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# COMICS IN SCIENCE TEACHING: A CASE OF SPEECH BALLOON COMPLETING ACTIVITY FOR HEAT RELATED CONCEPTS[1]

Ertuğrul Özdemir[2], Ali Eryılmaz[3]

## ABSTRACT

Comics have an important role in non-formal learning environments. However, how comics may be effective teaching/learning activitities in formal education is an ongoing debate in literature. The purpose of this study is to create and evaluate a series of instructional comics about heat related concepts to be used as teaching/learning activities in real classroom settings. This research is designed as a case study aiming to observe and explain students' reactions to the implementation of an instructional intervention. In this study, six instructional comics about heat related concepts having empty speech balloons were constructed and implemented to a group of 6th graders as balloon completing activities. It was observed that many students completed empty balloons with several wrong statements, and it was concluded that students' wrong statements have crucial feedback for dealing with students' preconceptions about science concepts.
**Keywords:** instructional comics, heat, science teaching, case study.

# FEN ÖĞRETİMİNDE KARİKATÜR KULLANIMI: ISI KAVRAMINA YÖNELİK KONUŞMA BALONU DOLDURMA ETKİNLİĞİ ÖRNEĞİ

## ÖZ

Karikatürlerin okul dışı öğrenme ortamlarında önemli bir rolü bulunmaktadır. Ancak, karikatürlerin örgün öğretim sürecinde etkili bir öğrenme etkinliği olarak ne şekilde kullanılabileceği alanyazında süregelen tartışmalardan biridir. Bu çalışmanın amacı ısı kavramı ile ilgili bir dizi kısa karikatür öykü geliştirip bunların gerçek sınıf ortamında öğrenme etkinliği olarak kullanımını değerlendirmektir. Bu çalışma, öğrencilerin sınıfta uygulanan bir öğretimsel müdahaleye ilişkin tepkilerini gözlemlemeyi ve açıklamayı amaçlayan bir örnek olay araştırması olarak tasarlanmıştır. Bu çalışma kapsamında her birinin içinde boş konuşma balonları bulunan ısı kavramı ile ilgili altı kısa karikatür geliştirilmiş ve bir grup 6. sınıf öğrencisine boşlukları doldurma etkinliği olarak uygulanmıştır. Bu etkinlik sırasında pek çok öğrencinin karikatür öykülerdeki boşlukları çeşitli yanlış ifadelerle doldurdukları gözlemlenmiştir. Öğrencilerin yazdığı yanlış ifadelerin öğrencilerin sahip olduğu önkavramları tespit edip gidermeye yönelik önemli dönütler içerdiği sonucuna ulaşılmıştır.
**Anahtar kelimeler:** öğretici karikatür öyküler, ısı, fen öğretimi, örnek olay araştırması.

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[1] This study is a part of an extensive dissertation research conducted by the first author with the supervision of the second author.

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## INTRODUCTION

Since prehistoric times, people have been using stories and tales to transmit culture and to teach acceptable social actions to their children. Hadzigeorgiou and Stefanich (2000) expressed that ancient people tried to describe natural phenomena with mythological tales. For instance, ancient Greeks described the connection between earthquakes and volcanoes with Titans who are huge and strong creatures imprisoned under the mountains. Storytelling is an effective teaching method, because, it makes learning context-based and consequently meaningful (Hadzigeorgiou & Stefanich, 2000). In recent times, stories are still being told in various types, such as, storybooks, cartoon animations, movies etc. Comics are among the common types of the modern stories.

Comics are playing an important role in non-formal education. However, how comics may be effective instructional aid in formal education is a good question for education researchers. In the literature, three main uses of comics and caricatures in formal teaching/learning environments exist: warm up activity, learning activity, and assessment tool. As an example of warm up activity, Cheesman (2006) described how to adapt comic strips published in newspapers and magazines into science classrooms as attention getters and starter for critical thinking. According to Cheesman (2006), comics contribute students in focusing on lessons and learning to think in a critical way.

According to the literature, comics may also be created in order to teach a specific concept as a main learning activity. Keogh and Naylor (1999) created and used concept cartoons that are a special type of single frame caricature including a series of conflicting ideas about a science concept. According to Keogh and Naylor (1999), concept cartoons may be successfully used to create cognitive conflict in students' minds in order to support them to be ready for accommodation of new concepts. Concept cartoons are not observed as the unique type of instructional comics in the literature. As another form of instructional comics, Rota and Izquierdo (2003) created and implemented comics specifically to teach biotechnology concepts in primary school level, and concluded that comics are very effective teaching/learning material because of combining two very rich forms of cultural expression: the literature and the art. In addition, according to Jee and Anggoro (2012), narrative structure of comics can make scientific contents more comprehensible because of having similar structure to everyday life situations. Similarly, Koutnikova (2017) reported that comics may be very beneficial to make science concepts interesting and comprehensible for children due to presenting everyday life experiences concealing scientific content. Besides, Rota and Izquierdo (2003) expressed that reading comics is not a passive activity because, while reading comics, the reader should complete the gaps between the panels that requires active thinking. Likewise, Olson (2008) developed and used comic strips in science classroom as a teaching/learning activity to promote science literacy. In the study, these comic strips were implemented to students as reading, thinking and discussion activities in the instructional process. The findings indicated that comic strips increased students' performance in some specific concepts. Moreover, students perceived comic strips entertaining and attractive learning activities.

A third way of using comics in formal education is using them as an assessment activity. Song, Heo, Krumenaker, and Tippins (2008) explored the ways of implementing comics as assessment tool in the classroom. In the study, three ways of using comics as assessment tool are mentioned. According to Song et al. (2008), firstly comics may be applied to evaluate students' ideas that they bring to classroom. That is, comics may be implemented to detect students' myths and misconceptions. Secondly, students' learning difficulties may be evaluated by comics. Comics may also be used to assess applications of students' learning into daily life situations (Song et al., 2008). On the other hand, Beard and Rhodes (2002) implemented comics as a reflective instrument in adult learning. In the study, the researchers used comics with blank balloons for collecting subjects' reflections. The results showed that comics are great tools for expressing feelings, anxieties, and other emotions that may not easily surface with conventional techniques (Beard & Rhodes, 2002).

