

# **Student Perception on Nature of Subjects: Impact on Difficulties in Learning High school Physics, Chemistry and Biology**

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# Student Perception on Nature of Subjects: Impact on Difficulties in Learning High school Physics, Chemistry and Biology

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**Abstract:** In the wake of increasing evidence that students' positive attitudes towards science particularly in chemistry and physics change strikingly as they move up in school, this study explores student perception of intrinsic and extrinsic factors that make them feel cognitive load in learning physics, chemistry and biology resulting in difficulty to learn these subjects. A four-fold classification of student perception of factors related to nature of subjects and their teaching learning with varying level of control over them for teachers is designed to develop a questionnaire, which was used to obtain student rating on difficulties. The sample is 300 high school students from Kerala. The differences among student difficulty in science disciplines is more due to the nature of subject matter and is minimal from factors related to teaching-learning over which teachers have an high degree of control. Results indicate that intrinsic cognitive load inherent in nature of physics and to a fair extent in chemistry interacts with extrinsic factors in teaching and especially in students' effort to learn them to make these subjects more difficult to learn. A good proportion of variation in student perception of difficulties in physics, chemistry and biology originates from what students feel generally about nature of content included in school science and the way it is taught which calls for school science curriculum reforms.

**Keywords:** Cognitive load, Nature of Science, Nature of discipline, Student Belief, Teaching-learning factors

Research in science education context has tended to focus on unpopularity of science subjects among students, irrelevance of science as taught in schools for students' lives and further development, content overloaded with past facts and theories with much repetition and little challenge, isolation of science education especially from social life and communication, and lack of attention to higher order learning like problem-solving and decision-making (Holbrook, 2003). Especially, science learning strategies and the role of the science teachers were main areas (Cheng, 2001) in understanding and solving student difficulties in science learning. This study compares student perception of

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factors that makes difficulty in learning three science disciplines in high school.

### **Beliefs about nature of science subjects, student difficulties and cognitive-load**

Students' positive attitudes towards science subjects change strikingly in the senior classes, particularly in chemistry and physics (Graber, 1993; Greenfield, 1997). Research has identified differing reasons for students to feel difficulty in three school sciences namely physics, chemistry, and biology. Chemistry is perceived difficult among other things because of its specialized language, mathematical and abstract conceptual nature, and the amount of content to be learned (Gabel, 1999; Moore, 1989). However, researches are not likeminded on reasons for difficulty even within a science subject, about particular topics or units being difficult for students (Gafoor, & Shilna, 2014a). Identifying reasons for and ways to reduce student difficulties in areas within science subjects is gaining new attention. Chemistry is loaded with terminology and concepts. Molecular level of many chemical phenomena (Ben-Zvi, Eylon & Silberstein, 1987; Gabel, Samuel & Hunn, 1987), assigning meaning to the unseen and the intangible (Kozma & Russell, 1997) and the like make students in secondary school and in the universities to have many difficulties in understanding chemistry. Many of these reasons are true of not only chemistry or physics, but are applicable to every subject perceived as difficult for students to learn. However, post-primary decline in interest, of both boys and girls, is sharper in chemistry, than in science in general (Gafoor & Shilna, 2014b).

Yet, decline in interest in physics as students move from upper primary through high school to senior secondary stages is even sharper (Gafoor, 2013) than chemistry. Though students and teachers may not fully agree on why subjects are difficult, both feel that student-related factors, such as not studying much have influence on students' success in physics. Students' perception about physics and its nature such as being cumulative and hence missing one concept makes hard to grasp the subsequent one, too much material to learn, being abstract and theoretical with many laws and rules, and being abundant with many formulas requiring mathematical background etc. makes them feel physics as difficult (Ornek, Robinson, & Haugan, 2008). Erinosh (2013) observes that major sources of difficulty in learning physics are related to nature of subject, teaching/teacher factors and curriculum/ assessment. Students have difficulty in understanding specific topics that lack in concrete examples and require a lot of

mathematical manipulations or visualization. Solving problems alone and asking questions in class are also difficult.

Biology is apparently the easiest in comparison to other science disciplines. This does not mean that it is not a challenge for students to learn. Topic wise difficulty is evidenced with topics like water transport in plants and genetics (Bahar, Johnstone, & Hansell, 1999). Even student teachers have not learnt biology as expected of its apparent easiness. An average student teacher has not attained at least a quarter of the concepts in biology that is being taught at primary school level. Three in every four student teachers have misconception regarding nearly one fifth of biology concepts in primary school. Half of the student teachers have misconception regarding more than one fourth of biology concepts taught at primary school basic science (Gafoor & Shyni, 2009).

