



## Evaluations on an Educational Game Developed for Temperature Unit Conversions: CFK Survivor

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**Abstract**

Educational games are the planned and purposeful educational activities improving knowledge and skills via reinforcing the previous learnings. Therefore, "Heat and Temperature", one of the units where misconceptions are seen the most and concretization is the least, was determined under 9<sup>th</sup> grade Physics lesson and CFK Survivor educational game was developed under "The students make calculations related to temperature units." acquisition and "Unit conversions for °C, °F, K are provided to be done." acquisition explanation. To evaluate CFK Survivor, this study under the phenomenology method was designed. 13 physics teachers working in private educational institutions and attending online lessons were selected through an easily accessible sampling method and the study group was formed. The game was evaluated in various aspects as eligibility, gamification, rules and data were analyzed by content analysis. It is concluded that several cognitive, affective and psychomotor skills could be gained via this game, and enjoyable and permanent learning would be supplied. Sample suggestions for physics subjects where educational games could be designed and for further studies are also presented.

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### INTRODUCTION

In all periods of her/his history, humankind has been in a constant effort to spend quality time and have fun. One of the most important and effective ways that she/he has found in these pursuits is game. By offering various opportunities to learn with their own experiences, games have a certain place in every stage of human life. (Aksoy & Kaleli Yılmaz, 2011; Özyürek & Çavuş, 2016). Games have various features not only affecting most people physically, socially, mentally, psychologically and emotionally but also supporting their development (Özer, Gürkan & Ramazanoğlu, 2006). Because games are voluntary activities, the people playing them experience internal motivation (Ayan & Memiş, 2012). Thanks to this internal motivation, it is possible to establish a link between conceptual knowledge and its implementation (Bayat, Kılıçaslan & Şentürk, 2014).

In this day and time, textbook or teacher-based approaches where the students are passive are obsolete. Henceforth, there are new educational models where learners' interests, desires, curiosities and abilities are centered. In other words, modern approaches aiming to raise active, creative, innovative and critical individuals in which the student plays the leading role, take the stage (Sarı, 2007). In student-centered modern approaches, the aim is to use the most

appropriate and short methods to achieve the determined goals. Techniques, which are the application of methods, have also gained more importance in this context (Karaağaçlı, 2011). From this point of view, including the games, one of the favorite and entertaining things of students, into education is quite beneficial. The games played for educational purposes are called educational games (Aymen Peker, 2018). Applying games to learning activities disentangle educational environments from being a place where only memorized information is stored. They also enable students to learn the knowledge and abilities required for their lives in a natural process. Therefore, they can increase their specific learning capacity with educational games (Kefeli, Yalçın, & Taş, 2018). So, educational games can be considered as natural learning tools. Thanks to using the knowledge and skills they need, during the games, students can get such facts as gaining habits and experience, acquiring knowledge and helping each other by doing and experiencing (Kaytez & Durualp, 2014). For this reason, it is aimed to carry out learning activities in teaching environments where students can learn more eagerly, contentedly and actively (Yükseltürk & Altıok, 2016). Therefore, these games provide active participatory learning, which is planned for a specific purpose in accordance with the goals of the teaching (Dönmez, 1999). Consequently, several games played in daily life can be performed educationally in teaching the subject if they are properly designed for their purposes.

Educational games are the learning techniques enabling the education and training process to be more efficient for both teachers and students (Hazar & Altun, 2018). In addition, it is stated that mental skills may be improved thanks to such activities as developing tactics and strategies during the games (Özer, Gürkan & Ramazanoğlu, 2006). One of the most basic features of educational games is that they activate students in cooperation with a competitive spirit (Canbay, 2012). The findings that group-shaped activities are more effective on student achievement obtained in the research supports this assertion (Aydın & Balım, 2005).

It is known that the personality development of the children cooperating with their friends in the educational game process and playing according to the rules, is positively affected (Saracho, 2001). Because the essence of educational games is to reach students' goals according to their existing intelligence, knowledge, skills and psychomotor characteristics within the scope of certain rules (Altun, 2013). Accordingly, educational games also positively affect students' social, cognitive and affective skills such as expressing themselves, being aware of their abilities, being autonomous, having self-confidence.