The current study is designed with the guidance of related literature summarized above. In this study, heat transfer is preferred as the core concept to be focused. There are two main reasons for choosing this concept. Firstly, heat transfer is somehow static concept that may be appropriate for comics as a medium composed of static images. Secondly, heat transfer may be accepted as a quite challenging subject for students (Sözbilir, 2003) providing opportunity for a better observation of students' learning difficulties and handling of these difficulties by using comics.

In the history of science education, science educators suggested many instructional methods and media to create more effective learning environments. In the instructional process, each individual method or medium is beneficial for different science concepts and different age groups. To determine a suitable method - media combination for specific science concepts and specific age groups requires massive and extensive research literature. The purpose of this study is to make a unique contribution to science education literature through the implementation of a specific method – media combination for a specific age group. Actually, this study does not suggest a new method or a new media for teaching/learning process. Instead, it examines application of comics as a kind of artwork created with the combination of storytelling and pictorial illustrations into science instruction. The purpose of this study is to create and evaluate a series of comics about heat related concepts to be used as learning activities in elementary science courses.

## ACTIVITY IMPLEMENTATION

This study is designed as a case study aiming to observe and explain individuals' reactions to an instructional intervention (Yin, 2003). As a subset of an extensive dissertation research, this study aims to explain the case of the implementation of instructional comics to a group of middle school students. In other words, in this study, a series of instructional comics about heat related concepts were implemented to a group of middle school students and their responses were analyzed and evaluated qualitatively.

### Participants

Participants were 52 sixth grade students from three intact classrooms in three different public middle schools including 26 female and 26 male students. The schools were selected among several convenient schools. In the selected schools, classes were chosen and assigned to this implementation by the school administrations. Necessary permissions were obtained from the National Education Directorate prior to the research.

### Material and Instruments

In this study, a series of comic stories was designed and developed for the sixth grade, matter and heat chapter in the curriculum of science and technology course. Matter and heat chapter introducing heat related concepts was covered with six comic episodes. These comics were similar to ones on newspapers and magazines. However, unlike regularly published comics, the instructional comics designed in this study carry academic messages integrated into the adventures of comic characters in the story.

Instructional comics implemented in this study were created by the researchers in cooperation with science education specialists. At first, main comic character who is a repairman was defined. As the occupation, repairman was preferred since he is a problem solver in the real life situations. In the next step, scenarios of six episodes were written by the researchers. Then, each episode was drawn, colored by using drawing hardware and software. Finally, speech balloons were written with a computer software. In each episode, a repairman who lives in a small town solves people's daily problems, while explaining concepts of heat, conduction, convection, radiation, insulation and so on. After creating initial versions of the comics, they were piloted in a small group of students in a public elementary school in order to get their suggestions for final version of the comics. In the pilot implementation, the teacher and the students mostly suggested that the amount of text in the comics should be decreased. They also suggested that interactivity should be increased in the implementation of instructional comics. With respect to the feedback from the pilot study,

scenarios were revised and comics were re-drawn for the main implementation. After re-creating the comics, each episode was reviewed by two experts who are science education specialists. Final versions of the comics were prepared by applying all modifications suggested by these experts. With these modifications, the amount of text was decreased and some speech balloons were left blank in the final version of the comics in order to add interactivity into the implementation. Therefore, unlike pilot study, main implementation became a balloon completing activity rather than a reading activity. Table 1 demonstrates the topics of all comic episodes. Figure 1 below shows final version of one of the six comic stories. All of the comic stories are available in Appendix 1.

**Table 1.** Titles of the Comic Episodes

| Episode | Title |
|---|---|
| Ep. 1 | Matter and Heat |
| Ep. 2 | Conduction |
| Ep. 3 | Convection |
| Ep. 4 | Radiation |
| Ep. 5 | Heat Insulation |
| Ep. 6 | Thermos |

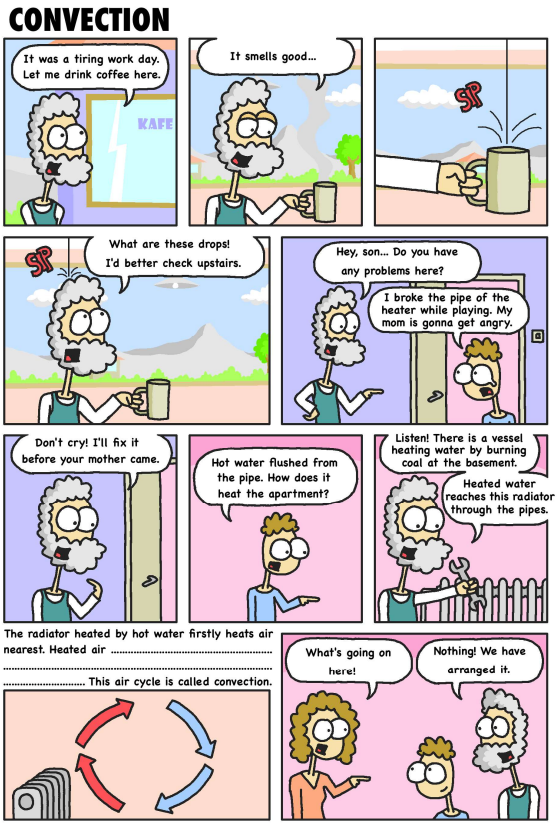


**Figure 1.** Thumbnail View of One of the Six Comic Stories Used in This Study

A more profound consideration of students' opinions about comics by open-ended responses might be helpful for explaining the real situation in the classroom during the implementation. Therefore, an open-ended questionnaire for students including five open-ended questions was built to get deeper information on students' opinions about instructional comics. In this questionnaire, students were asked about whether comics can make teaching/learning process more entertaining, whether comics can help learning, their advantages and disadvantages and how instructional comics can be improved.

In addition to students, the teachers might also have significant feedback for the design and development process of instructional comics. Thus, an open-ended questionnaire for the teachers was constructed. In addition to the questions in the students' questionnaire, teachers were also asked about the influence of instructional comics on classroom management, students' participation to the lesson, gender groups and students with various socioeconomic backgrounds.

