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IDENTIFYING PRE-SERVICE TEACHERS' INITIAL IMPRESSIONS OF THE CONCEPT CARTOONS IN THE SCHOOL CORRIDORS AND INFORMAL PHYSICS LEARNING

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Abstract. *Since concept cartoons give an important opportunity for students to achieve informal physics learning, the current research focused on pre-service teachers' initial impressions of the concept cartoons in the school corridors and informal physics learning. The aim of the research was to determine pre-service teachers' initial impressions of the concept cartoons in the school corridors and informal physics learning via the concept cartoons. After a 14-week intervention, a questionnaire with seven open-ended questions was administered to 542 pre-service teachers from primary, mathematics and science teacher education programmes. Their responses to the questionnaire were exposed to qualitative content analysis via two categories (advanced and poor impression). The results showed that pre-service teachers generally refered to advanced impressions of the concept cartoons. In light of the results, it can be deduced that the concept cartoons have enhanced their initial impressions of informal physics/ science learning via the concept cartoons. The current research recommends that pre-service teachers should be encouraged to produce their own concept cartoons on the topic(s) they found difficult.*

Keywords: *concept cartoon, informal learning, initial impression, science education.*

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Introduction

Concept cartoons, which use scientific cases through visual stimuli, enable students to notice different viewpoints. Hence, they purpose to make these scientific cases more negotiable. Dialogs between cartoon characters pose their views and make the problem comprehensible to think possible solutions and/or arguments (Naylor & Keogh, 1999b). That is, concept cartoons, which handle real-life problems within dialogic learning and/or argumentative discourses (Naylor & Keogh, 2000), develop student's scientific literacy and thinking skills. Thus, they not only make school hours more enjoyable (Keogh & Naylor, 2000) but also improve students' self-confidence levels of communication or argumentation skills (i.e., defending and explaining their views of any scientific context) (Atasoy, 2011; Kabapinar, 2005).

Because concept cartoons provide an interactive learning environment through dialogic statements (Atasoy & Zoroğlu, 2014), they have a pivotal role in discovering students' pre-existing ideas, engaging them in inquiry-based learning, and ensuring sustainability for learning motivation (Keogh & Naylor, 1999; Naylor & Keogh, 1999b). Further, concept cartoons may be used to evaluate students' misconceptions, beliefs and pre-existing knowledge (Chin & Teou, 2009, 2010; Keogh & Naylor, 1999; Sexton, Gervasoni & Brandenburg, 2009; Stephenson & Warwick, 2002). Thereby, the use of concept cartoons gives an opportunity for teachers to plan their instructional activities that involve discussion(s) or argumentative discourse(s).

Concept cartoons mostly have two different formats (e.g., poster and worksheet) (Atasoy & Ergin, 2017; Minárechová, 2016; Naylor & Keogh, 1999a, b). Worksheet format, which generates a discussion environment, encourages students to do scientific investigation/inquiry (Atasoy, Tekbıyık & Gülay, 2013; Atasoy & Ergin, 2017; Minárechová, 2016; Taşlıdere, 2013). Poster format, which asks the question 'What do you think?', enables students to probe their views/ideas/beliefs of science topics/concepts (Aydın, 2015; Chin & Teou, 2010; Naylor & Keogh, 1999a). Hence, concept cartoons help students realize

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tentativeness of science as a component of nature of science (NOS). That is, if much more evidence is provided, they may alter their beliefs and/or worldviews (Naylor & Keogh, 2000). In other words, concept cartoons may afford students to evolve their scientific habits of mind (i.e., open-mindedness), which is a milestone for scientific attitude, nature of science, scientific inquiry and scientific literacy (e.g., Çalık & Coll, 2012; Çalık, Turan & Coll, 2014; Çalik & Karataş, 2019). Overall, producing their own arguments through concept cartoons may increase students' awareness levels of conceptual scaffolds and knowledge construction (Chin & Teou, 2009). Hence, an alternative enriched learning environment boost their learning capacities (e.g., Karslı & Çalık, 2012; Naylor & Keogh, 2013).