In the light of all these, in order for science education in every field of life to be effective, the students should be ensured to be able to create meaningful learning by getting rid of memorizing and internalizing their knowledge. Non-concreted information does not stay in mind for a long time and even affects new information negatively (Maskan & Maskan, 2007). The developments and innovations in science and technology today, make updating the science curriculum necessary. Science education at schools is also revised within the framework of education programs in accordance with age. However, researchers working in the field of science have found that students do not like science subjects at schools (Erdemir, 2009). Likewise, because of being abstract and requiring intense effort physics, one of the science courses, is generally perceived as a difficult and incomprehensible lesson (Örnek, Robinson & Haugan 2008). Physics is a science-based on experimental and quantitative measurement for understanding natural phenomena. In other words, the things people see, do and use throughout their lives, constitute the subjects of physics. For this reason, the purpose of physics education is to provide students with scientific knowledge, attitude, mental process

skills and abilities necessary to solve the problems they scientifically encounter (Bayrak & Eden, 2007).

Due to their features such as providing active participation, being interesting and motivating, reducing forgetting and consequently accelerating learning, it is thought that educational games can also be effective in physics teaching. Because in a learning environment supported by concrete materials, it gives students the opportunity to learn by doing and experiencing (Gülsoy, 2013). For example, the educational games developed by Can and Yıldırım (2017), on "change of state" subject, by Yıldız, Şimşek and Araz (2016), on "circulatory system" subject and by Gençer and Karamustafaoglu (2014), on "static electricity" subject were applied. Thanks to those educational games, a significant difference was found for the students' academic achievement in their research. In this way, educational games facilitate the learning of many rules and concepts that students have difficulty understanding and applying (Coşkun, Akarsu & Kariper, 2012). However, it is mentioned in the literature that among the physics topics, the concepts of heat and temperature cause such difficulties as being used interchangeably (Jara-Guerrero, 1993), misunderstanding (Jones, Carter, G. & Rua, 2000) and forming misconceptions (Ayvacı & Durmuş (2016); Yeo & Zadnik, 2001).

In this context, within the scope of the 9<sup>th</sup> grade Physics lesson "Heat and Temperature" unit, it was decided to develop an educational game on the "*The students make calculations related to the temperature units.*" acquisition. For this reason, under the acquisition description, "*Unit conversions for  $^{\circ}\text{C}$ ,  $^{\circ}\text{F}$ , K are provided to be done.*" CFK Survivor game, which aims to learn the heat unit conversion calculations of Celsius, Fahrenheit and Kelvin thermometer types, was developed. Getting the opinions of the teachers, being both the practitioners and evaluators of the process, would be one of the most important tools in determining the effect of the developed game on the learning of the subject. However, it could not be possible to implement the game because schools were closed due to the coronavirus epidemic. Therefore, the physics teachers' views and evaluations were taken to determine the effects of CFK Survivor via interviews. In this context, the problem sentence of the research is "*What are the opinions and evaluations of physics teachers on the educational game prepared for calculations of heat unit conversion among Celsius, Fahrenheit and Kelvin thermometers?*". In this research, it has been tried to reach the relevant acquisition in the physics lesson program through an original educational game "CFK Survivor". For this reason, it is thought that this research will make valuable contributions to the literature.

## METHOD

### **Study Design**

This study designed to take the views and evaluations of physics teachers for the developed game "CFK Survivor" whose stages as meeting the acquisition, preparation, rules and implementation are explained step by step in Annex-1, was conducted under qualitative research. Qualitative research methods can be used to show perceptions and events more clearly through examples, explanations and experiences (Özmen & Karamustafaoglu, 2019).

Schools being closed due to the Covid-19 epidemic did not allow the game to be implemented. Therefore, the opinions of physics teachers giving 9<sup>th</sup> grade lessons online in this period, about the game were consulted. In the light of their professional experiences, the phenomenology method under qualitative research design was used in this study to reach their evaluations about the game firsthand. In phenomenology, data are collected at first hand by focusing on the facts that are recognized in daily life but are desired to be examined in depth

and detail (Yıldırım & Şimşek, 2018). Phenomenology makes it possible to reveal individual experience and the personal meanings attributed to them (Titchen & Hobson, 2005).

### Sample

In line with the purpose of the study, under the 9<sup>th</sup> grade Physics lesson "Heat and Temperature" unit the acquisition of "*The students make calculations related to temperature units.*" was focused elaborately. So, in accordance with the relevant acquisition description, "*Unit conversions for  $^{\circ}C$ ,  $^{\circ}F$ , K are provided to be done.*" The game "CFK Survivor" was developed. In order to get their opinions and evaluations about the game, all the physics teachers working in private education institutions in the central districts of a metropolitan city in the Middle Black Sea Region formed the universe of the study. Among those, the sample was determined with 13 teachers actively giving online 9<sup>th</sup> grade Physics lessons during the Covid-19 pandemic. In the selection of the sample, due to such factors as being available for the research, making video calls and reaching in a short time, easily accessible sampling, one of the purposeful sampling methods, was used. It is stated that the phenomenology samples are determined by the sampling method for the purpose, between 5 and 25 participants, which generally has a certain characteristic feature such as being a teacher (Creswell, 2013; Patton, 2015; Rubin & Babbie, 2016). The demographic features of the participant teachers in the sample were presented in Table 1.