Before the application of instructional comics, each lesson was planned step by step in detail by the researchers. Lesson plans were prepared in order to ensure that the teachers comprehended what exactly instructional comics are and how they should be implemented. The implementation of the comic stories was planned to take six lessons in two weeks. Thus, six lesson plans including some directives and cautions about the implementation of the comics were constructed. The directives and the cautions were determined by the researchers with respect to the review of the related literature, the expert opinions and pilot implementation. For instance, in the first episode of the comics, the atoms were shown as small balls around a microorganism. Yet, they were drawn unrealistically huge with respect to the size of the microorganism. Thus, one of the experts suggested that a caution about unrealistic size of the atoms should be placed in the related lesson plan. Before the implementation, all lesson plans were explained to the teachers of the participant students. The teachers read and followed them before and during the implementation in order to learn how to carry out intended authentic implementation.

A comprehensive implementation checklist was constructed by the researchers to check authenticity of the implementation and to prevent the internal validity issues. This checklist contained a number of items about implementation of comics and data collection procedures. The checklist was constructed mainly based on the lesson plans, because the implementation in real settings should resemble intended implementation described in lesson plans as much as possible. It was also built with respect to potential threats to internal validity to avoid unintended situations during the implementation that may influence the results. The implementation checklist was carried out by one of the researchers during the observations of lessons and data collection sessions in the classrooms. In addition, teachers used this checklist after their lessons for the purpose of self-evaluation.

**Implementation and Data Collection**

In this study, a series of comic stories about heat related concepts was implemented to a group of sixth graders as instructional activities. Before starting implementation, the teachers were informed in detail about instructional comics and their implementation in the instructional process. In addition, a set of lesson plans was shared with the teachers to clarify the details of intended implementation. The implementation started with the explanation of the purpose of instructional comics to participating students in the first lesson of the first week. During two weeks, six instructional comics were implemented in six lessons in each selected classroom. After the implementation of instructional comics, students were asked to take open-ended questionnaire in the last lesson of the second week.

Instructional comics were implemented with three steps in each lesson. In the first step, the teacher informed the students about learning activities in the lesson, and then the students were asked to read a comic story and to complete the blank balloons for ten minutes. In the second step, the teacher asked some students to tell what they read in the comics without mentioning the blank balloons. Then, the teacher asked a number of students to explain what they wrote in the blank balloons in the comics. In this step, the teacher started a discussion in which conflicting ideas of students come across in the classroom. In this step, the students finally found out correct statement for blank balloons through teacher's feedback. In the third step, the teacher explained the concepts discussed during the lesson briefly at the end. Figure 2 describes implementation of instructional comics. As an example, detailed learning-teaching process of the lesson about "convection" is given in Table 2.

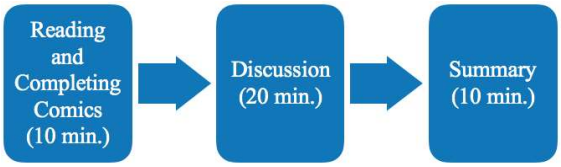


**Figure 2.** Description of the Implementation of Instructional Comics in a Lesson

**Table 2.** An Example Lesson Process

| Step | Explanation |
|---|---|
| 1 | At the beginning of the lesson, one student summarized the previous comic story. |
| 2 | The students read the comics whose title is "convection" and completed the blank balloons. |
| 3 | Two students summarized the comic story about convection. |
| 4 | Many students expressed what they wrote in the blank balloons and explained why. |
| 5 | A whole class discussion was held, emphasizing students' various conflicting ideas. |
| 6 | During the class discussion, the teacher highlighted students' correct or partially correct ideas about heat transfer by convection. |
| 7 | After the discussion, the teacher explained a correct answer that could be written in the blank balloons. |
| 8 | The teacher explained heat transfer by convection briefly. |

In this study, data from various sources were collected at different times. However, there were two main data in this study: students' entries in the blank balloons and their responses to open-ended questionnaire. During the lessons, the students were asked to read the comics and complete the blank balloons. At the same time, one of the researchers had the observer role and collected data by using the

implementation checklist to ensure the authenticity of the planned activities. In the last lesson, the researcher implemented open-ended questionnaires to the students and teachers in order to get some deeper feedback.

**Analysis**

Data from participants' responses in the blank balloons were analyzed through qualitative content analysis. Most of the students completed blank balloons correctly, however wrong statements in these balloons had some significant implications for this study. Therefore, wrong statements in the blank balloons were identified and analyzed in order to get feedback for development process of instructional comics.

Data gathered from open-ended questionnaires administered to the participants were also analyzed via qualitative content analysis in order to reveal more detailed information of the students' and teachers' opinions about the use of instructional comics in science teaching. The data were used to make inferences about how the students and teachers experienced instructional comics and how they responded to them.

**Findings**

As stated above, each comic story had empty balloons that students were requested to complete after reading. Most of the students completed these balloons with correct or partially correct statements, yet some remarkable wrong answers were observed. Table 3 demonstrates percentages of correct and wrong statements in the empty balloons.

**Table 3.** Percentages of Speech Balloon Completing Activities

| Blank Balloons | Correct Responses (%) | Wrong Responses (%) |
|---|---|---|
| Ep. 1 | 78.8 | 21.2 |
| Ep. 2 | 73.1 | 26.9 |
| Ep. 3 | 59.6 | 40.4 |
| Ep. 4 | 86.3 | 13.7 |
| Ep. 5 | 60.8 | 39.2 |
| Ep. 6 | 51.9 | 48.1 |

As seen in Table 3, students' responses in the fourth episode that is related to heating with radiation have the largest percentage of correct statements (86.3%). On the other hand, their responses in the sixth episode that is about to thermoses have the largest ratio of wrong statements (48.1%).

Students' correct and wrong responses may be helpful for revealing the image of the comics from students' perspective. Some examples of students' responses that can be regarded as correct are listed below.

- Whey the water is boiled, particles get much into motion and crash the microbe with the collisions and the microbe is dead. (Ep. 1)
- When some atoms vibrate, they cause other atoms vibrate as well. (Ep. 2)
- Heated air rises, then it becomes cold and goes down. Convection is displacement of air. (Ep. 3)
- For example, sunlight comes and heats Earth but it heats just one side of Earth that faces toward Sun.(Ep. 4)
- Heat insulation is to prevent heat transfer between inside and outside of the house. (Ep. 5)

Students' remarkable wrong and partially wrong statements in balloon completing activity are listed below. Numbers in the parenthesis are the number of students whose responses having the same meaning.

