



# **Teachers' and Students' Perceptions on Introduction of Astrophysics in Bhutanese Curriculum: An Exploratory Study**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author TD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TD and KU managed the analyses of the study. Authors KU and UP managed the literature searches. All authors read and approved the final manuscript.*

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## **ABSTRACT**

Astronomy education is rapidly growing because of its significant benefits to everyday life. Hence, Royal Education Council has introduced Astrophysics content for Bhutanese students in the curriculum from 2015. Royal Education Council is the highest decision-making body that initiate and implement educational reforms and school curriculum in Bhutan. Using Mixed-methods approach, this study investigated the perceptions of teachers and students on introduction of Astrophysics in Bhutanese curriculum. The study was carried out in four schools under Trashigang District from 1<sup>st</sup> March to 20<sup>th</sup> March 2020. The data were collected through survey questionnaire and structured interview. The sample comprised of 298 students (119 male and 179 female) and 11 teachers. The study found out that the teachers and students possess negative perceptions towards teaching and learning of Astrophysics. For majority of the students, the concepts of Astrophysics were found to be abstract and difficult to understand. The study also revealed that the

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students' find difficult to see the real-life applications of Astrophysics concepts as well as had minimal knowledge on the relevant career opportunities in future. Some of the recommendations from the study include revisiting the content on Astrophysics to make it suitable for the learners, focus on teacher preparation and make students aware of the career opportunities.

*Keywords: Astrophysics; abstract; astronomy; perception; application; difficult; education.*

## 1. INTRODUCTION

### 1.1 Brief Background

Science is offered from class IV to VIII in Bhutanese schools as one of the subjects. From IX onwards, science is offered separately as Physics, Chemistry and Biology. A major reform in science curriculum to make paradigm shift from traditional to constructivist approach was initiated by Royal Education Council, a body providing guidance and directions on curriculum, professional development of teachers, and educational research in Bhutan in 2012. With the initiative, the reformed Science Curriculum was implemented in phases: Primary in 2013, Classes VII and VIII in 2014 and 2015, and IX to XII in 2016.

According to [1], the contents in the reformed textbooks are organized into four strands, working scientifically, life processes, materials and their properties, and physical processes, which are horizontally and vertically progressive. Besides, one of the major reforms was the inclusion of Astrophysics content in class IX as a chapter though some information on it is included in lower classes. Astronomy is the study of the universe beyond the earth's atmosphere and Astrophysics is the branch of astronomy concerned with the physical processes associated with the celestial bodies and the intervening regions of space [2]. In this study, the terms 'Astrophysics' and 'Astronomy' are used interchangeably.

Whether it is the basis of planning for an elaborate religious ceremony or working on the cutting-edge of science and technology, astronomy remains at the forefront of the public's attention and interest [3]. Astrophysics uses the laws of physics and chemistry to explain the birth, life and death of stars, planets, galaxies, nebulae and other objects in the universe [4]. These are included in new Physics textbook for class IX and X in Bhutanese science curriculum.

As Astronomy education act as an important source of technology and capacity development

for a global space economy, it is also given due importance in Bhutan. In 2016, through His Majesty the Fifth King's vision to raise awareness and interest in Space Science and Technology, the country's first satellite named BHUTAN-1 was developed and launched in 2018 by Bhutanese students. It has acted as one of the milestones in the field of space science for Bhutanese. Therefore, as the country move forward with advancement of science and technology, it is important for our children to have enough information and knowledge on space science and Astronomy.

### 1.2 Problem Statement

The basic concept about Astrophysics is taught to Bhutanese students from class IV onwards in science subject. The Astrophysics concepts till class VIII are basic and easy to understand and easy to teach. For example, content on Earth, rotations and revolution, phases of Moon, and Solar system are discussed from classes IV to VIII Sciences and some of these topics are included in other subjects like Social Studies and Geography also.

However, the Astrophysics concept included in classes IX and X textbook do not have proper link from lower classes and are not reflected in any other subjects. In addition, the topics included require more imaginative thinking and cannot be shown practically in the classroom. Moreover, there are topics like cosmic microwave background and red shift, formation and evolution of stars, black holes and wormholes; and asteroids which are difficult for teachers to teach and students to learn. Though, [5], pointed out that Physics in class IX and X includes abstract content and equations, many students found it manageable, interesting and enjoyable compared to other sciences. However, their study did not look into specific topics like Astrophysics.