Table 1. Demographic features of the participants

Participant	Gender	Age	Professional Experience (Year)	Employed Institution Type
P1	Female	41	18	Private Education Course
P2	Male	40	10	Private School
P3	Female	39	15	Private Education Course
P4	Male	46	22	Private Education Course
P5	Male	43	19	Private Education Course
P6	Female	31	6	Private School
P7	Male	45	21	Private School
P8	Male	43	21	Private Education Course
P9	Male	39	13	Private School
P10	Female	32	8	Private School
P11	Male	42	18	Private School
P12	Male	40	15	Private School
P13	Male	44	22	Private Education Course

As presented in Table 1, a total of 13 physics teachers, 4 females and 9 males, participated in the study. Professional experience of the participants, between the ages of 31 and 46, varied between 6 and 22 years. Six of them were working at private education courses while seven of them at private schools. All those private schools and private education courses continuing their activities in the central districts of a metropolitan city in the Middle Black Sea Region were under the Ministry of National Education General Directorate of Special Education.

### Data Collection Tool and Process

In this study organized to determine teachers' views on the CFK Survivor game, the data were collected through a "Semi-Structured Interview Form" consisting of 7 questions prepared by the researchers. The interview questions were prepared in accordance with the necessary criteria as below factors to determine the effect of the developed game on learning the relevant subject:

- being appropriate to the purpose and method of the research,

- being clear and understandable,
- not leading the participants,
- not having conditional or complex statements,
- allowing participants to give comprehensive and detailed answers,
- ordering from general to specific and being consistent with each other,
- being correct in terms of grammar, spelling and punctuation.

So as to increase the content validity of the interview form, it was handed in to two professors who are experts in the field, for reviewing. Therefore, the relevant corrections were made according to their feedback and presented in Table 2.

Table 2. The feedback and corrections on interview questions

<b>Q*</b>	<b>FEEDBACKS</b>	<b>CORRECTION</b>
1	<p>The first question should include the most general statements about educational games. Later, additional questions may be asked in terms of physics lesson (P1).</p> <p>At the beginning of the interview, the opinions of the participants can be revealed in a more comprehensive way thanks to the questions prepared from general to specific (P2)</p>	The first question was revised as "What do you think about educational games, the use of educational games in physics teaching and the instruction of educational games?"
2	<p>After getting their views on teaching with educational games, the physics teachers can be asked about what they are doing to use it in their lessons (P1).</p> <p>First of all, this question should be aimed at determining the competence of the participants to teach with educational games. Later, it can be asked to what extent he/she uses educational games (P2)</p>	The second question was designed as: "How do you evaluate yourself about teaching via educational games? Do you apply educational games in your lessons, if so, how often?
3	<p>The third question should be supported with additional questions to provide detailed data about the rules and gameplay of CFK Survivor. Therefore, more comprehensive answers can be obtained regarding the impact of the game on the subject (P1)</p> <p>A comprehensive question should be written to evaluate the general lines, advantages, disadvantages of the developed game. Also, whether it might be easy or difficult to be implemented can be asked (P2)</p>	The third question was designed as "Are the gameplay and rules of CFK Survivor understandable? Are there any points that might not be understood or might force the teacher and/or students during the process? How might the game contribute to the teaching of the subject?"
4	<p>I think the fourth question should be about getting the opinions of the teachers about to what extent the developed game could meet the acquisitions of the subject (P1).</p> <p>After evaluating the game in the third question, the participants may be asked to interpret the game in terms of the relevant acquisitions (P2)</p>	The fourth question was designed as "Could CFK Survivor meet the acquisitions of the subject? If so, to what extent and how?"
5	This question can be prepared to provide extended data on how the developed game will have an impact on the students when applied (P1).	The fifth question was designed as "When applying CFK Survivor in your lesson, do you