- When polluted water is boiled, bacteria and viruses disappear (become nonexistent). (8)
- Far end of the needle is heated by collisions of the particles. (5)
- Moon heats the planet Earth by radiation. (4)
- The far end of the needle is heated, because heated particles at the near end of the needle move to the far end. (1)
- Radiator panels heat the room through evaporation. (1)
- Sun cannot heat Earth much, because some of sunlight is blocked by stars. (1)

As demonstrated in the list above, one of the most important findings is that there are a remarkable number of students believing that bacteria and viruses in boiling water disappear or vanish. Another significant finding is that some students believe that heat conduction in solid objects occurs by the collisions of atoms

and molecules. Another remarkable finding about students' responses to empty balloons is that a few students confused about Sun, and considered it as Moon in the fourth episode. Actually, the source of this confusion was probably the stars around Sun in the related panel. These students seemed to know little about this drawing of Sun that is a view from outside of Earth's atmosphere. To make the panel clearer, a small satellite emphasizing out of the Earth's atmosphere might be drawn near the Earth.

At the end of the two-week implementation, the open-ended questionnaire including five questions was given to 52 students in the selected classrooms. Open-ended questions and students' remarkable responses to these questions are categorized in Table 4. Numbers in the parenthesis are the frequency of the responses.

**Table 4.** Students' Responses in Open-ended Questionnaire

| Question | Response |
|---|---|
| Can instructional comics make learning funnier? Why? | Yes, because comics are humorous. (6)<br>Yes, because children like comics. (4) |
| Can instructional comics provide an effective learning? Why? | Yes, because comics are funny. (23)<br>Yes, because comics attract attention. (10)<br>Yes, because comics are visual. (10) |
| What are the advantages of instructional comics? | Children will not forget course topics. (14)<br>Children are eager to read comics. (7)<br>Comics make children learn quickly. (4) |
| What are the disadvantages of instructional comics? | Comics may be time wasting. (1)<br>Some children may not like reading comics. (1)<br>Some students may be spoilt while reading comics. (1) |
| How can this instructional activity be made more effective? | There should be comics in other courses. (9)<br>There should be more comics in science course. (6)<br>There should be comics in textbook. (3)<br>Comics can be computerized. (3) |

As seen in Table 4, one of the most crucial findings is that students demanded instructional comics in the textbooks of not only science but also the other courses. Another significant result is that students found comics useful in long-term learning. As another remarkable finding, most of the students found comics useful because of being funny or humorous.

In addition to positive opinions mentioned above, a small number of the students reported three disadvantages of instructional comics. One student, who is one of the most hard-workers in the classroom, found instructional comics time wasting. In addition, one student stated that he does not like reading comics. Another student reported that comics may ruin the discipline in the classroom. These negative opinions do not seem to represent common views of the participants.

## CONCLUSIONS and SUGGESTIONS

In this study, the qualitative data obtained from balloon completing activities and the open-ended questionnaires implemented to the students and teachers were analyzed. Additionally, the non-participant observations by the researchers were also examined as a supplementary analysis for the validity of the results. These analyses yielded a series of findings that is possible to make some general conclusions.

As mentioned above, students gave some important incorrect responses in balloon completing activities and some of these statements may be directly related to the drawing style of the comics. For instance, four students from different classrooms wrongly stated that moon heats the earth. They might think the shiny object illustrated in dark space should be the moon, because sun cannot be seen at nights. In other words, they probably could not distinguish sun in space and moon at night. To avoid this misunderstanding, this panel may be redrawn in a different perspective. In addition, five students in different classrooms wrongly stated that heat is transferred by collisions of particles in the metal needle. It seems that, for these students, comics were not sufficiently useful for realizing the difference between vibrations and collisions. Actually, as stationary drawings, comics may not be appropriate to describe the

types of movements, which is one of the most important disadvantages of comics. Besides, most of the students stated that viruses and bacteria die in boiled water, however eight of them wrongly believed that viruses and bacteria disappear or totally vanish in boiled water. They might think that boiling process results in a kind of evaporation of viruses and bacteria taking them out of water. In general, students' wrong statements discussed above have crucial feedback for revising instructional comics and should be focused during development process of instructional comics.

In this study, it was mainly found that instructional comics make learning an entertaining activity. Similar findings were available in the literature, for instance, science comic books are found to increase students' interest and enjoyment of learning more than text-only booklets (Lin, Lin, Lee, & Yore, 2015). On the other hand, it was also observed that they may have some positive "side effects." One of the most important "side effects" of instructional comics may be related to reading enjoyment. Some children do not like reading text-only stories. However, in this study, it was clearly observed that students read comics willingly with great interest during the reading sessions in the classroom. It may be claimed that comics have potentially positive effects on children's reading enjoyment. This observation seems to be parallel with the findings in the literature. For example, Spiegel, McQuillan, Halpin, Matuk, and Diamond (2013) reported that teenagers approximately five times more likely to want to engage comic type reading material than essay type reading material. Another remarkable positive "side effect" of instructional comics may be about their contribution to classroom management. In open-ended questionnaires, the teachers expressed that classroom management was much less tiring during comics activities, because the students were so motivated to read the comics and to complete the empty balloons that the teachers made less effort to manage the classroom.

Another one of the important findings of this study is that some of the students demanded comics in the course textbooks, not only in the science and technology course, but also in the other courses. This clear request may have an important implication for formal education pointing a demand for more humor and entertainment in the classroom.

As a general conclusion, when the effects and "side effects" of instructional comics discussed above are taken into account, they seem to be useful learning aid in science education by making science lessons more humorous and enjoyable as well as making the classroom management easier.