The teacher training colleges of the Royal University of Bhutan, do not offer Astrophysics as a standalone module though a small part of it is present in other Physics modules. Hence, the

graduates of the training colleges may not have sufficient knowledge to teach Astrophysics. As such, the students learning outcome and teachers' knowledge to teach Astrophysics in class IX and X is a concern. Therefore, this study was basically intended to explore the perceptions of introduction of Astrophysics in Bhutanese curriculum.

## **2. LITERATURE REVIEW**

### **2.1 Introduction of Astrophysics and Its Importance**

Choudhuri [6] defined Astrophysics as science that deals with study of stars, galaxies and the entire universe. [7] has further elaborated that in order for the human beings to perceive themselves and the events taking place around them, they must perceive the universe first. Additionally, [8] also pointed out that new astronomical discoveries, such as new planets outside the solar system and discovery of new thing will offer a nice opportunity to cultivate scientific habits of mind. Therefore, Astrophysics is all about understanding planets, space objects and galaxies. Since these objects directly influenced our evolution, it is important to learn and know how things evolved.

### **2.2 Teachers' Perceptions and Knowledge on Astrophysics**

Astronomy education is mainly introduced in schools to understand our existence and to make the universe safe place to live. [9] study on stated that Astrophysics is an effective means to arouse greater interest of young people in science and to develop their abstract thinking that is necessary to connect everyday life to the complexity of the world. [10] found that students do not understand the basic of astronomy, despite the repetition in the topics in different level of classes due to the abstract content and difficulty in relating in everyday life.

Iyibil [11] study on teachers' found that many teachers lack enough information on astronomy and contain unscientific knowledge. He stated teachers can describe the concept and teach in the class but often fail to explain the reason. For example, teachers can easily explain 'what is the Earth's shape?', but they cannot not reason out 'why the Earth has this shape'. Therefore, for effective teaching and learning, it is important that teachers should have enough knowledge on Astrophysics. As [12] also observed that

teachers do not have adequate knowledge to match the given astronomy concepts with their characteristics. Moreover, they found that teacher' responses to concepts and examples of these concepts were not sufficient to construct good classroom learning environment.

According to [13], teachers need to receive in-service education in order to teach Astronomy effectively. Therefore, in order to teach astronomy effectively, [13] also pointed out that teachers need special training, access to specific research, to new educational materials and methods and the opportunity to exchange experiences. Moreover, a study by [14] found out that the pre-service teachers could not develop models compatible with scientific knowledge regarding basic astronomy concepts. They also said that this result was closely related to the lack of courses covering astronomy topics. Therefore, it is important for pre-service teachers in teacher training colleges to offer courses on astronomy so that teachers can impart their knowledge to the students in later part of their career.

### **2.3 Application of Astrophysics**

According to [15], Astrophysics allow understanding of how the entire cosmic panorama emerged from the universe's hot, dense beginning. Further, [16] pointed that Astrophysics revealed the cosmic roots, and the place in time and space, and shows a universe that is vast, varied, beautiful, and inspiring. Astrophysics has many positive applications in education. [17] stated that Astronomy has practical application such as time keeping, calendar, changes in weather, tides, navigation, effect of solar radiation, impacts of asteroids and comets with Earth. Though Astrophysics has lots of application, [18] pointed out that the students experience the most extreme and constant decrease in interest from middle to college in the field of Astronomy. If expertise have to be put in place in countries, students should be provided with opportunities to explore on space education [19].

### **2.4 Difficulties in Learning Astrophysics**

Rees [15] is of the view that the real challenge in Astronomy is to see the planets and space object directly. [20] added that there are a lot of resources to be developed but we also need to address the access of new technologies in different contexts. In case of students' learning,

[21] in their study found out that nature of topic was found to be the most predominant challenge and students tend to have a negative attitude towards Physics because they lack interest in the subject and the syllabus itself. However, [22] said that construction and handling of concrete 3-D material models, children's use of pictures and the globe helps young children develop their understanding of fundamental Astronomical concepts. Therefore, despite lots of challenges in teaching and learning of Astrophysics, learning through laboratory experiment and other models is a useful way to overcome those difficulties. Therefore, to make Astrophysics interesting, [23] pointed out that same astronomy topic must be used over different disciplines, and this must serve as an ideal project for interdisciplinary teaching.

### 2.5 Research Questions

To explore the perception on the introduction of Astrophysics in the Bhutanese curriculum, the following research questions were used.

#### 2.5.1 Principal question

What are the teachers' and students' perceptions on the introduction of Astrophysics in Bhutanese curriculum?