	The most important thing is to be satisfied with the work you do. So, it can be asked how much fun the CFK Survivor will provide for students in the teaching of the subject (P2)	think students can learn the subject by having fun? If so, why and how?
6	Our aim is to enable the students to comprehend this subject in the best possible way. Therefore, this question should be about what skills and how the game can gain the students (P1). The questions should be asked about to what extent the relevant cognitive, affective and psychomotor skills can be gained thanks to this game (P2)	The sixth question was designed as; "What kind of skills do you think CFK Survivor provides to the students? Do you think this game upskill cognitive, affective, psychomotor skills? Explain please."
7	As the last question, it may be asked which classes, courses and subjects' educational games are suitable. Educational game sample suggestions can also be obtained with add questions (P1) They are the teachers who manage the process. Therefore, educational game suggestions should be taken from them at all levels that can be designed for the future (P2)	The seventh question was designed as: "To which grade level and subject do you think educational games are suitable? Explain by giving an example, please?"

\*Q: Question

The teachers, selected within the scope of the study, were contacted in a short span of time. The purpose, significance and content of the research were explained in detail and they were asked to review the game provided by e-mail thoroughly. Then, the semi-structured interviews were conducted with them on the determined days and hours with an appropriate video call program and their evaluations for the game were recorded. In this context, the interviews through a video call program between 09 - 16 April 2020, lasted for an average of 40-45 minutes. During the interviews, not only interrupting the teachers but also using gestures and mimics that could distract them were especially avoided. The interview questions that they could not understand were asked again and relevant explanations were made when necessary. Thanks to the interviews, it was possible to learn the opinions and evaluations of the physics teachers for CFK Survivor in a more natural and detailed way. The obtained data were transcribed and stored by using appropriate computer programs.

## Data Analysis

The participant teachers' names were not used in the study, but they were given codes such as "P1, P2, P3..." for the order of the interview. In order to be understood more easily, the raw data obtained from the interviews were arranged according to the themes determined to include certain expressions and concepts and analyzed with content analysis. Tables were used in the presentation of the emergent codes and themes. The obtained data can be perceived differently by two different researchers (Yıldırım & Şimşek, 2018). Therefore, direct quotations may become more important. In the analysis of the collected interview data, consistency was achieved in the themes created by the consensus of two faculty members who are experts in field education. The reliability value between coders was calculated as .89 by using the formula "[Reliability = Consensus): (Agreement + Disagreement) x 100]" stated by Miles and Huberman (1994). In order to ensure coding reliability, the percentage of harmony between coders should be above .80 (Miles & Huberman, 1994).

In the abbreviations of the participants, in the sample, no distinction was made in terms of gender, age, experience or the institution of work. The codifications such as P1, P2 etc. were

added to the end of the quotations, considering only the interview order. During the interviews, the participants' statements regarding daily life as well as their professional experiences were also taken within the scope of the research. Therefore, it was aimed to increase the internal reliability of the study. As a result of the content analysis, the relevant codes and themes were presented in tables and figures via an appropriate computer package program.

## FINDINGS

To present the data obtained from the study in a more detailed and clear way, this section was arranged into 7 subtitles within the framework of the interview questions.

### Evaluations on Educational Games and Applying Educational Games in Physics Teaching

In line with the purpose of the study, the participants answered the question "*What do you think about educational games?*" defined educational games in different ways. For example, one participant (P5) described it as "*Educational games are the gamification of the activities such as experiments and demonstrations that can attract the attention of the students and make them learn entertainingly.*" Another participant (P6) said, "*I think the educational game is a very effective teaching tool making the education process enjoyable, increasing the active participation of the students and enabling them to learn by doing and experiencing.*"

According to a participant (P11) "*The gamified form of the phenomenon we call modeling in physics is called an educational game. Appealing to both eyes and ears, it is a tool that enables the students to learn by having fun.*". Another participant (P12) said "*The games making students available to learn not only visually but also through experience and have educational features are called educational games.*" Another participant (P13) also made a definition as "*In a game without the teacher's expression, the activities providing the students to reach knowledge actively with their own efforts are called educational games.*".

The views and thoughts of the participants about applying educational games in Physics lessons were brought together under certain concepts and presented in Table 3.