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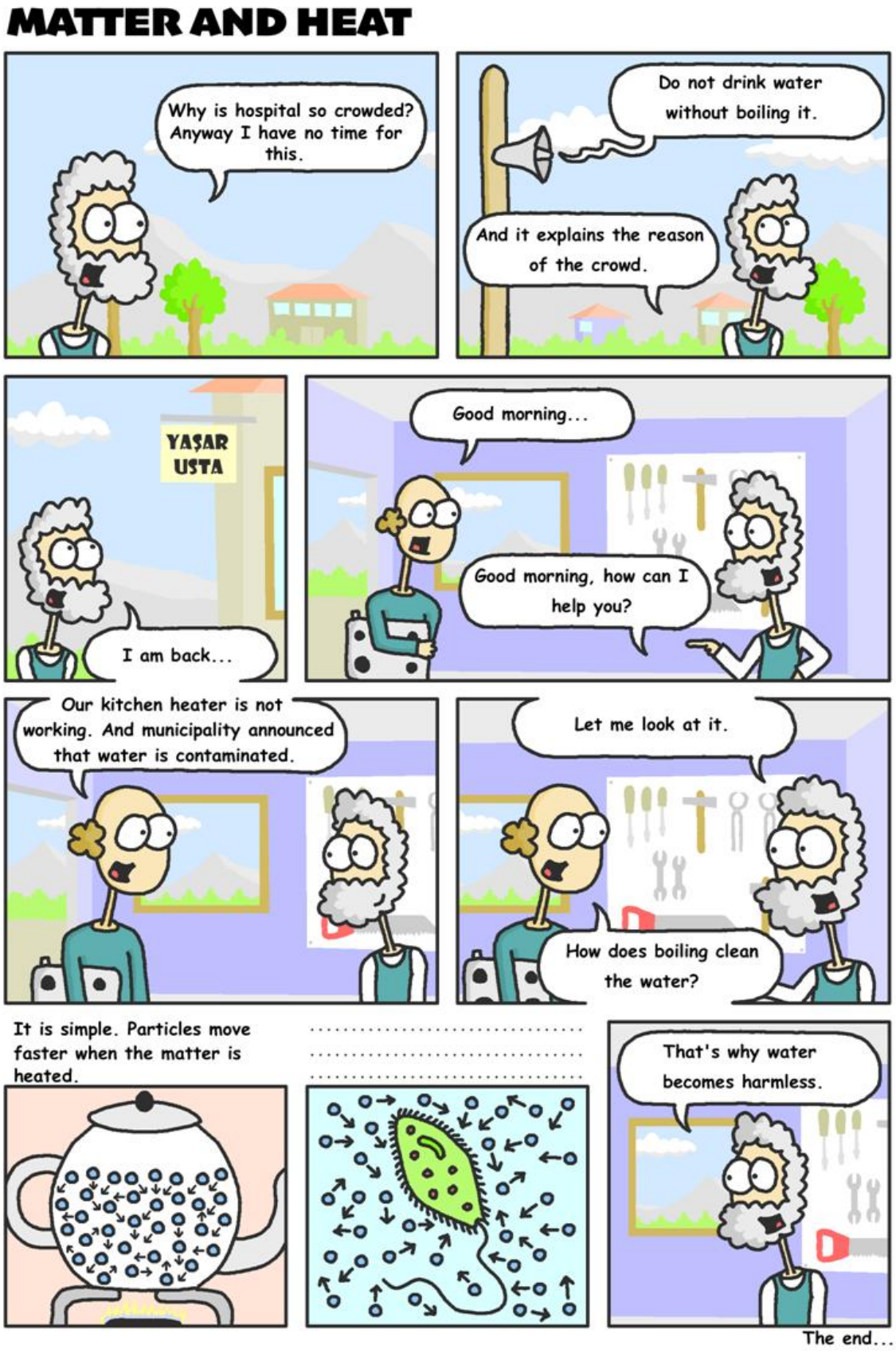
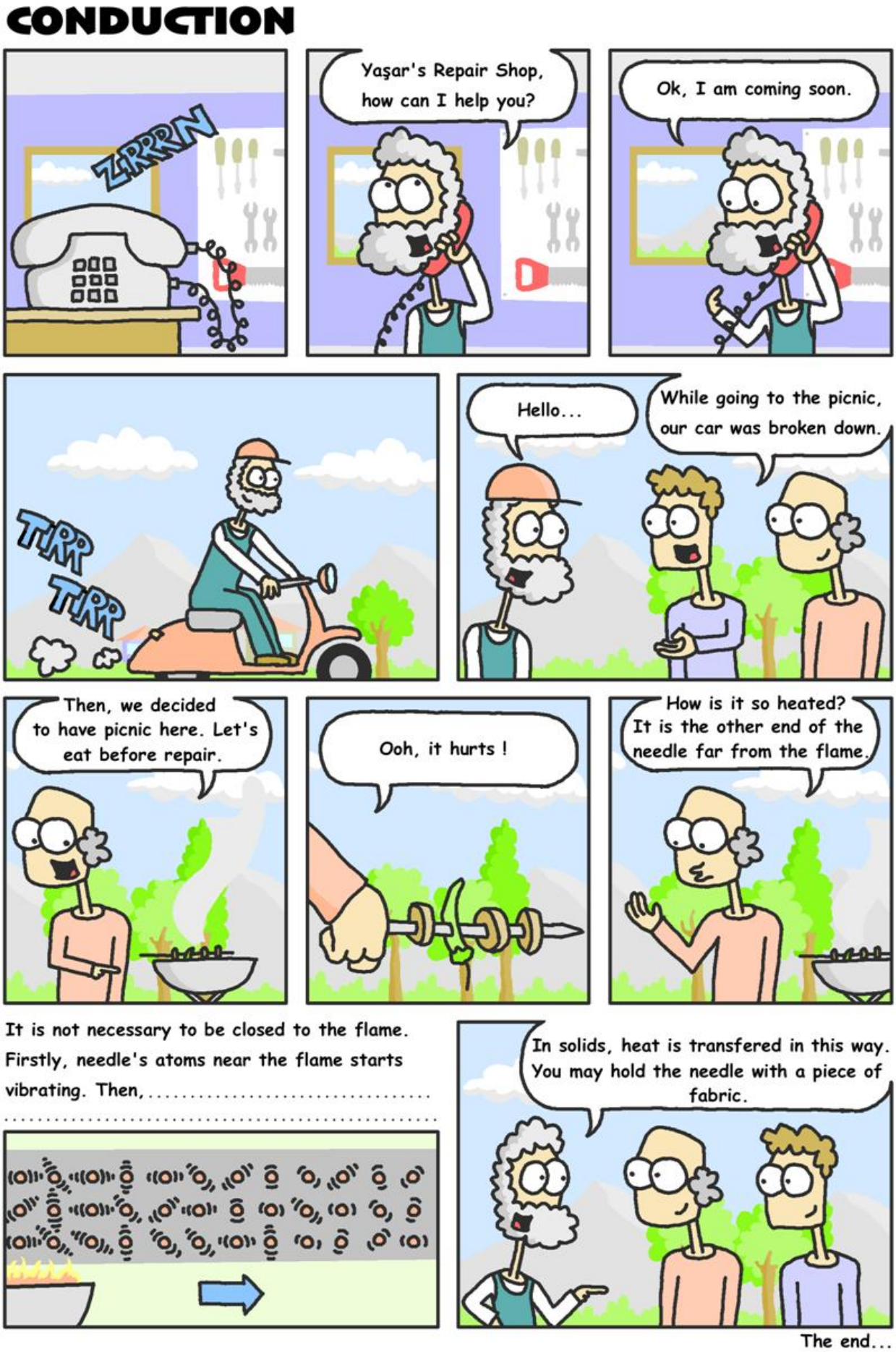
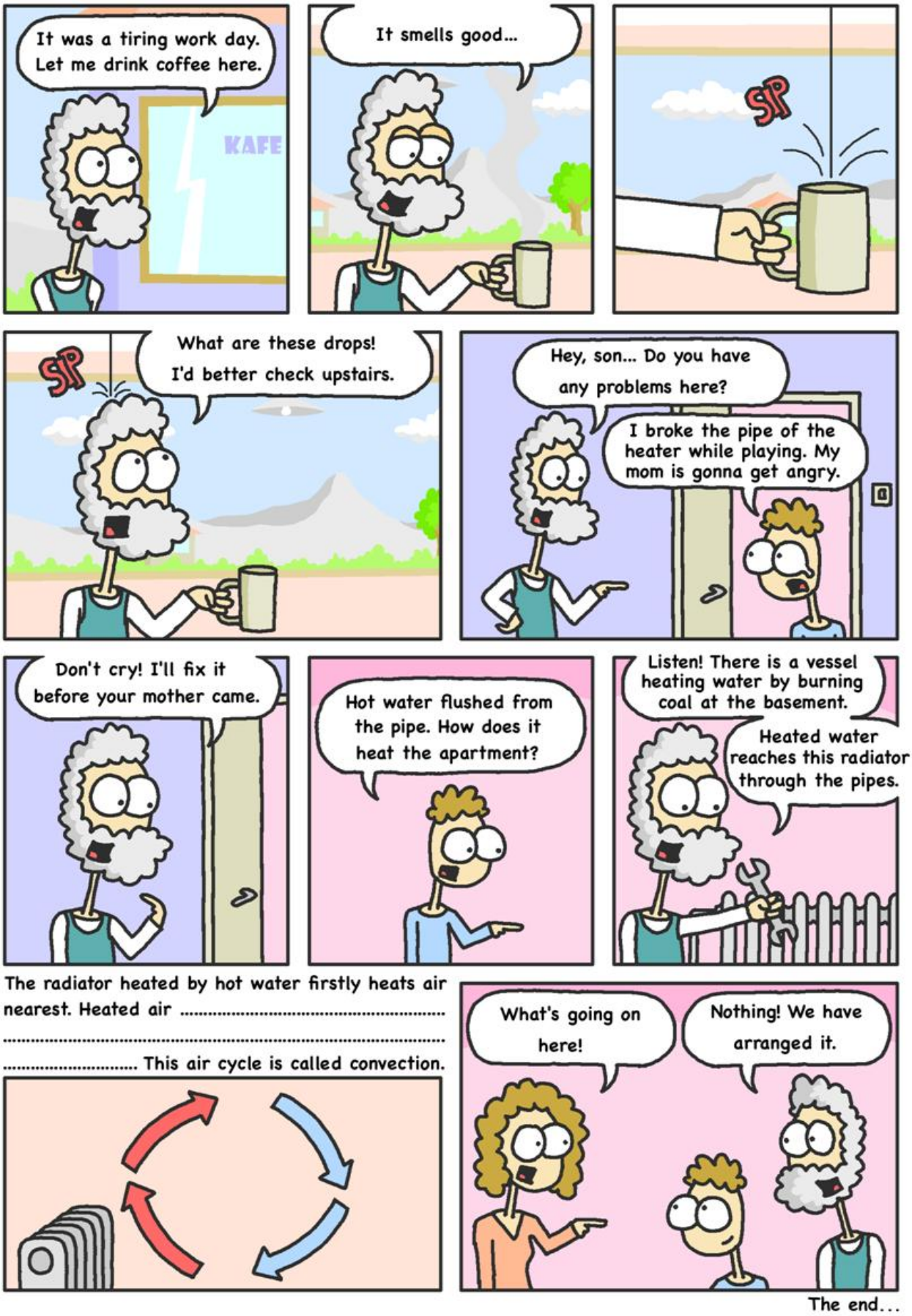