In brief, even though the concept cartoons are potential to bridge formal science learning to informal one (Naylor & Keogh, 2013), they prioritize varied foci within formal and informal science learning. For example, embedding the concept cartoons within formal science learning emphasizes students' high order thinking (e.g., Chin & Teou, 2009), learning enthusiasm/motivation (Keogh & Naylor 1999), active engagement with scientific inquiry (Keogh & Naylor, 1999, 2000; Naylor & Keogh, 1999a) and conceptual change or conceptual understanding (Atasoy & Ergin, 2017; Kabapinar, 2005; Keogh & Naylor, 1999). Further, integrating the concept cartoons into informal science learning fosters people from different ages/professions/cultures to informally talk about the concept cartoons, think about the posed questions, and ultimately enhance their understanding of science (Naylor & Keogh, 1999a). This means that the use of the concept cartoons in informal science learning stimulates people's learning curiosity regardless of their professions/interests (Naylor & Keogh, 1999a) and develops their public understanding of science, and responsible citizenship (i.e., Naylor & Keogh, 1999a, 2013). Thus, they are able to analyze and evaluate science-related issues in the concept cartoons via their own worldviews and/or science backgrounds.

Research Focus

The related literature on the physics concept cartoons has emphasized to: conceptual understanding/conceptual change (Atasoy et al., 2013; Atasoy & Ergin, 2017; Minárechová, 2016; Taşlıdere, 2013, 2014), effective science teaching (Sasmaz-Oren & Meric, 2014; Say & Özmen, 2018), problem solving (Balım, İnel-Ekici & Özcan, 2016; Balim et al., 2014; İnel & Balım, 2013, nature of science (Çil & Çepni, 2016), and teachers' practical teaching experiences (Atasoy & Zoroğlu, 2014). This means that earlier researches have recruited the concept cartoons to facilitate students' conceptual understanding and evaluate their learning procedures. Further, they have sometimes integrated the concept cartoons into varied learning methods/strategies/models (i.e., problem-based learning) to increase students' learning capacities. Also, few research have employed them to make students aware of environmental problems/issues and science (Aydın, 2015; Naylor & Keogh, 1999a). For example, Aydın (2015), who developed computer-aided concept cartoons, found that the concept cartoons were effective in making grade 7 students aware of light pollution and offering possible solutions to prevent light pollution (Aydın, 2015).

The foregoing research have also concentrated on different grades and/or samples: primary school students (Minárechová, 2016), middle school students (Atasoy et al., 2013; Balım, İnel-Ekici & Özcan, 2016; Çil & Çepni , 2016; İnel & Balım, 2013; Sasmaz-Oren & Meric, 2014; Say & Özmen, 2018), high school students (Atasoy & Ergin, 2017), kindergarten children (Atasoy & Zoroğlu, 2014), pre-service teachers (Taşlıdere, 2013, 2014), academic staff (Atasoy & Zoroğlu, 2014) and teachers (Atasoy & Zoroğlu, 2014). Because the concept cartoons affect personal arguments or discourses, pre-service teachers need to learn and prepare various instructional materials (i.e., concept cartoons) for their students. Hence, they may have a chance to overcome their future students' pitfalls of physics and/or positively change their attitudes, interests, perceptions and awareness towards physics. These research have emerged the need of the current research focusing on pre-service teachers' initial impressions of the concept cartoons in the school corridors and informal physics learning via the concept cartoons. Even though the concept cartoons have extensively been used in the school courses, little research has concentrated on how to integrate them into informal physics learning (Naylor & Keogh, 1999a).

The Aim and Research Questions

Because the current research illustrated the use of the concept cartoons in the school corridors, it purposed to illuminate their role(s) on informal physics learning. Also, the concept cartoons would not only give an opportunity for pre-service teachers to compete their views with scientific ones but also enhance their initial impressions of scientific problems/issues. Further, pre-service teachers might at least have a chance to learn how to make science learning funny, interesting and attractive.

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The aim of the present research was to determine pre-service teachers' initial impressions of the concept cartoons in the school corridors and informal physics learning via the concept cartoons.

The following research questions guided the current research:

1) What are pre-service teachers' initial impressions of the concept cartoons in the school corridors?

2) What are their initial impressions of the informal physics learning via the concept cartoons?