Table 3. Participants' views on applying educational games in physics

Theme	f	Sample Sentence
Increasing active participation	13	"Educational games can stir up the students sitting in the classroom by only looking passively at the blackboard." (P10)
Increasing permanence	13	"Physics lessons consist of the subjects that need to be very closely related to each other. So, linking a topic to another or associating subtitles of a topic with each other increases the subject's persistence." (P11)
Ensuring concretization	13	"Such courses as physics, it would be very useful to concretize abstract concepts by associating them with daily life via a game. So, students can immediately understand what you try to explain rather than using thousands of words and sample questions." (P3)
Increasing motivation	12	"Students will get out of the mood as "Are we going to memorize lots of things again?" and get the hang of "Oh, how good is this lesson, we will play a game too." The rest is easy, whatever you give after that, they get it easily." (P7)

Decreasing memorization	9	"Physics concepts that students have difficulty in understanding and can simply be taught through gamification." (P5)
Breaking prejudices	9	"It breaks students' existing fears / prejudices and makes them willing to enter Physics lessons in a more motivated and lively mood." (P6)
Being time-consuming	7	"Educational games have many benefits, but the main disadvantage is consuming much time and requires much preparation for a little learning." (P5)
Being less effective without reinforcement	6	"After the game, reinforcing activities such as problem-solving, test or trial exam can be done. If not, the effect of educational games on teaching and permanence for complex subjects won't be high. (P12)
Not being applicable for all the subjects	3	"Of course, you cannot explain all physics subjects with games. Firstly, students should have a knowledge of history for the subject. In addition, they must have a mathematical infrastructure to perform mathematical operations on that subject." (P4)

As seen in Table 3, the participants thought that applying educational games in physics lessons could be greatly positive, such as "*Increasing active participation, Increasing permanence, Ensuring concretization, Increasing motivation, Decreasing memorization and Breaking prejudices*". On the other hand, they also expressed such concerns as "*Being time-consuming, Being less effective without reinforcement and Not being applicable for all the subjects*". In addition, all participants stated that educational games are more entertaining, participatory and instructive according to class level.

### Evaluations on Applying Game-based Teaching

Within the scope of the second question of the interview, the participants were asked whether they had ever taught any subjects via educational games before. In line with the answers given, it was determined that none of the 13 teachers had applied educational games or used game-based teaching techniques. In addition, 6 participants stated that they had heard for the first time that lessons could be taught via educational games without teacher expression. Except for P6 who was continuing their doctoral studies, 12 participants stated that they had not been interested in an educational game before. On the other hand, all the participants declared that so as to make physics lessons permanent by concretizing them, making them enjoyable and increasing active participation, they had already used such tools and methods as posters, figures, graphics, slides, videos, simulations, experiments, storytelling.

Within the bounds of possibility, all 13 participants stated that they would like to design or apply an educational game one day in the future. Despite that willingness, they expressed their hesitations about designing or applying educational games as "I would like to use it, but ...". These expressions of the participants were brought together under certain concepts and presented in Table 4.

Table 4. Participants' hesitations about applying educational games

Theme	f	Sample Sentence
Intensive curriculum	11	"Physics is a very intensive lesson with a wide curriculum. Because there are too many abstract concepts and mathematical operations, we often have difficulties in finishing the subjects on time." (P5)

Insufficient lecture hours	11	"It doesn't necessarily need to be out-of-class, I would like to teach a topic or a part of it with a game that can be played in the class but, our lesson time is usually barely enough to teach the units. " (P7)"
Administration / parent / student expectation	9	"In private schools, parents and students are generally more exam-oriented as ' <i>Firstly, we process and finish the subject, then we immediately solve all the questions of the tests or trial exams correctly</i> '. That's all they want, nothing more." (P12)
Being time-consuming	8	"Educational games might be instructive, but we don't have the opportunity to play 50-60 minutes for a topic that we can tell in 10 mins. Instead, I do experiments, competitions and watch videos." (P5)
Being demanding	7	"Designing an educational game seems very demanding at each stage. The teacher has to devote a lot of time to this." (P13)
Being costly	3	"I feel myself qualified for preparing an educational game, but the financial situation is important. Also, keeping those after the game is another problem." (P8)

As seen in Table 4, the participants generally had hesitations about the intense curriculum of the physics course and the shortage of the lesson time allocated for the subjects. In addition, because of working in private institutions, the fact that expectations of school administrators, parents and students are more in the direction of solving questions for the university entrance exam also negatively affects their thoughts of using educational games. Moreover, when compared to the classical methods, they thought that educational games would be very time-consuming. According to them, in classical lessons the subjects could be explained in a shorter time and then reinforcement activities could also be made with extra questions or tests. Some participants also declared that because before, during and after activities, educational games could be more demanding and the procurement of the game materials might be costly. Only two participants (P6 and P10) stated that they were in the decision to design or apply an educational game without making any hesitations.

