Treagust and Duit (2012), science teachers can use analogies more effectively through a carefully planned strategy. The conclusion by Cruz-Hastenreiter (2015) suggests that during teaching learning activities the use of analogies can be planned to promote analogical reasoning. From the study of Jonane (2015), it is found that 'purposeful use of analogy develops students' ability to apply knowledge to new situations and assist development of transfer skills.' Duit and Glynn (1996) have said that analogies are 'double edged swords' as it can create misconception. Treagust and Duit (2012) claimed that attributes that are not similar between analogy and the target often cause misunderstanding. Research has shown that it is essential for teachers to ensure that their explanations using models are student friendly and compatible with students' existing knowledge. Exploring students' prior knowledge and daily life experience is considered as helpful for students to understand the unfamiliar and abstract concept by Halder and Rahman (2015, p.57).

Researchers suggest that analogy acts as an effective pedagogical approach which needs to be presented systematically for avoiding its negative features. There are several models of using analogy such as FAR guide, TWA model, WWA model and GMAT model. Teachers need to follow any recommended model for using analogy according to their choice or comfort. Teachers need training on how to use analogy and need to be informed about models of using it. Jonane (2015) claimed that famous

analogies in science frequently reveal an ability to make mental leap, so teachers need a good source of analogies to get access to famous analogies easily.

*The FAR (Focus-Action-Reflection) guide is recommended by Curtis & Reigeluth (1984)
*Teaching-with-Analogies (TWA) model is developed by Glynn (1991)
*Working with Analogies model is suggested by Nashon (2000)
*General Model for Analogy Teaching is provided by Zeitoun (1984)

From the above discussion, we can say that, using analogy need to be systematic and planned before using it in the classroom. Analogies need to be used to understand difficult and abstract concepts and to reduce the problem of misleading. Uncritical use of analogies need to be avoided. Suitable analogy is must in this regard. Prior knowledge exploration of students is necessary before using analogy and drawing similarities and dissimilarities is crucial. Mental leap of students is a must for learning with analogies and analogy itself can develop imagination among students, but it must be used purposefully. Teachers need a good source of analogies with famous and effective analogies as previous researches suggest that famous analogies have positive effect on students.

Teachers' practices

Case studies were conducted to examine teachers' practices. Lesson observations (9 lessons) of three teachers and analyzing students' classwork copies (3 from each case) were combined together to understand teachers' practices.

Table X. Teachers' understanding on using analogy

Lesson No	Analogue	Target
1	Tailorbird, their baby and their function around the nest	Structure of atom (nuclease, electron, proton, neutron)
2	Flow of water	Heat transfer
3	Traditional fishing gear (Horga)	Capacitor
4	Pushing students during assembly	Movement of sound wave

5	Bald head, satellite dish	Concave and convex mirror
6	Flow of heat	Current flow (I) ∝ Potential difference (V)
7	Football and goalpost bar	Sound wave forming echo
8	Thread wheel	Structure of solenoid
9	Flow of water from water tank	Difference between static and current electricity

Table XI. Analogues and targets of analogies from document analysis

Analysis	Analogue	Target
1	Prayer beads	Direction of current flow

Total classification of analogies from lesson observation and document analysis is given below.

Here are nine analogies from nine lesson observations and one from document analysis which are categorized into different types on the basis of five categories. The types of analogies according to these categories are given below.

Table XII. Classification of analogy from lesson observations

Lesson	Relationship	Presentation	Abstraction	Position	Enrichment
1st	Structural-functional	Verbal	Concrete-abstract	Embedded-activator	Enriched
2nd	Functional	Pictorial-verbal	Concrete-abstract	Advance the organizer	Simple
3rd	Functional	Verbal	Concrete-abstract	Advance the organizer	Enriched
4th	Functional	Verbal	Concrete-abstract	Post-synthesizer	Simple
5th	Structural	Pictorial-verbal	Concrete-concrete	Post-synthesizer	Simple
6th	Functional	Verbal	Abstract-abstract	Advance the organizer	Simple
7th	Functional	Pictorial-verbal	Concrete-abstract	Advance the organizer	Simple

8th	Structural	Verbal	Concrete-concrete	Advance the organizer	Simple
9th	Functional	Verbal	Concrete-abstract	Advance the organizer	Simple

Table XIII. Classification of analogy from document analysis

Analysis	Relationship	Presentation	Abstraction	Position	Enrichment
Analysis 1	Functional	Verbal	Concrete-abstract	Post-synthesizer	Simple

Graphical representations of classified analogies are given below.