#### 2.5.2 Sub-questions

- i. What are the teachers' perceptions about introduction of Astrophysics?
- ii. What are the students' perceptions about introduction of Astrophysics?
- iii. How does study of Astrophysics benefited children in building their career?
- iv. What are the strategies adopted by teachers to help students to learn Astrophysics?

## 3. METHODOLOGY

### 3.1 World Views and Design

Guided by pragmatism world view, this research employed mixed methods approach. This study used convergent parallel mixed methods to collect quantitative and qualitative data. According to [24], convergent parallel mixed methods design converges or merges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem.

### 3.2 Research Instrument

The instruments that were used in data collection were closed-ended 5 point Likert scale survey questionnaire for students with 15 items having 3 sections to find out students' perception about Astrophysics, students' basic knowledge and application and career opportunities which were pre-determined themes. Structured interview for Physics teachers and students were used for qualitative.

A questionnaire enables quantitative data to be collected in a standardized way so that the data are internally consistent and coherent for analysis [25]. [25] also pointed out that there are four different types of questionnaire designing for a survey. They are contingency questions/Cascade format, matrix questions, closed-ended questions and open-ended questions. Structured interview is used to get first-hand information directly from students and teachers in the field. Structured interview is a typical form of interview in survey research. These structured interviews were gathered in written form from both teacher and student participants. (See. Appendix A, B and C).

### 3.3 Population and Sampling

A purposive non-probability sampling was used to collect quantitative data. [26] stated that the purposive sampling is selected by arbitrary method because it is known to be representative of the total population, or it is known that it will produce well matched groups. Further, they said it is to pick out the sample in relation to criteria which are considered important for the particular study.

**Table 1. Sampling procedure for quantitative data**

	<b>Sampling procedure</b>
Population	Four schools of Trashigang dzongkhag
Groups (Clusters)	High and middle secondary schools
Sample	All class X and XI science students

The study employed 184 class X students and 114 class XI students from four schools under Trashigang District. The schools were selected based on the accessibility of motor roads as the researchers had limited time for data collection.

The students were purposefully selected as they have already studied Astrophysics content. Class IX students were not part of the study as the chapter on Astrophysics is reflected as the last chapter in the textbook and this study was conducted in the beginning of the academic session.

A convenience sampling method was used to collect interview data from students and Physics teachers. According to [27] convenience sampling is a type of nonprobability or non-random sampling where members of the target population that meet certain practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate are included for the purpose of the study. 5 students and 11 Physics teachers were interviewed. The physics teachers interviewed were teaching class IX students during the time of data collection and had taught classes X and XI in the previous years.

### 3.4 Data analysis

The Statistical Package for the Social Sciences (SPSS, Version 22) programme was used for processing and analyzing the data obtained from the survey. Mean and standard deviation were used to interpret the result. For the five-point Likert-scale, the interpretation and description were adapted from [28] as given in Table 1.

**Table 2. Mean score interpretation**

Mean score	Interpretation/Level of acceptance
1.00 – 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.20	Medium
3.21 – 4.20	High
4.21 – 5.00	Very High

*The qualitative data was thematically analyzed*

## 4. RESULTS

The data obtained from survey questionnaires using five-point Likert-scale are presented using tables. For the presentation of the findings from the students' survey questionnaire, each theme was interpreted in terms of descriptive statistical mean by using SPSS 22 (Statistical Package for the Social Sciences). Mean and standard deviation were used to interpret the result.

### 4.1 Perception on Astrophysics content of class IX and X Physics

To examine the perceptions, participants were asked to rate five items to describe their perception on introduction of Astrophysics. The result is shown in Table 2.

As shown in Table 2, the average mean under this category was 2.62 and standard deviation was 1.32 indicating general perception towards Astrophysics was moderate. On the item, Astrophysics is easy to understand, the mean was low (2.49). It indicated that majority of the students were finding difficulty to learn Astrophysics. Students in the interview expressed that they do not enjoy learning Astrophysics as it deals with imagination. For example, one student expressed as follows:

I am not enjoying topics related to Astrophysics since I do not understand the concept because I have to memorize and do lots of calculation.

Out of 11 teachers in this study, 9 teachers pointed out that Astrophysics content is vague and difficult for students to comprehend. This was evident from the statements made by a teacher as follows:

While the general content of the chapter is fine, many of the concepts are beyond the understanding of class IX and X standard.

To find out the nature of the Astrophysics content, an item was used. The finding is given in Table 2 which showed that the mean (3.8) was high. This indicated that that majority of the respondents felt that the content was abstract in nature.