One possible explanation of difficulty levels to vary for the three sciences is cognitive load. Whether from the real nature of the subject matter or from the way the subjects are taught or learnt, or from the learnt beliefs about the school subjects and their nature, students perceive subjects differently as to their level of difficulty. Multiple factors that cause difficulty for students in learning sciences are not uniformly distributed among physics, chemistry and biology. Extraneous cognitive load interferes with factors that impede effective learning, and make such subjects more difficult to learn (Sweller, 1995). Hence, teaching-learning factors also become more crucial in subjects with more intrinsic factors related to its nature that make it harder, than in subjects with less intrinsic factors related to its nature. Hence, it is prone to hypothesise that physics and chemistry which have abstract, symbolic content with a cumulative nature and physics especially with its emphasis on problem solving makes them more difficult than biology. This study explores student perception of factors in nature of subjects and their teaching-learning with varying level of control over them for teachers and learners (intrinsic and extrinsic factors that cause cognitive load) that make them to feel physics, chemistry and biology as difficult to learn.

Among reasons for science being difficult, Holbrook (2003) identified two broad problem areas namely teacher's lack of training to teach higher order cognitive skills and problems of the context in which the science content is taught. This study probes into nature of content or subject matter, now described as epistemological beliefs, for possible explanations of perception of difficulty among students. These factors can be conceived falling broadly into four categories on a two dimensional grid. Dimension 1. Nature of subject matter – nature of teaching learning; and Dimension 2. Low teacher control – high teacher

control in helping learners to face the difficulties emerging from the first dimension. To a certain extent, Low teacher control – High teacher control continuum can be read reversely as high control- low control for learners in modifying own beliefs about the nature of subject matter and teaching-learning. The four-fold classifications of student perception of factors that make them perceive difficulty in learning science disciplines are depicted in Figure 1.

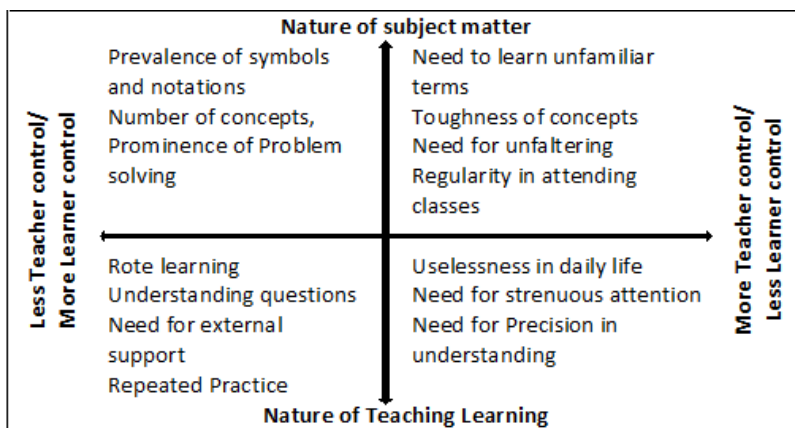


Figure 1. Four-fold classification of factors related to nature of disciplines that make students perceive difficulty in learning them

**Objectives**

This study is to reveal factors in nature of subjects and their teaching-learning (intrinsic and extrinsic factors that cause cognitive-load) that make school students to feel difficulty in learning physics, chemistry and biology. These factors are further divided based on high vs. low control for teachers over them. In order for this, this study initially compares the level of difficulty of science subjects viz., Physics, Chemistry and Biology as perceived by students; and then proceeds to compare Perceived reasons for difficulty in learning these three subjects.

**Method**

Descriptive Survey procedure with statistical analyses including Mean, Paired t-test and Pearson’s r is employed.

**Tool**

Questionnaire on ‘students’ Difficulties in learning’, containing 14 items was administered. Rating the school science subjects namely Physics, Chemistry and

Biology in the order of feeling of difficulty was followed up with a detailed rating on 13 reasons related to nature of different science subjects that makes the subject difficult to learn. The reasons included are Uselessness in daily life, Rote learning, Prevalence of symbols and notations, Need to learn unfamiliar terms, Understanding questions, Need for external support, Toughness of concepts, Number of concepts, Repeated Practice, Prominence of Problem solving, Need for strenuous attention, Need for unfaltering Regularity in attending classes and Need for Precision in understanding. Participants have to rate their feeling of difficulty of science subjects for each of these reasons.