Research Methodology

General Background

Because the current research sought pre-service teachers' initial impressions of the concept cartoons in the school corridors and informal physics learning via the concept cartoons, it employed one-shot design within pre-experimental research methodology (Campbell & Stanley, 1963). This research did not include any control group and formal measurement (i.e., pre-test) before the treatment. Given the current research's scope of the informal physics learning and pre-service teachers' initial impressions, such a pre-test might formally drive them to look for the concept cartoons in the school corridors. For this reason, the current research paid more attention to the results after the treatment instead of any relation/comparison between the treatment and results (Singleton & Straits, 2010). The main purpose of this research was to neither compare the concept cartoons with any other instructional design/method nor investigate its effectiveness, but to portray pre-service teachers' initial impressions of the concept cartoons in the school corridors and informal physics learning via the concept cartoons (i.e., Yakmaci-Guzel, 2013). Overall, a lack of a control group and/or pre-test may be seen as a limitation of the current research.

Sample

Primary, mathematics and science teacher education programmes at the faculty of education under investigation included 797 pre-service teachers. The first researcher initially invited them to respond the questionnaire. If they agreed to take the questionnaire, they were informed about any ethical issue (i.e., anonymous responding) in the present research. Further, whenever they would like to quit responding the questionnaire, they were free to do this. Thereby, 673 pre-service teachers from these programmes voluntarily participated in the current research. When the researchers firstly reviewed their responses to the questionnaire, they excluded 131 from the data in that they did not see the concept cartoons or leave all questions blank. Overall, the sample of the current research consisted of 542 pre-service teachers (see Table 1).

Table 1
The sample of the current research over the year of the four-year teacher education programme

Programmes	The first-year of the programme	The second-year of the programme	The third-year of the programme	The fourth-year of the programme	Total
Science teacher education	30	25	47	26	128
Primary teacher education	14	26	108	36	184
Mathematics teacher education	35	72	71	52	230

All pre-service teachers took compulsory physics courses (General Physics I-II for Science and Mathematics Teacher Education Programmes; and Fundamental Physics for Primary Teacher Education programme). Hence, dialogues in the concept cartoons were drawn from underlying physics concepts at three programmes.

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Materials and Procedures

The current research comprised of two main stages: *development of the concept cartoons and exhibition of the concept cartoons in the school corridors*.

Development of the concept cartoons

Given Naylor and Keogh's (1999b) guidelines about the development of the concept cartoons, the researchers followed the subsequent steps:

- After reviewing the related misconceptions in the literature, multiple alternative ideas/conceptions of physics subjects (force, sound, motion, magnetism and astronomy) were presented to create a cognitive conflict. Hence, pre-service teachers had an opportunity to compete their alternative ideas with each other.
- These ideas were equally included in the concept cartoons without any clue (e.g., the use of scientific language in the correct dialogue, facial mimic of each character, gender or age).
- The concept cartoons stressed science in everyday life (context-based learning) to make unfamiliar scientific knowledge familiar.
- By refraining from complex or long texts (with technical terms), the concept cartoons engaged pre-service teachers in finding a scientific problem and/or problem statement that could be negotiated and solved.

The present research initially adapted the existing concept cartoons of sound (Atasoy et al., 2013) and force and motion (Atasoy, 2008) for pre-service teachers. All concept cartoons, except for the adapted ones, were collaboratively designed with four postgraduate students from science education programme. Thus, 23 concept cartoons were prepared to exhibit in the school corridors. A group of experts (three physics/science educators, three science teachers, and two physics teachers) reviewed the concept cartoons and gave some suggestions for conceptual explanations in the dialogues, images of cartoons and cartoon characters. Then, given their feedbacks and suggestions, the researchers revised the concept cartoons. Also, their revised forms were pilot-tested with a small group of pre-service teachers, who did not take part in the real research. After ensuring their applicability and understandability, the researchers printed them in a color format of 50cm x 70cm (see Appendix A).

Exhibition of the concept cartoons in the school corridors

The concept cartoons were exhibited in the shared school corridors (i.e., the canteen entrance) for a period of 14 weeks (one semester) (see Appendix B). To exhibit two different subjects a week, the concept cartoons were weekly changed. The researchers did not foster pre-service teachers to look at and go over the exhibited concept cartoons since the current research underpinned informal physics learning.