In addition, one participant (P4) implied that all the educational games cannot cover physics subjects and students also should have a sufficient level of readiness before the application as;

"Of course, you cannot explain all physics subjects through games. First of all, the students must have a knowledge of history and mathematical background to perform mathematical operations on that subject. If not, how will you explain such topics as refractive to the students who cannot make addition and subtraction calculations?"

### Evaluations on the Rules and Gameplay of CFK Survivor

Within the framework of the 3<sup>rd</sup> question of the interview, the participants were asked to evaluate how the rules and gameplay of the CFK Survivor game are. All the participants stated that the rules are clear and accurate and can be easily understood by the students. One participant (P6) said, "*I think the rules of the game are clear. How many times the referees will blow their whistles and even what the numbers of these whistles mean is explained line by line. Thus, students can easily understand the rules.*". Only one participant (P3) said "*That is to say, the rules of the game are clear and exact.*" and asked, "*Will the game have a certain*

*time, or will there be a period of time for the tracks to be prepared again?"*. Therefore, she replied by informing in detail.

Stating that the game could be easily understood and applied by students, the participants drew attention to the importance of the figures. In this regard, a participant (K10) said, "*Anyone looking at the figures could easily understand what to do in the game. In addition, short and clear sentences suitable for the level of 9<sup>th</sup> grade students are used.*".

8 participants emphasizing that the rules and gameplay of the game are clear and exact, drew attention to the fact that if these were supported with a poster, picture, video or simulation, the students could concentrate on those easier. At this point one participant (P7) said;

*"I could not understand the gameplay of CFK Survivor for the first time, but after looking at the visuals, I easily picture it for myself. However, it would be better if there were a simulation video about the gameplay. Because the students could easily imagine what they would do like watching a movie, before going down to the garden."*

In the continuation of the 3<sup>rd</sup> question of the interview, two extra questions were directed to the participants as "*Are there any parts of the game that are not generally understood or that you think will cause difficulty to the teacher and / or the students during teaching period? How do you think the game will contribute to the teaching of the subject?*" All 13 participants made evaluations regarding both explaining thermometer conversions in the classical methods and learning it via CFK Survivor. In this context, all the participants expressed their opinions on how the game would affect the teaching of the subject by giving such answers starting as "*In CFK Survivor game, the students / teachers have less / more difficulty because....*". These expressions were brought together under certain concepts and presented in Table 5.

Table 5. Evaluations on CFK Survivor in terms of teachers/students

Concept	f	Sample Sentence
Students will get less mentally tired	13	"If you could teach the thermometer conversion units to students as a classroom lesson, they would get bored after 5-10 minutes. But thanks to this game, they will solve the problems by understanding the whole logic of transformation as if playing a game at the break." (P1)
Teachers will get more mentally tired	11	"I can't believe but if the 18 students there would be silent with the sound of the whistle would not interfere with the game, this would be perfect. The noise of the students constantly shouting and screaming with the excitement of the game would chew their ears off." (P11)
Lower-level students will have more difficulty	11	"The students might have difficulty in solving the questions in the first stage. It is important to look at the formula board, but even if an academically unsuccessful student looked, he/she wouldn't not pass the first stage and so would be eliminated." (P8)
Teachers will get more physically tired	10	"However, it could be more effective and permanent than learning in the class; designing the educational game, buying the materials, setting up the platform, managing the game, collecting

		the materials again after the game is over and finding a place to keep them would be a long and difficult process." (P12)
Students will get more physically tired	9	"Because calculation errors, inability to overturn the bottles, late opening of the chest, incorrect placement of the wooden block on the board not only might cause students to lose time but also increase their stress levels. Moreover, following the other player and the referee could make the game challenging for them." (P13)
Teachers will have more difficulty	7	"How could the referees check not only two students playing but also 18 other students who are waiting or finished their game at the same time? How would they prevent chaos from breaking out in that noisy and cheering environment?" (P5)
Teachers will have less difficulty	6	"Two teachers will direct the game anyway. If they could maintain discipline and order in the game, they would more easily control both the players and those waiting their turn. I think it might be less tiring, because there would be two teachers." (P2)
Students will have less difficulty	2	"In the first stage, the students could solve questions by looking at the formulas written on white cardboards and placed on the ends of the tables. This would also keep the formulas in mind and make calculations faster with the feeling of winning the game." (P3)

As can be seen in Table 5, the advantages and disadvantages of the CFK Survivor game were discussed in terms of students and teachers compared to the classroom lesson. In this context, 11 participants stated that the students with low academic achievement level or with insufficient processing skills would have more difficulty in the game. On the other hand, 2 participants stated that since there would be no level difference, they could only look at the formula cardboard and process, thus they would have less difficulty. 7 participants thought that teachers would have less difficulty in the game compared to the classroom lesson due to the presence of two teachers and the willingness of the students, while 6 participants claimed that the teachers would have more difficulty. In fact, most of the participants stated that both the teacher and the students might be physically tired as they would constantly be on the move in the game. In addition, there were 11 participants who stated that teachers would experience more mental fatigue than the classroom lesson. On the contrary, all the participants expressed that the students would experience less mental fatigue in the game compared to the classroom lesson.