**Participants**

Participants were 300, standard 8th students randomly selected from government and aided schools from urban and rural areas of Kerala with equal weightage to gender.

**Result & Discussion**

Results are discussed under five major headings namely Difficulty level of school sciences as perceived by students, Difficulty of science subjects owing to teaching-learning factors having more teacher control, Difficulty of science subjects owing to teaching-learning factors having more learner control, Difficulty of science subjects owing to their nature upon which there is less teacher control and Difficulty of science subjects owing to their nature upon which there is more teacher control.

**Difficulty level of science subjects viz., Physics, Chemistry and Biology**

The perceived difficulty of the three science subjects are put alongside and compared with each other in Table 1.

**Table 1**

*Results and Descriptive Statistics for Paired t -test of Perception of Difficulty of Science Subjects*

Subjects	M	SD	subjects compared	R	t
Physics	1.91	0.58	Phy. Vs. Chem.	.19**	0.07
Chemistry	1.91	0.65	Phy. Vs. Bio.	0.09	5.33**
Biology	1.66	0.64	Chem.Vs. Bio.	.30**	5.74**

*Note.* N= 300

\*\*p<.01.

Physics and Chemistry are perceived more difficult compared to Biology ( $p < .01$ ). Student perception of Difficulty in Physics has significant positive but negligible correlation with perception of difficulty in Chemistry ( $p < .01$ ). Nevertheless, there is no significant correlation between student perception of difficulty in learning Physics and Biology ( $p > .05$ ). However, perception of difficulty in Chemistry has significant positive low correlation with perception of difficulty in Biology ( $p < .01$ ).

**Difficulty of Science subjects Owing to Teaching-learning factors having more teacher control**

The perceived difficulty of Science subjects owing to Teaching-learning factors having more teacher control are put alongside and compared each other in Table 2.

**Table 2**

*Results and Descriptive Statistics for Paired t -test of Perception of Difficulty of three Science subjects Owing to Teaching-learning factors having more teacher control*

Reason difficulty	for	Subjects	M	SD	Subjects compared	R	t
Uselessness in daily life		Physics	1.84	0.71	Phy. Vs. Chem.	.65**	2.26*
		Chemistry	1.75	0.71	Phy. Vs. Bio.	.51**	6.93**
		Biology	1.55	0.70	Chem. Vs. Bio.	.58**	5.26**
Need for strenuous attention		Physics	2.14	0.68	Phy. Vs. Chem.	.57**	1
		Chemistry	2.18	0.69	Phy. Vs. Bio.	.44**	3.01**
		Biology	2.01	0.74	Chem. Vs. Bio.	.62**	4.64**
Need for Precision in understanding		Physics	1.72	0.45	Phy. Vs. Chem.	.41**	1.61
		Chemistry	1.67	0.47	Phy. Vs. Bio.	.18**	6.83**
		Biology	1.48	0.50	Chem. Vs. Bio.	.29**	5.83**

Note. N= 300

\*  $p < .05$ , \*\* $p < .01$ .

Physics is rated more difficult than Chemistry ( $p < .01$ ) and Biology ( $p < .01$ ) as the material learned are not applicable in daily life. Chemistry is rated more difficult than Biology ( $p < .01$ ). However, inter correlations among Physics, Chemistry and Biology in perception of difficulty because of uselessness in daily life is significant, positive and substantial.

Physics is rated more difficult as it needs strenuous attention to learn concepts in comparison to Biology ( $p < .01$ ) but is at par with Chemistry ( $p > .05$ ). In this respect too, Chemistry is rated more difficult than Biology ( $p < .01$ ). Again, inter-correlations among Physics, Chemistry and Biology in perception of difficulty because of need for strenuous attention is significant, positive and substantial.

Physics is rated more difficult due to need for precision in understanding concepts in comparison to Biology ( $p < .01$ ) but is at par with Chemistry ( $p > .05$ ). Yet again, Chemistry is rated more difficult than Biology ( $p < .01$ ). Student perception of difficulty due to need for precision in understanding in Physics has significant positive substantial correlation with such perception in Chemistry ( $p < .01$ ) and significant positive but negligible correlation with such perceptions of Biology ( $p < .01$ ). Student perception of difficulty due to need for precision in understanding in Chemistry has significant positive low correlation with such perception in Biology ( $p < .01$ ).

As the material learned being inapplicable in daily life, students feel Physics as more difficult than the other two science subjects do. As they need strenuous attention to understand concepts and precision in understanding concepts, students feel Physics and chemistry as more difficult than Biology.