Data Collection and Analysis

Given the questions used in the project 'Science on the Underground' by Naylor and Keogh (1999a), the researchers developed a questionnaire with seven open-ended questions. Four science/physics educators and 15 pre-service teachers were interviewed to check its understandability and clarity. They ensured its content validity and understandability (see Appendix C). At the end of the 14-week semester, the researchers handed hardcopies of the questionnaire out to pre-service teachers. The researchers firstly looked over the data to emerge the categories and label their responses to the questionnaire. Then, two categories (advanced and poor impression) were apparent given their similarities and differences (i.e., codes and themes) (see Table 2). Later, their responses to the questionnaire were exposed to qualitative content analysis via these two categories. The researchers independently analyzed and grouped the data. Inter-rater consistency was found to be .90. Any disagreement was resolved through negotiation.

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Table 2
Categories and related criteria

Categories	Criteria
Advanced impression	Examining, reflecting, making decision about the concept cartoons Developing positive/negative ideas and/or behaviors of the concept cartoons Making suggestions for the concept cartoons, and/or criticizing them (i.e., content, visuality or design). Finding the concept cartoons interesting, and significant Feeling a learning need about the concept cartoons Stimulating learning curiosity for the concept cartoons
Poor impression	Examining the concept cartoons without any reflection or decision-making Inability to develop any idea/attitude/behavior of the concept cartoons

Research Results

Table 3 presents the percentages of the 'advanced impression' category in regard to sub-categories, codes and teacher education programmes.

Table 3
The percentages of the 'advanced impression' category in regard to sub-categories, codes and teacher education programmes

Sub-categories	Codes	Science teacher education	Primary teacher education	Mathematics teacher education
First reaction to the physics concept cartoons	Difference	30	46	47
	Didactic quality	34	10	14
	Attractiveness	23	30	19
	Simplicity	6	4	4
Decision-making process	Cognitive conflict	33	19	24
	Recalling prior physics knowledge	20	29	26
	A lack of physics subject matter of knowledge	7	17	13
Way(s) to search correct answer(s)	Peer discussion and/or student-teacher discourse	71	53	60
	Reviewing instructional resources	10	7	7
	Inferences through cognitive activities	12	21	17
The effect(s) of the physics concept cartoons on science/ physics learning	Noticing misconceptions	5	6	3
	Becoming aware of pre-existing knowledge of physics	16	5	13
	Acquiring a new knowledge	9	8	13
	Relating physics knowledge to daily life	7	4	3
	Funny to teach physics	4	1	2
	Stimulating learning curiosity	5	5	12
	Developing positive attitudes towards physics/science	41	45	54

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Sub-categories	Codes	Science teacher education	Primary teacher education	Mathematics teacher education
The effect(s) of the physics concept cartoons on relating physics/science to daily life	Facilitating physics/science learning	19	13	16
	Awareness of the relationship between physics and daily-life	21	27	23
	Comprehending the relationship(s) between physics and daily-life	23	9	17
The effect of the physics concept cartoons on interest in physics/science	Positive effect(s) on understanding the nature of physics	10	5	5
Suggestions for the physics concept cartoons	Content	24	25	33
	Design	28	30	34
	Student-generated concept cartoons	13	7	11
	Alternative ways for exhibition / presentation	11	17	10

As seen from Table 3, pre-service teachers' responses to the questionnaire appeared various sub-categories and codes. Their first-reactions to the concept cartoons mostly fell into the 'difference, didactic quality and attractiveness' codes. Also, the percentages of pre-service primary school and mathematics teachers' first reactions to the concept cartoons were almost the same for all codes, except for the 'attractiveness' code. Furthermore, these pre-service teachers paid more attention to the 'difference' code, while pre-service science teachers made more emphasis on the 'didactic quality' code. Further, the percentage of pre-service primary school teachers referring to the 'attractiveness' code was higher than those of pre-service science and mathematics teachers.

The 'decision-making process' code contained three codes 'cognitive conflict, recalling prior knowledge and a lack of physics subject matter of knowledge.' Their initial impressions of the 'decision-making process' code generally referred to the codes 'cognitive conflict and recalling prior knowledge'. Pre-service science teachers had the highest percentage for the 'cognitive conflict' code, whilst pre-service primary school teachers possessed the highest percentages for the 'recalling physics knowledge' and 'a lack of physics subject matter of knowledge' codes.