Total 10 analogies form lesson observation and document analysis were analyzed through five categories. The graphical representations of these categories are presented here:

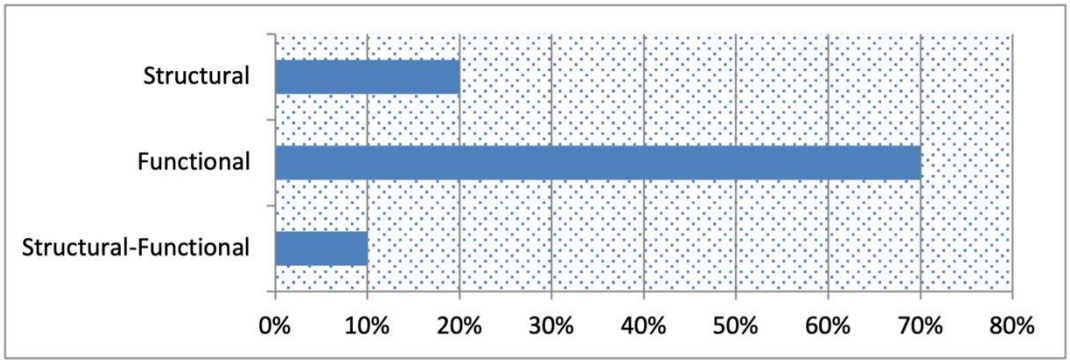

Figure 1. The analogical relationship between analogue and target

Mostly functional similarity (70%) was drawn between analogue and target, some were of structural similarity (20%) and only 10% were of structural and functional both similarities.

Curtis and Reigeluth (1984) stated that a purely structural analogy focuses on a unique similarity between an analogue and a target but the number of differences between an analogue and a target is also high. According to them, functional analogies tend to be used to teach complex and abstract subjects. Curtis and Reigeluth (1984) suggested to use structural-functional analogies as they are more comprehensive and more powerful in terms of expression.

The recommendation for analogical relationship during using analogy is

Structural-Functional > Functional > Structural

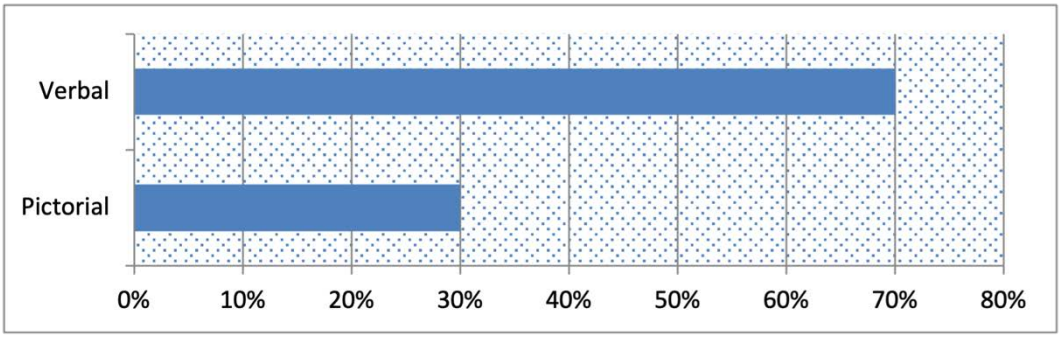

Figure 2. The presentational format

Majority of the analogies were verbally (70%) presented, others were presented both pictorially and verbally (30%).

According to Treagust and Duit (2012), if teachers provide verbal analogies, the students are left to compare and conclude about the target from the description of analogy on their own. Pictorial analogies can highlight more of the desired features of the analogy to the students and this visualization can reduce the insufficiency of familiarity with the analogy.

From this statement, we can say that pictorial-verbal analogies are more effective than only verbal analogies. From observation and document analysis, it is found that most analogies were used verbally. This should be changed and more pictorial-verbal analogies need to be included. But from the studies of Treagust, Duit, Joslin & Lindauer (1992); Dagher (1995); Venville and Treagust (1996) and Sizmur and Ashby (1997), it is found that the presentation of analogies is mainly through verbal descriptions (cited in Ramos, 2010). Curtis and Reigeluth (1984) stated that verbal presentation format may be sufficient for teaching analogical relationships but pictorial-verbal format is preferable for students at lower level.