**Difficulty of Science subjects Owing to Teaching-learning factors having more learner control**

The perceived difficulty of Science subjects Owing to Teaching-learning factors having more learner control are put alongside and compared each other in Table 3.

**Table 3**

*Results and Descriptive Statistics for Paired t -test of Perception of Difficulty of Science subjects Owing to Teaching-learning factors having more learner control*

Reason for difficulty	Subjects	M	SD	subjects compared	r	t
Rote learning	Physics	2.04	0.62	Phy. Vs. Chem.	.47**	0.44
	Chemistry	2.06	0.66	Phy. Vs. Bio.	.34**	3.49**
	Biology	1.89	0.70	Chem. Vs. Bio.	.53**	4.46**
Understanding questions	Physics	1.92	0.65	Phy. Vs. Chem.	.50**	1.05
	Chemistry	1.87	0.69	Phy. Vs. Bio.	.39**	5.79**
	Biology	1.67	0.64	Chem. Vs. Bio.	.57**	5.45**
Need for external support	Physics	2.10	0.59	Phy. Vs. Chem.	.36**	1.01
	Chemistry	2.06	0.64	Phy. Vs. Bio.	.30**	6.15**
	Biology	1.83	0.68	Chem. Vs. Bio.	.48**	5.85**
Repeated Practice	Physics	2.16	0.58	Phy. Vs. Chem.	.48**	1.46
	Chemistry	2.11	0.65	Phy. Vs. Bio.	.26**	6.72**
	Biology	1.88	0.64	Chem. Vs. Bio.	.42**	5.79**

Note. N= 300

\*\* $p < .01$ .



Physics is rated more difficult than Biology ( $p < .01$ ) but is at par with Chemistry ( $p > .05$ ) because of need for rote learning. On this count, Chemistry is rated more difficult than Biology ( $p < .01$ ). Student perception of difficulty due to Need for rote learning in Physics has significant positive substantial correlation with such perception in Chemistry ( $p < .01$ ). Student perception of constraint from need for rote learning in Physics has significant positive low correlation with such perception of Biology ( $p < .01$ ). Also, student perception of difficulty due to need for rote learning in Chemistry has significant positive substantial correlation with such perception in Biology ( $p < .01$ ).

Physics is rated more difficult due to constraint in understanding questions in comparison to Biology ( $p < .01$ ) but is at par with Chemistry ( $p > .05$ ). In this respect too, Chemistry is rated more difficult than Biology ( $p < .01$ ). Student perception of difficulty due to constraint in understanding question in Physics has significant positive substantial correlation with such perception in Chemistry ( $p < .01$ ) and significant positive low correlation with such perception in Biology ( $p < .01$ ). Student perception of constraint due to difficulty in understanding question in Chemistry has significant positive substantial correlation with such perceptions of Biology ( $p < .01$ ).

Physics is rated more difficult due to constraint from external support needed in comparison to Biology ( $p < .01$ ) but at par with Chemistry ( $p > .05$ ). Chemistry is rated more difficult than Biology ( $p < .01$ ). Student perception of difficulty due to constraint from external support in Physics has significant positive low correlation with such perception of both Chemistry and Biology ( $p < .01$ ). However, student perception of difficulty due to constraint from external support in Chemistry has significant positive substantial correlation with such perception in Biology ( $p < .01$ ).

Physics is rated more difficult because of repeated practice needed in comparison to Biology ( $p < .01$ ) but is at par with Chemistry ( $p > .05$ ). In this respect, Chemistry is rated more difficult than Biology ( $p < .01$ ). Student perception of difficulty due to the need for repeated practice in Physics has significant positive substantial correlation with such perception in Chemistry ( $p < .01$ ) and significant positive low correlation with such perception in Biology ( $p < .01$ ). Student perception of difficulty because of repeated practice needed in Chemistry has significant positive substantial correlation with such perceptions of Biology ( $p < .01$ ).

Due to the material learned requires rote learning, due to difficulty in understanding questions, repeated practice needed and due to need for external support, students feel Physics and chemistry as more difficult than Biology.

### Difficulty of Science subjects Owing to their nature upon which there is less teacher control

The perceived difficulty of Science subjects Owing to their nature upon which there is less teacher control are put alongside and compared each other in Table 4.