Students in the interview also supported that Astrophysics was abstract for them and difficult to relate with daily life. This was evident from the following expressions:

Astrophysics concepts are really abstract and difficult to understand.

Though Astrophysics was difficult some students pointed out that additional information from internet and other sites helped them to understand more clearly. This was evident from:

Some Astrophysics concepts are difficult and abstract in nature. I am facing difficult to interpret but I browse net and get more information from you tube.

**Table 3. Students' perception towards astrophysics content**

	Statement	Mean	SD	Level
1	I like to study Astrophysics content in school.	2.95	1.47	Moderate
2	Astrophysics is easy to understand.	2.49	1.25	Low
3	I enjoy studying Astrophysics in school.	2.80	1.35	Moderate
4	I understand Astrophysics content when I read on my own.	2.32	1.30	Low
5	I get good marks in Astrophysics whenever my teacher conduct test.	2.54	1.23	Low
	Average	2.62	1.32	

**Table 4. Items analysis under the theme, nature of content and terminology**

	Item	M	SDV	Level
6	Astrophysics content is abstract in nature.	3.8	1.05	High

Further, 90% of the teachers pointed out that they are finding it difficult to explain the concept and terminologies. This was evident from the response given by teacher as follows:

The most difficult part I faced while teaching Astrophysics topic is its concept and terminologies related to it. I feel that Astrophysics content is abstract because as you know that we cannot explain relative size of heavenly bodies and its position simply reading from the textbook and what if I compare class IX and X, I feel class X has more complex concept than class IX.

Though content is difficult, some teachers stated that they use online resource to explain to the students. According to the teachers:

Content is abstract and not easy to show them in reality. But there are lots of online resources for the same.

#### 4.2 Career Aspiration in the Field of Astrophysics

The students rating on aspiration to join a career related to Astrophysics was moderate with mean 2.77 and standard deviation 1.37 as shown in

Table 4. This indicated that only few students were interested to take Astrophysics as their major area of study in future.

The item, *I see good career opportunities in Astrophysics* rated moderate (M=2.83) which indicated that students had limited awareness on job and career opportunities in Astrophysics.

During the interview, students did not express much interest to choose career related to Astrophysics.

"I have no interest to study Astrophysics in future since it is very tough. I heard that Astrophysics is all about space and beyond, and I don't see scope in Bhutan now. Beside that I have different ambition"

Despite difficulties in learning Astrophysics, a student in the study found it interested to pursue career related to Astrophysics as it was evident from:

"Job related to Astrophysics can be interesting; if we work hard we may become scientist and even get opportunity to work in NASA."

**Table 5. Students' career aspiration in the field of astrophysics**

	Statement	Mean	SD	Level
7	I see good career opportunities in Astrophysics	2.83	1.39	Moderate
8	I want to explore more on Astrophysics in future	2.86	1.42	Moderate
9	I want to do research on Astrophysics in future	2.75	1.42	Moderate
10	Studying Astrophysics will contribute in achieving my goal in life	2.69	1.27	Moderate
11	My teacher often shares about career opportunities in learning Astrophysics	2.75	1.39	Moderate
	Average	2.77	1.37	

**Table 6. Applicability of astrophysics in daily life**

	<b>Statement</b>	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Level</b>
12	Astrophysics concepts are easily applicable in real life.	298	2.52	1.29	Low
13	Astrophysics helps me to develop good thinking skills that are necessary to succeed in any career.	298	2.80	1.81	Moderate
14	Studying Astrophysics will contribute greatly to achieving my goals	298	2.69	1.27	Moderate
15	My teachers relate the Astrophysics taught in the class with daily life activities	298	3.18	1.29	Moderate
	Average		2.79	1.41	

### 4.3 Applicability of Astrophysics Lesson in Daily Life

Students' survey revealed that Astrophysics content in class IX and X was hardly applicable in daily life activities. The Table 5 about the applicability of Astrophysics in real life with mean 2.79 and standard deviation 1.41 indicated that most of the students find it difficult to apply the Astrophysics in real life.

Teachers also stated that Astrophysics content helps to build curiosity and would encourage young Bhutanese to become astronauts in future. On the other hand, they said that meaningful Astrophysics teaching needs good internet connection and other teaching materials to help students get information more easily. This was evident from the following quote.

Learning Astrophysics would help students to become astronaut and allow them to relate in real life experience after watching movies. However, schools need good internet facilities and necessary equipment to teach Astrophysics such as telescope, digital camera, UV protected sunglasses, etc.