The recommendation for presentation format is

Pictorial-Verbal > Verbal

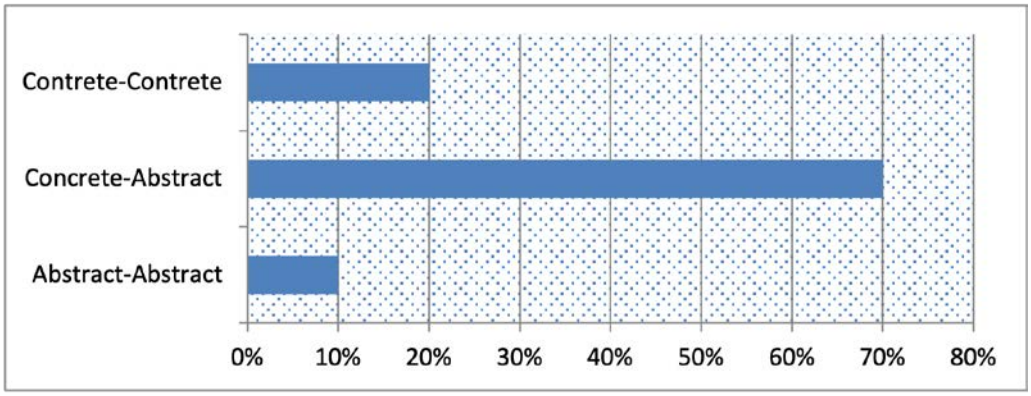

Figure 3. The level of abstraction of the analogue and target concepts

Analogues were mostly concrete and targets were abstract. In 70% cases, analogues were concrete and targets were abstract. On the other hand, in 20% cases analogues were concrete and targets were abstract. Only in 10% cases both analogues and targets were abstract.

Concrete analogies facilitate understanding of abstract concepts by pointing to similarities between objects or events in the students' world and the phenomenon under discussion (Aubusson, Treagust & Harrison, 2009). This means that analogues should not be abstract.

The recommended level of abstraction for analogues is

Concrete > Abstract

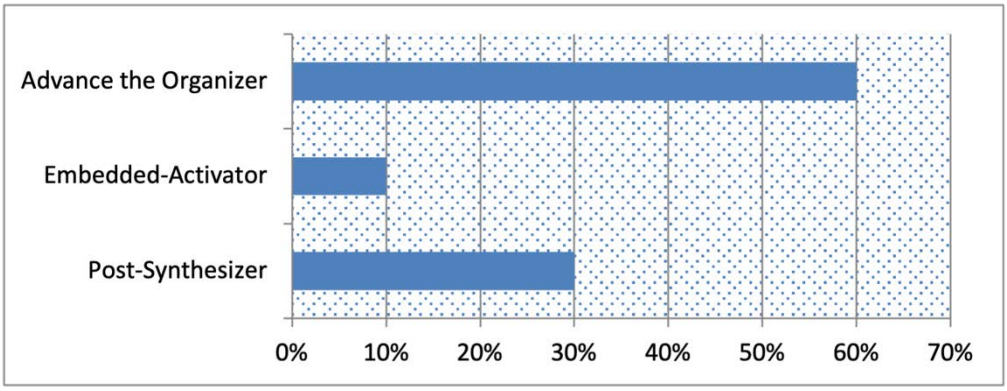

Figure 4. The position of the analogue relative to the target

In more than half of the cases (60%), analogues were presented before targets (advance the organizer). In some classes (30%) targets were presented before analogues (post-synthesizer). Only in 10% cases, targets were presented along with analogues (embedded-activator).

Curtis and Reigeluth (1984) and Newton (2003) mostly found Advance the Organizer and Embedded-Activator analogies through their studies and these are better than Post-Synthesizer.