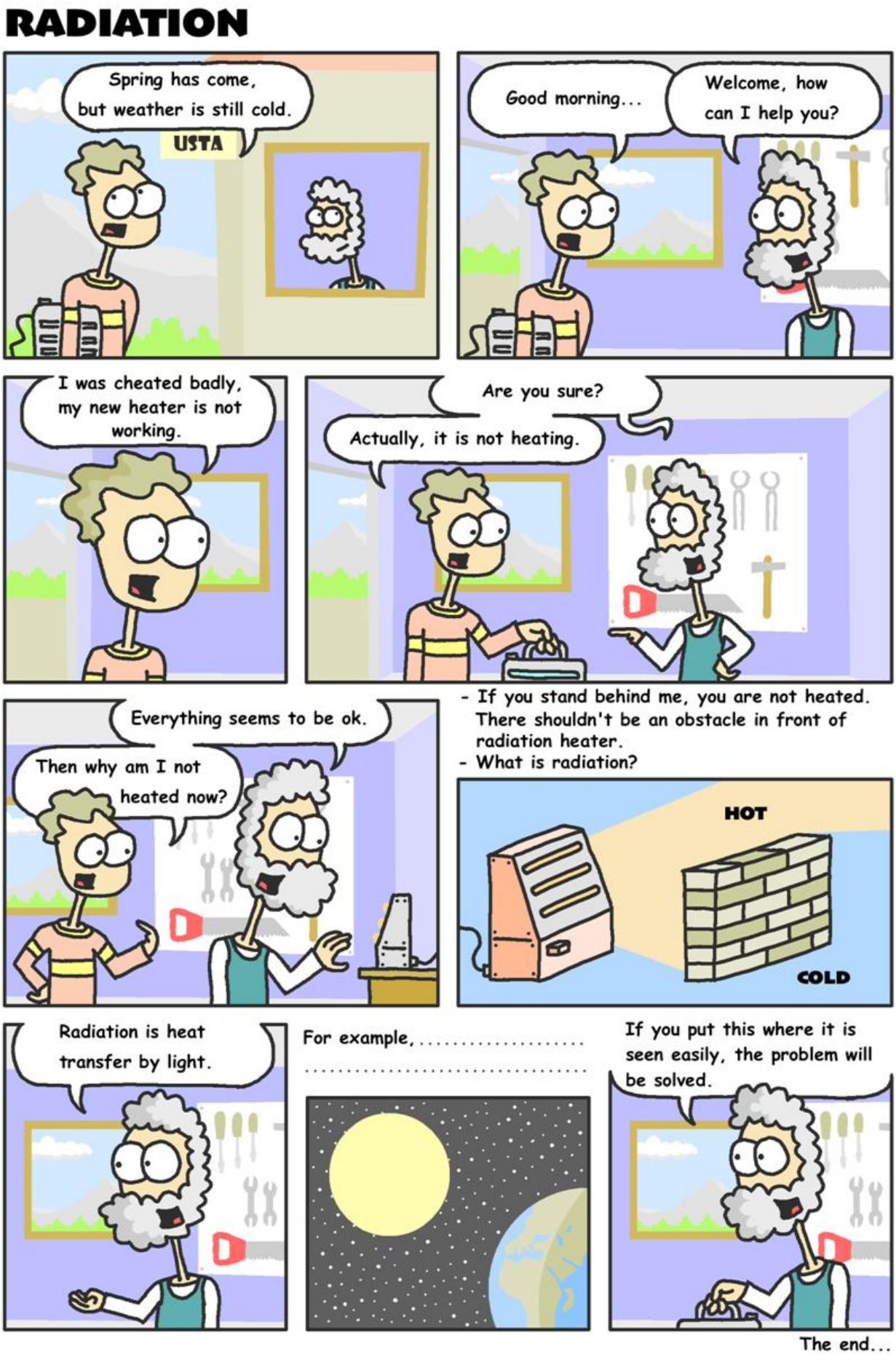
Appendix 1
Instructional Comics Created in This Study
(Turkish version of the comics may be obtained by contacting the first author)