In terms of the general rules and gameplay of CFK Survivor, one participant (P1) commented it positively as "*It is absolutely ideal for 9<sup>th</sup> grade students at both Science High Schools and Anatolian High Schools. It is a very exciting game that eliminates the level difference between students, therefore everyone can participate actively.*" However, some admonitory comments were made regarding the structure of the game. For example, a participant (P8) emphasized the importance of post-game reinforcement as:

"It would be perfectly instructive in terms of temperature conversion between thermometers, but only for the students at the intermediate and advanced levels. Even if you deal with this issue with a game, it would still be insufficient for the students who are unsuccessful or at lower levels and uninterested in physics lessons. For this reason, you either have to play this game a few times or assign homework with questions like in those envelopes."

Another participant (P5) expressed his criticism and suggestions for the rules of elimination as:

“There is a rule saying, ‘*The player solving the questions in the envelopes at the first stage incorrectly 3 times or placing the wooden block at 4<sup>th</sup> stage incorrectly 3 times is eliminated.*’ Okay, the rule is very clear, certain and logical for me. So, how will the student who has been eliminated after doing wrong, learn this subject? She/he couldn’t do the questions because she/he doesn’t have any knowledge about them. If that were not enough, she/he would be eliminated. First of all, this can disincline her/him from the topic or physics lesson. Secondly, if the students knew all the questions correctly and finished the stages, but the other player would pass her/him and she/he would still lose. This situation might affect her/him negatively both after the game and in her/his class life. Maybe she/he would become an object of derision. I am not talking about this game specifically, but every game with a winner and a loser creates psychological traumas in any case. In other words, the student who would be eliminated because she/he couldn’t learn anything from the game or not to do it as fast as the other player, might be exposed to the teasing of his friends. Therefore, the games where there is no winner/loser but anyone can play easily or based on race against time might be more appropriate for education.”

Thus, participant evaluations were taken regarding the impact of the CFK Survivor game on the teaching of the subject.

### **Evaluations Regarding the Game's Meeting of the Relevant Acquisition and Its Effect on the Lesson**

Within the scope of the 4<sup>th</sup> question of the interview, the participants were asked to what extent the CFK Survivor game, prepared to provide unit conversions for °C, °F, °K, meets “*The students make calculations related to temperature units.*” acquisition. All participants stated that the game would be suitable for the acquisition and could meet the acquisition.

Only 2 participants, (P1) and (P6) stated that the game could unaidedly meet the acquisition without any other activity as:

“If we taught the subject in class, perhaps only a few students could respond to the written examples and most students would not even attend the lesson. But due to the nature of this game, all students will have to actively participate and solve four transformation questions. I mean CFK Survivor could strongly meet the acquisition of the subject.” (P1).

“We do not stay in our closed houses and go out into the open air at odd times. Therefore, the students would absolutely be more willing than a class-lesson. Since they would not have to do the conversion calculations by force. I think they would be able to gain the acquisition easily, without any necessity to anything.” (P6).

The other 11 participants stated that thanks to the support to be given before and after the CFK Survivor game, it could fully meet the relevant acquisition and thus permanent learning for thermometer conversions could be realized. In this context, the suggestions of the 11 participants for both before and after the implementation of the game were associated with certain concepts and presented in Table 6.

Table 6. Suggestions on reinforcing activities for CFK Survivor

Concept	f	Sample Sentence
Solving extra questions in the class	11	"To gain the formulas in the acquisition and learn the subject very effectively, many questions should be solved in the classroom." (P3)
Giving homework as intensifier questions / tests	10	"Thanks to this game, each student will have to solve 4 questions. But the conversions learned in the game should definitely be reinforced at home with extra questions or tests". (P4)
Replaying the game	4	"Even if you dealt with this issue with a game, it would still be insufficient for the students who are unsuccessful or at lower levels or uninterested in physics. So, you either have to play this game a few times or assign homework like in the envelopes." (P8)
Announcing the game time in advance	4	"Since the playing time of each player would be 3-4 minutes, it would be very difficult for the students to improve themselves academically in this short time. Especially for lower-level students, if the time of the game was announced in advance and they prepared properly, they could not run away from the game and make conversion calculations." (P5)
Giving a project / term paper	2	"Since there might be no time left after the game, questions couldn't be solved in the classroom, therefore weekly projects or term papers should be given about conversions." (P2)
Making a quiz or oral exams	2	"The subject should be reinforced by assigning homework or similar questions like written on the envelope or wooden block. If not, the teaching would fall behind. So, reinforcement exercises ought to be done as a quiz or an oral exam." (P7)