## 5. DISCUSSION

The main findings are discussed and condensed into two themes to provide a vibrant connection with other findings. Condensed themes are: Perception on Astrophysics and nature of topic. The first theme 'perceptions on Astrophysics' is discussed from three sub-themes abstract in nature of the content, applicability and career opportunities.

### 5.1 Perception on Astrophysics

**Abstract nature of the content:** The finding showed that Astrophysics was an important chapter for students to learn. Teachers stated that learning Astrophysics will help learner to

understand the correlation between human existence and development of the universe. This finding is in line with the study by [9] as he stated that Astrophysics is an effective means to arouse greater interest of young people in science and to develop their abstract thinking that is necessary to connect everyday life to the complexity of the world. However, both students and teachers in this study found difficulty in understanding Astrophysics as the content in the textbook was abstract in nature. Due to this, the teachers were finding it difficult to explain the concept clearly to the students. In line to this, the study by [10] stated that students do not understand the basics of astronomy, despite the repetition of the topics in different level of classes due to the abstract nature of content and difficulty faced in relating to everyday life.

**Career:** The finding from this study showed that most of the students were not interested to pursue career related to Astrophysics. Two reasons that prominently came up in this study are the students' difficulty in learning Astrophysics and lack of awareness on job opportunities. The low awareness on job opportunities in the country could be because Bhutan is a developing country and job opportunities related to astronomy is very limited at present. In Bhutan, career related to Astrophysics such as spectral software developer, staff scientist, systems engineer, and telescope optics group leader are not there at all. However, job like applications engineer, electrical engineer, modelling & simulation and laser engineer are available but are limited. Due to the lack of awareness and limited job opportunities, students were less interested to pursue Astrophysics related career. However, students who are aware of the scope of studying Astrophysics were interested to pursue career related to Astrophysics. A student in the study stated that excellence in the field of Astrophysics will have opportunity to study in NASA (National Aeronautics and Space Administration). The

findings of this study on career in Astrophysics aligns with the study by [29] that students were not interested in building careers in Astronomy. Moreover, [29] also found out that students lack experience and skills in Astronomy.

**Application:** This study showed that there is a concern of application of Astrophysics in real life context. Students didn't get a clear picture on how Astrophysics is applied in day-to-day life. This clearly depicts that the student is not able to link the concept learned in the class to practical application in day-to-day life. The finding showed that teachers relate it to religion and used analogy to teach other subject but do not relate it to the basic application of Astrophysics such as communication satellite, personal computers, communication satellites, mobile phones, global positioning systems, solar panels and magnetic resonance. Recent study conducted [30] also found that the schools do not teach Astronomy that promote scientific literacy and scientific-technological courses to communicate, debate and present scientific results.

## 5.2 Nature of Topic

Ibrahim et al. [21] found out that nature of topic was found to be the most predominant challenge. Similarly, [31] revealed that difficulty in learning Astrophysics is "due to the fact that it is an observational science where they do not have objects of study they can interact with directly". In agreement with the study, this study confirmed that Astrophysics is difficult to learn and understand. The responses from the majority of the students indicated that the abstract topics were most difficult to learn. Therefore, additional relevant information and resources are required to simplify difficult topics in Astrophysics for better understanding.

Though Astrophysics was difficult, teachers used various teaching learning materials and resources for the benefit of students. The study showed that a teacher used online resources, videos and simulation to make the concept clear to the students. A study by [32] found out that digital activity (animations and digital games) was helpful in teaching-learning abstract concepts in Astronomy. However, [32] also pointed out that teacher need to conduct classroom activities followed by digital activities to lead to better understanding rather than showing the video or animation directly. [33] pointed out that videos, simulation and animations were "helpful in making difficult

concepts much more palatable and save the students effort in visualizing their occurrence in different contexts". [31] also found out that "technological innovation had brought unprecedented growth in the understanding of the universe through the use of computer simulations". Therefore, it is important that teacher must use animation, simulation and online resources to compliment what is taught in the class.

## 6. CONCLUSION

In this study, it was found that the students and teachers in schools currently have negative perceptions on Astrophysics. The two prominent reasons spelled out by teachers and students were abstract content to teach and limited information for some of the concepts in the textbook. At the same time students find the content difficult and they were not aware of its applications and job opportunities.

Like any other study, this study too has its limitations. First, the results of this study are limited to four schools in Trashigang Dzongkhag. Therefore, the findings of this study may not be generalized to other schools. Secondly, Inclusion of stakeholders such as principal and curriculum developers in the study would have provided a wider perspective and understanding of the issues related to Astrophysics.