**Table 4**

*Results and Descriptive Statistics for Paired t -test of Perception of Difficulty of Science subjects Owing to their nature upon which there is less teacher control*

Reason for difficulty	Subjects	M	SD	subjects compared	r	t
Prevalence of symbols and notations	Physics	1.93	0.67	Phy. Vs. Chem.	.51**	2.59**
	Chemistry	2.02	0.64	Phy. Vs. Bio.	.37**	11.79**
	Biology	1.44	0.61	Chem. Vs. Bio.	.31**	13.86**
Number of concepts	Physics	2.11	0.61	Phy. Vs. Chem.	.49**	0
	Chemistry	2.11	0.66	Phy. Vs. Bio.	.21**	2.57**
	Biology	1.98	0.70	Chem. Vs. Bio.	.47**	3.13**
Prominence of Problem solving	Physics	2.19	0.59	Phy. Vs. Chem.	.39**	8.44**
	Chemistry	1.84	0.71	Phy. Vs. Bio.	.23**	14.84**
	Biology	1.53	0.64	Chem. Vs. Bio.	.52**	8.00**

Note. N= 300

\*\*p<.01.

Chemistry is rated more difficult than Physics ( $p < .01$ ) and Biology ( $p < .01$ ) due to the prevalence of symbols and notations. In this respect, physics is rated more difficult than Biology ( $p < .01$ ). Student perception of difficulty due to prevalence of symbols and notations in Physics has significant positive substantial correlation with such perception in Chemistry ( $p < .01$ ) and significant positive but low correlation with such perception in Biology ( $p < .01$ ). Student perception of constraint due to prevalence of symbols and notations in Chemistry has significant positive low correlation with such perceptions of Biology ( $p < .01$ ).

Physics is rated more difficult by the students due to number of concepts in comparison to Biology ( $p < .01$ ) but is at par with Chemistry ( $p > .05$ ). Here also, Chemistry is rated more difficult than Biology ( $p < .01$ ). Student perception of difficulty due to number of concepts in Physics has significant positive substantial correlation with such perception

in Chemistry ( $p < .01$ ) and significant positive low correlation with such perception in Biology ( $p < .01$ ). Student perception of constraint due to number of concepts in Chemistry has significant positive substantial correlation with such perceptions of Biology ( $p < .01$ ). Physics is rated more difficult than Chemistry ( $p < .01$ ) and Biology ( $p < .01$ ) due to the Prominence of Problem solving. Chemistry is rated more difficult than Biology ( $p < .01$ ). Student perception of difficulty due to Prominence of Problem solving in Physics has significant positive low correlation with such perception in both Chemistry ( $p < .01$ ) and Biology ( $p < .01$ ). Student perception of constraint due to prevalence of symbols and notations in Chemistry has significant positive substantial correlation with such perceptions of Biology ( $p < .01$ ).

As there is prevalence of symbols and notations in Chemistry, students feel it as more difficult than Physics and Biology. As there is Prominence of Problem solving in Physics, students feel it as more difficult than Chemistry and Biology. Students feel Physics and chemistry as more difficult than Biology due to number of concepts involved.

**Difficulty of Science subjects Owing to their nature upon which there is more teacher control**

The perceived difficulty of Science subjects Owing to their nature upon which there is more teacher control are put alongside and compared each other in Table 5.

**Table 5**

*Results and Descriptive Statistics for Paired t -test of Perception of Difficulty of Science subjects Owing to their nature upon which there is more teacher control*

Reason for difficulty	Subjects	M	SD	subjects compared	r	t
Need to learn unfamiliar terms	Physics	2.07	0.66	Phy. vs. Chem.	.61**	1.57
	Chemistry	2.02	0.68	Phy. Vs. Bio.	.44**	5.74**
	Biology	1.83	0.73	Chem. Vs. Bio.	.54**	4.84**
Toughness of concepts	Physics	2.11	0.60	Phy. vs. Chem.	.40**	0.84
	Chemistry	2.08	0.65	Phy. Vs. Bio.	.25**	5.31**
	Biology	1.87	0.65	Chem. Vs. Bio.	.32**	4.64**
Need for unfaltering Regularity in attending classes	Physics	2.18	0.60	Phy. vs. Chem.	.46**	1.09
	Chemistry	2.14	0.64	Phy. Vs. Bio.	.28**	6.66**
	Biology	1.88	0.67	Chem. Vs. Bio.	.44**	6.35**

Note. N= 300

\*\* $p < .01$ .