The recommended position of the analogue and target is

Advance the Organizer / Embedded-Activator > Post-Synthesizer

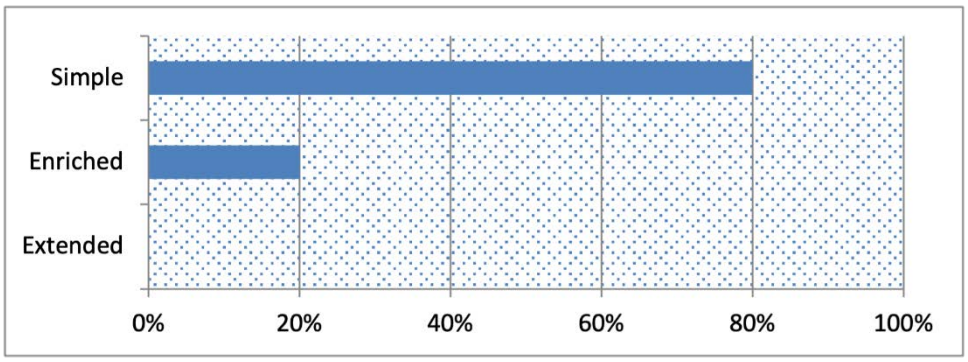

Figure 5. The level of enrichment

80% used analogies were simple and only 20% were enriched. No extended analogies were found.

Harrison and Treagust (2006) recommended that the recognition and mapping problems can be reduced if teacher explicitly alert students to the analogical conditions, which means they suggested using enriched analogies over simple ones. The research studies of Glynn and Takahashi (1998) found that in an extended analogy, analogue features are systematically mapped onto the target features and verbal and imaginary process are also active. Another study of Carey's (cited in Harrison & Treagust, 2006) claims that extended analogy promotes deep thinking and conceptual understanding. According Akcay (2016), misunderstandings or misinterpretations can be avoided by enriched analogies through providing details on the extent and limitations of specific analogies. The above discussion represents that simple analogy may generate alternative conception or confusion among

students so it is better to use enriched and extended analogies with analogical conditions.

The recommended level of enrichment for analogies is

Extended / Enriched analogies > Simple analogies

In our country, simple analogies are mostly used and presented verbally. In most cases, functional relationship between analogue and target is established. Analogues are mostly presented before targets. Most of the used analogues are concrete. We can say that, the types of analogy used and their presentation format is not up to the mark.

From literature, preferable analogies are of enriched or extended types and it is better to present through both verbally and pictorially. Analogues need to be presented before or along with targets and should be of concrete in nature. Functional or structural-functional analogies are preferred over only structural analogies.

Implications

This study can inform our science teachers about the importance of this pedagogy. It has the potential to motivate them to use analogy more often during teaching learning and avoid the negative features. Teachers can include more analogical items in tests to develop mental leap among students. This study will be beneficial for the school authorities as it finds that teachers face problem due to high workload and time constraint. The findings of this study can inform the educators about the negative impacts of using this pedagogy without any structured model and inspire them to provide guideline for teachers through in-service and professional teacher trainings. The effectiveness of purposeful use of analogies can influence our educators to include it in our curriculum as a pedagogical approach. This study explores types of analogies which are effective. Textbook writers can follow this study to include suitable analogies for abstract and complex targets.

There are many scopes to conduct researches on this pedagogy as it is quite new in our country. Analyzing the types of analogies in our existing science textbooks, recognizing the effective ones and the ones that may induce misconception demand urgent concerns. This study only included secondary level physics teachers. Further research on secondary chemistry, biology teachers or teachers of primary or junior secondary level can be conducted.

Conclusion

This study has revealed a critical problematic situation in secondary physics teaching practice of Bangladesh. Teachers mostly use inappropriate analogies. Views of teachers indicate that promoting the use of analogies would be effective as a way to compensate for the lack of instrument in science classes. Teachers are not competent enough and not trained for using analogies, which need to be resolved immediately. Analogy is an effective pedagogy and it has also some negative features. Teachers have no guideline for using analogy. Analogies need to be used through a suitable model and there are already some established effective models. Teachers of our country do not have any idea about these models and use analogy unconsciously and unsystematically which may bring the negative features. This pedagogy is not included in any professional training programs or in-service trainings. Although the findings of this study may seem trivial, the concept of Analogy as pedagogy is still a very new one in Bangladesh and almost all of our teacher are unaware about it. Through this study, the importance of guideline for teachers is revealed and teacher educators can take a step to include it in the current education programs to minimize the problems.

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