## 7. RECOMMENDATIONS

This study indicated that students require practical classes on Astrophysics to work with real examples. Hence, schools need materials like telescope, astrolabe, and bolometer to help students learn Astrophysics. The study has shown that the abstract concepts led to difficulty in learning Astrophysics. Therefore, it is important for teachers to teach using model, ICT technology, and through online tutorials. It would be good for schools to be affiliated to other institutes in and outside country to enhance knowledge sharing on Astrophysics. Further, the study showed that there was an over-lap in the content of Astrophysics with other subjects. Curriculum developers and relevant stakeholders need to relook into the Astrophysics content across subjects and make the content interdisciplinary for all the topics.

Also, study may be conducted in class XI and XII to examine the impact of introduction of Astrophysics in students' learning outcome.



## CONSENT AND ETHICAL APPROVAL

For this study, the data were collected only after getting approval from Chief District Education officer and Principals of selected schools. A consent form for participants was used during the time of data collection. Participants were informed of the research ethics and confidentiality about their names and the schools.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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## APPENDIX A

### Students Survey Questionnaire:

School Name:..... District:.....

1. Gender: Male  Female  Others

2. Please indicate how much you agree or disagree with the following general statements by ticking the given number from 1-5 on each row against the given sentences. Please tick only one from each row.

Statement	SDA (1)	DA (2)	N (3)	A (4)	SA (5)
1 I like to study Astrophysics content in school.					
2 Astrophysics is easy to understand.					
3 I enjoy studying Astrophysics in school.					
4 I understand Astrophysics content when I read on my own.					
5 I get good marks in Astrophysics whenever my teacher conduct test.					
6 Astrophysics content is abstract in nature.					
7 I see good career opportunities in Astrophysics					
8 I want to explore more on Astrophysics in future					
9 I want to do research on Astrophysics in future					
10 Studying Astrophysics will contribute in achieving my goal in life					
11 My teacher often shares about career opportunities in learning Astrophysics					
12 Astrophysics concepts are easily applicable in real life.					
13 Astrophysics helps me to develop good thinking skills that are necessary to succeed in any career.					
14 Studying Astrophysics will contribute greatly to achieving my goals					
15 My teachers relate the Astrophysics taught in the class with daily life activities					

*Key: SA=Strongly Agree, A=Agree, N=Neutral, DA=Disagree, SDA=Strongly Disagree*

## APPENDIX B

### Interview Questionnaire for Teachers:

*The following questions are part of interview to get information on "Perception on Introduction of Astrophysics for class IX and X."*

*Thank You for your cooperation and time in advance.*

### Interview Questions:

1. How do you feel about the introduction of Astrophysics in class IX and X?
2. Does science in lower classes prepare students to learn Astrophysics in class IX and X?
3. What are the difficulties you faced in teaching Astrophysics content from the test book?
4. What are the strength and weakness of the Astrophysics sub topics given in class IX and X physics textbook?
5. What are the follow-up activities you give to your students after teaching Astrophysics in Class IX and X?

6. How do you assess students understanding of the topics?
7. What are the teaching and learning materials that you use while teaching Astrophysics in class IX and X?
8. How do you relate those concept mentioned in the text to real life situation while teaching Class IX and X Astrophysics?
9. What are the common teaching strategies/classroom CL structures you use while teaching Astrophysics?
10. Which sub-topics is most easy to teach from the chapter "Earth and Beyond" and which sub topics is difficult for you to teach?
11. Any suggestions or additional comments.

## APPENDIX C

### Interview Questionnaire for Students:

The rationale to interview five students is to acquire the true opinions from the students on how they perceive and study Astrophysics. This is also to do comparative study with the data collected from survey questionnaire. Semi-structured interview would be more viable to probe the students to share their feelings.

### Interview Questions:

1. Do you enjoy learning Astrophysics in schools?
2. Do teachers use teaching and learning materials in creation of interactive teaching and learning of Astrophysics?
3. Is teaching and learning materials important for your learning in Astrophysics?
4. Do you feel difficult in understanding the concept and terminology used in the text? Tell some topics/ concept that you find difficult to learn.
5. Will you opt for Astrophysics related job/career in future? Explain
6. Do find the lesson you have learned from Astrophysics applicable in daily life activities?
7. Do you find link/continuity in the topics you have learned in lower classes to what you are studying now? Which topics are new to you?
8. Any suggestion or comments.

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