Most of their responses classified under the 'way(s) to search correct answer' sub-category fell into the 'peer discussion and/or student-teacher discourse' code(s). Further, a significant amount of pre-service primary school teachers referred to the 'inferences through cognitive activities' code. Pre-service science teachers had the highest percentages for the 'peer discussion and/or student-teacher discourse' and 'reviewing instructional resources' codes, while pre-service primary school teachers possessed the highest percentage for the 'inferences through cognitive activities' code.

As seen from Table 3, the sub-category 'the effect(s) of the concept cartoons on science/physics learning' contained seven codes. Approximately half of them addressed that the concept cartoons resulted in developing positive attitudes towards physics/science. Pre-service science teachers showed the highest percentages for the 'becoming aware of pre-existing knowledge of physics' and 'relating physics knowledge to daily life' codes, while pre-service mathematics teachers possessed the highest percentages for the 'acquiring a new knowledge,' 'stimulating learning curiosity' and 'developing positive attitudes towards physics/science' codes. Moreover, pre-service science teachers had the highest percentages for the codes 'facilitating physics/science learning' and 'comprehending the relationship(s) between physics and daily-life', whereas pre-service primary school teachers possessed the highest percentage for the code 'awareness of the relationship between physics and daily-life'. Furthermore, the percentages of the 'positive effect(s) on understanding the nature of physics' code was 10, 5 and 5 for pre-service science, primary school and mathematics teachers respectively. Also, the sub-category 'suggestions for the concept cartoons' incorporated four codes. A considerable amount of them implied the 'content' and 'design' codes. Also, some of them suggested the codes 'student-generated concept cartoons' and 'alternative ways for exhibition/presentation'. Pre-service mathematics teachers had the highest percentages for the 'content' and 'design' codes, whilst pre-service science teachers possessed the highest percentage for the 'student-generated concept cartoons.' Moreover, pre-service primary school teachers showed the highest proportion for the 'alternative ways for exhibition/presentation' code.

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Table 4
The percentages of the 'poor impression' category in regard to sub-categories, codes and teacher education programmes

Sub-categories	Codes	Science teacher education	Primary teacher education	Mathematics teacher education
First reaction to the concept cartoons	Poor sustainable interest	7	8	13
Decision-making process	Poor informal reasoning	20	8	50
Way(s) to search correct answer(s)	Poor learning curiosity for physics/science subjects	27	74	29
The effect(s) of the concept cartoons on science/physics learning	Poor influential role	52	50	51
The effect(s) of the concept cartoons on relating physics/science to daily life	Poor influential role for pre-service teachers	16	25	23
The effect of the concept cartoons on interest in physics/science	Poor effect	47	44	38
Suggestions for the concept cartoons	No suggestion	20	23	16

As can be seen from Table 4, nearly half of them stated poor influential role of the concept cartoons on science/physics learning, whilst almost four tenth of them depicted their poor effect(s) on interest in physics/science. Pre-service primary school teachers possessed the highest percentage for the 'way(s) to search correct answer(s)' code, while pre-service mathematics teachers had the highest ratio for the 'decision-making process' code.

Discussion

As seen from Table 3, pre-service teachers stated that they informally read the concept cartoons, and discussed or negotiated their physics learning or subject-matter knowledge. Such an informal learning process seems to have resulted in enhancing their initial impressions of physics/science. This may come from the dialogic talks in the concept cartoons. As a matter of fact, they showed the 'difference, didactic quality and attractiveness' codes in their first-reactions to the concept cartoons. This indicates how the concept cartoons under investigation created an alternative learning environment for them (Naylor & Keogh, 1999a). Indeed, some deficiencies of infrastructure facilities in the schools generally force them to spend their break times in the school corridors. Therefore, the current research seems to have enabled them to effectively spend their break times by engaging them in the informal physics learning via the concept cartoons. For example, pre-service teachers tended to use peer discussion and/or student-teacher discourse to search the correct dialogues at the concept cartoons. This means that the concept cartoons seem to have developed their argumentation skills, which is a pre-request for science literacy (i.e., Bağ & Çalık, 2017; Çapkınoğlu & Yılmaz, 2018; Torres & Cristancho, 2018).