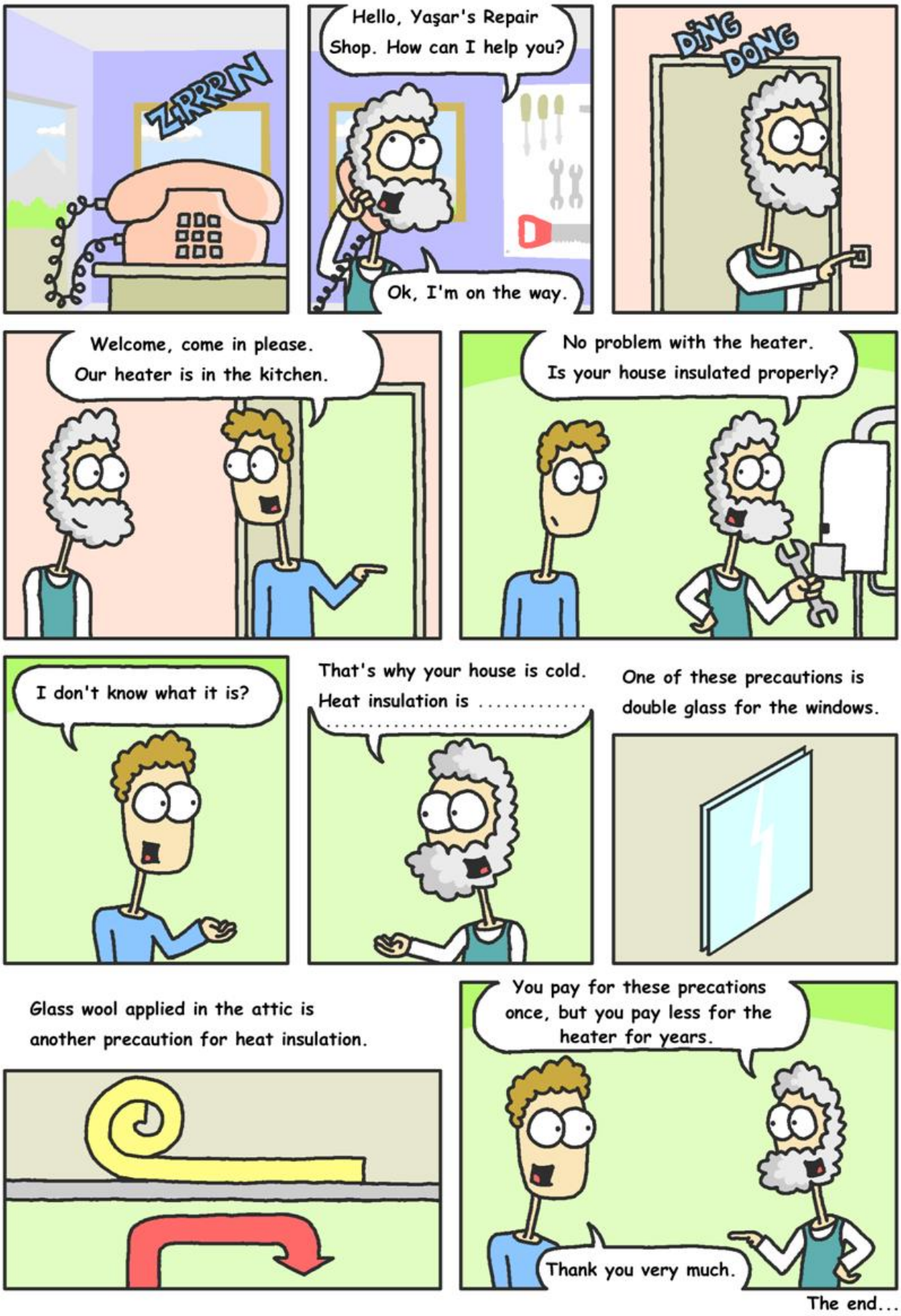

CONDUCTION
ZIRRRN
Yaşar's Repair Shop, how can I help you?
Ok, I am coming soon.
TIRR TIRR
Hello...
While going to the picnic, our car was broken down.
Then, we decided to have picnic here. Let's eat before repair.
Ooh, it hurts !
How is it so heated? It is the other end of the needle far from the flame.
It is not necessary to be closed to the flame. Firstly, needle's atoms near the flame starts vibrating. Then,.....
In solids, heat is transfered in this way. You may hold the needle with a piece of fabric.
The end...