Physics is rated more difficult because of need to learn unfamiliar terms in comparison to Biology ( $p < .01$ ) but is at par with Chemistry ( $p > .05$ ). Here also, Chemistry is rated more difficult than Biology ( $p < .01$ ). All three inter correlations among Physics, Chemistry and Biology in perception of difficulty because of need to learn unfamiliar terms is significant, Positive and substantial.

Physics is rated more difficult due to toughness of concepts in comparison to Biology ( $p < .01$ ) but is at par with Chemistry ( $p > .05$ ). Chemistry is rated more difficult than Biology ( $p < .01$ ). Student perception of difficulty due to toughness of concepts in Physics has significant positive substantial correlation with such perception in Chemistry ( $p < .01$ ) and significant positive low correlation with such perception in Biology ( $p < .01$ ). Student perception of constraint due to toughness of concepts in Chemistry has significant positive low correlation with such perceptions of Biology ( $p < .01$ ).

Physics is rated more difficult due to need for unfaltering regularity in attending classes in comparison to Biology ( $p < .01$ ) but is at par with Chemistry ( $p > .05$ ). Chemistry is rated more difficult than Biology ( $p < .01$ ). Student perception of difficulty due to need for unfaltering regularity in attending classes in Physics has significant positive substantial correlation with such perception in Chemistry ( $p < .01$ ) and significant positive low correlation with such perception in Biology ( $p < .01$ ). Student perception of constraint due to need for unfaltering regularity in attending classes in Chemistry has significant positive substantial correlation with such perceptions of Biology ( $p < .01$ ).

Students feel both Physics and chemistry as more difficult than Biology due to the need to learn unfamiliar terms, toughness of concepts and need for unfaltering regularity in attending classes.

### **Conclusion and Implications**

On the nature of subject matter, irrespective of teacher control over them, physics and chemistry cause equal difficulty, though there are qualitative differences in student perception of these difficulties. Anyhow due to factors inherent to the nature of subject matter over which teachers have less control, physics and chemistry on all the three reasons have higher rating of difficulty than biology. Prevalence of symbols and notations in Chemistry is more than in Physics and Biology. Prominence of Problem solving is more in Physics than in Chemistry and Biology. Number of difficult concepts involved in Physics and chemistry are more than in Biology. Again, because of all three factors inherent to the nature of subject matter over which teachers have some degree of control, physics and

chemistry are equal, but have greater difficulty than biology. Physics and chemistry are more difficult than Biology due to the need to learn unfamiliar terms, toughness of concepts and need for unfaltering regularity in attending classes.

On account of factors related to nature of teaching learning irrespective of teacher control over them, difficulty for physics is visibly more than chemistry; and entirely easier for biology than both physics and chemistry. Students feel Physics as requiring rote learning more than the other two sciences. Physics and chemistry pose equal difficulty for students in understanding questions, need for repeated practice and external support but more than in Biology. On factors related to nature of teaching-learning with high teacher control, difficulty for physics is visibly more than in chemistry; and entirely easier for biology than both physics and chemistry. Students perceive Physics learned in school is inapplicable in daily life more than the other two sciences. Physics and chemistry need strenuous attention to understand concepts and need precision in understanding them, more than Biology.

The most important reason for physics to be difficult for students in high school is its inherent nature of involving problem solving than the other two sciences. Chemistry is difficult even more than physics on account of prevalence of symbols and notations; and it is at par with physics on most other factors related to the nature of subject matter and teaching learning other than problem solving; especially so on need for attention, number of concepts, need for students to learn rote. Biology is counted quite easier than both physics and chemistry in all respects related to nature of subject matter and nature of teaching learning. The findings give the impression that the differences in perception of difficulty among the three sciences declines as the teacher control over such factors increases. The differences among student difficulty with physics, chemistry and biology is more due to the nature of subject matter and is minimal from factors related to teaching-learning over which teachers have an high degree of control. It is clear that intrinsic cognitive load inherent in nature of physics and to a fair extent in chemistry interacts with extrinsic factors in teaching and especially in students' effort to learn them in making such subjects more difficult to learn.

Even as there are differences in factors that leads to difficulty in learning the three science disciplines in schools, substantial positive correlations among the rating of factors indicate that a good proportion of variation in student-perception of difficulties in physics, chemistry and biology originates from what students feel generally about nature of content included in school science and the

way it is taught. Hence, student difficulties especially in school physics and to a great extent in chemistry have to be dealt at the level of course designing, approach to teaching-learning, use of appropriate language in text books, inclusion of socially and culturally relevant science, relating the subject to other subjects in school, active teaching methods, and in encouraging meaningful learning through reforms in assessment practices.

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