Because the concept cartoons encouraged them to handle the topics/issues with their peers and/or teachers (Keogh & Naylor, 1999, 2000; Naylor & Keogh, 1999a), pre-service teachers engaged scientific and social dimensions of any socio-scientific issue in evaluating their peers' views and learning the nature of science (Kolsto, 2001; Sadler, 2004; Wiyarsi & Çalik, 2019). Furthermore, peer discussion and/or student-teacher discourse may come from social interactions (peer-to-peer or student-to-teacher) in an informal learning environment (e.g., concept cartoons in the school corridors).

Since the concept cartoons triggered their learning curiosity and cognitive frameworks (i.e., cognitive conflict, recalling physics knowledge) (see Tables 3-4), pre-service teachers seem to have felt a learning need. This means that the concept cartoons served as an informal physics learning tool to pose their learning needs and extend or revise their conceptual understanding (Naylor & Keogh, 2000). Hence, the concept cartoons played a significant role in remedying their biases of physics and attracting their learning interests towards physics (see Table 3). This means that the concept cartoons have a complementary role in physics/science learning. Given

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their suggestions for the concept cartoons (see Table 3), future studies should develop similar concept cartoons for other disciplines or science topics. Also, students may generate these concept cartoons by electronically animating them. Hence, online boards or TVs may alternately broadcast them for encouraging informal physics/ science learning.

Even though pre-service science and mathematics teachers had a science background and attended several compulsory physics courses in upper secondary schools and teacher education programmes, their initial impressions of the concept cartoons somewhat differentiated from pre-service primary school teachers. Phrased differently, although pre-service primary school teachers had a limited science background and only took a compulsory physics course (e.g., Bursal, 2008; Çalik & Cobern, 2017), they possessed the highest percentages for some codes (i.e., attractiveness, recalling physics knowledge, inferences through cognitive activities, awareness of the relationship between physics and daily-life, and alternative ways for exhibition/presentation). This may refer to their open-mindedness of the informal physics learning via the concept cartoons. Moreover, nearly half of them depicted the positive effect(s) of the concept cartoons on their attitudes towards physics/ science. This means that the concept cartoons, as an informal physics learning tool, develop positive attitudes towards physics/science even if science backgrounds of the participants are different.

As seen from Tables 3-4, the concept cartoons somewhat grasped pre-service teachers' learning interests and curiosity. For example, pre-service primary school and mathematics teachers had high ratios for the 'poor learning curiosity for physics/science subjects' and 'poor informal reasoning' codes respectively. They may have viewed physics knowledge in the dialogues as useless for their future teaching careers. In other words, these codes may result from the idea that they will not teach physics/science in their future teaching careers. On the other hand, these pre-service teachers may have tended to disregard scientific literacy (i.e., science for all, and public understanding of science) within informal learning/reasoning (i.e., Keogh & Naylor, 2013).

Conclusion and Implications

The current research concluded that the concept cartoons in the school corridors not only enhanced pre-service teachers' initial impressions of the informal physics learning via the concept cartoons but also created an alternative learning environment fostering scientific literacy. Further, peer discussion and student-teacher discourse through the concept cartoons seems to have improved their argumentation skills. Because the concept cartoons posed a learning need for pre-service teachers, they played a significant role in overcoming their biases of physics and attracting their learning interests towards physics. Given types of the teacher education programmes, pre-service science and mathematics teachers somewhat differentiated from pre-service primary school teachers. This means that pre-service teachers from different departments tended to differently interpret the concept cartoons in the school corridors because of variation in their subject-matter knowledge.

Given the results of the current research, future studies may encourage pre-service teachers to produce their own concept cartoons on the topic(s) they found difficult. Hence, they may have an opportunity to overcome their own difficulties. Moreover, to make concept cartoons more attractive, future studies may animate them in miscellaneous exhibition formats.

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APPENDICES

A. A sample physics concept cartoon

B. Some photos from the exhibition in the school corridors

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C. Questionnaire

1. What was your first reaction to the physics concept cartoons? Please explain your reason.
2. Did you have any difficulty about the dialogues in the physics concept cartoons? Please defend your response.
3. How did you search the correct answer(s)? Please illustrate your response.
4. Do you think that the physics concept cartoons have helped you to learn physics/science? Please illustrate your response.
5. Do you think that the physics concept cartoons have enabled you to link physics/science with everyday life? Please illustrate your response
6. Do you think that the physics concept cartoons have improved your interest in physics/science?
7. 7. Do you have any suggestion for the physics concept cartoons in the school corridors? Please illustrate your response.

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