# CONVECTION

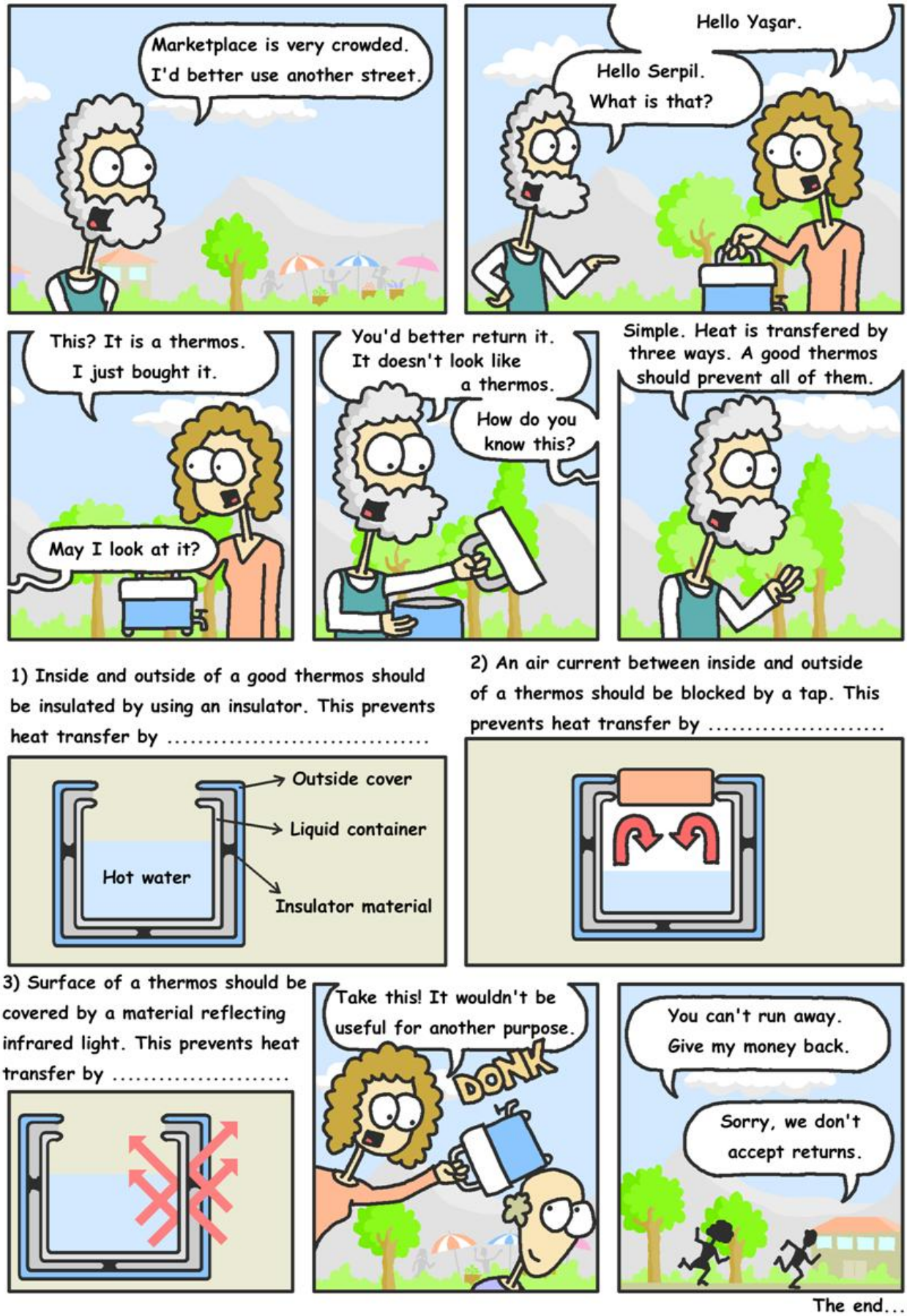

It was a tiring work day. Let me drink coffee here.
KAFE
It smells good...
SIP
What are these drops! I'd better check upstairs.
Hey, son... Do you have any problems here?
I broke the pipe of the heater while playing. My mom is gonna get angry.
Don't cry! I'll fix it before your mother came.
Hot water flushed from the pipe. How does it heat the apartment?
Listen! There is a vessel heating water by burning coal at the basement.
Heated water reaches this radiator through the pipes.
The radiator heated by hot water firstly heats air nearest. Heated air .....
.....
..... This air cycle is called convection.
What's going on here!
Nothing! We have arranged it.
The end...


RADIATION
Spring has come, but weather is still cold.
USTA
Good morning...
Welcome, how can I help you?
I was cheated badly, my new heater is not working.
Are you sure?
Actually, it is not heating.
Everything seems to be ok.
Then why am I not heated now?
- If you stand behind me, you are not heated. There shouldn't be an obstacle in front of radiation heater.
- What is radiation?
HOT
COLD
Radiation is heat transfer by light.
For example, .....
.....
If you put this where it is seen easily, the problem will be solved.
The end...

# HEAT INSULATION



# THERMOS


Marketplace is very crowded. I'd better use another street.
Hello Yaşar.
Hello Serpil. What is that?
This? It is a thermos. I just bought it.
May I look at it?
You'd better return it. It doesn't look like a thermos.
How do you know this?
Simple. Heat is transfered by three ways. A good thermos should prevent all of them.
1) Inside and outside of a good thermos should be insulated by using an insulator. This prevents heat transfer by .....
Outside cover
Liquid container
Hot water
Insulator material
2) An air current between inside and outside of a thermos should be blocked by a tap. This prevents heat transfer by .....
3) Surface of a thermos should be covered by a material reflecting infrared light. This prevents heat transfer by .....
Take this! It wouldn't be useful for another purpose.
DONK
You can't run away. Give my money back.
Sorry, we don't accept returns.
The end...