As stated in Table 6, 11 participants, excluding the two teachers (P1 and P6) thinking that the CFK Survivor game could be enough for the acquisition without extra things, stated that some reinforcing activities should be done both before and after the game. Since the current education system is exam-based, 11 participants suggested doing reinforcement exercises as solving extra questions after the game, 10 of them as giving homework. 4 of them by replaying the game and 2 of them by giving the project homework and by doing a quiz/oral exam. They also added that the learned formulas gained in the game could be reinforced and so the acquisition could be fully understood. 4 of the participants stating that not all students are at the same level, said that by telling the game time beforehand, students with low academic achievement could prepare and thus, they could also gain the acquisition.

Supporting the statements in Table 6, a participant implied that the CFK Survivor game prepared for the relevant acquisition might also be effective and positive in terms of upper-class acquisitions as:

"In addition, since they will process the remaining 6 weeks of the 'heat and temperature' subject in the classroom, extra tests should be given to reinforce what they have learned in the game. If it were up to the student, she/he would demand playing games every week. However, according to current circumstances there is an existing curriculum and examination system in Turkey. Therefore, it is necessary to reinforce the acquisition."

P10, considering that the game would generally be sufficient in terms of meeting the acquisition suggested extra activities as "*The game is visually designed, but I think it would*

*be more useful if the usage areas of thermometers in daily life could be added. For example, as 'Which thermometer measures air temperature, temperature of metals, LED lights?'.*

In addition to these findings, one participant (P11) emphasized that the CFK Survivor game would not only teach the topic but also be very effective and useful for the subject and physics lesson as:

“The game would be effective for thermometer conversions because the students could operate by just looking at the formula cardboards. In addition, it is a very simple acquisition anyway. But rather than doing those processes quickly, I think the most important advantage of the game is that it could show the student how easy and doable the thermometer and its calculations are. I am sure that even students complaining especially because they cannot do physics would say, "Were we afraid of such an easy thing?"

### **Evaluations for the Case of CFK Survivor's Implementation**

Within the scope of the 5<sup>th</sup> question of the interview, all the participants stated that it would be enjoyable to learn the unit conversions for  $^{\circ}\text{C}$ ,  $^{\circ}\text{F}$ , K via CFK Survivor, therefore the students participating actively could have more effective and permanent learning. One participant stated that CFK Survivor could increase the desire and motivation of the students and ensure their active participation, thus create permanent learning about thermometer conversions as:

“In the game, there wouldn't be any student in front of you looking at the blackboard like looking at the smartphone. On the contrary, there would be active students completely involved in the process and could reach that information themselves. Moreover, they would also be in competition and then reach the award. As such, the game might be hundreds of times more useful than what you told for hours, all the questions you solved, even the videos you watched, the experiments you did. Because students could learn by having fun thanks to CFK Survivor. So, this could both increase their interests in physics and make them enthusiastic about other subjects. Do you eat the food you don't like? If there is no death on its end you wouldn't eat it, would you? Just like that, why would you learn the subject forcibly rather than grasping it joyfully?".

Another participant (P7) pointed out that each stage of the CFK Survivor game is exciting and it could make the subject enjoyable by saving it from boredom as:

“Just going out of the 4 walls already brings happiness to the student. You could see this from their energy before the game begins. Bringing the Survivor, which the students admire on television, to them would of course make them excited. Therefore, they could learn word by word whatever the game would present to them by having fun and being thrilled to bits. I think this game will provide a very enjoyable lesson because it can both save the lesson from boredom and bring a different excitement to each stage.".

Another participant (P2) stated that he'd like to apply the developed CFK Survivor game in his own lessons as:

“Rest assured that I read this game twice and every time I read it, I imagined that I could apply it to my own students. I want to implement this game if it's alright with you. If I get the chance to apply for it, I think they will definitely have fun and learn the subject easily.".

Apart from these expressions, the opinions and evaluations of 13 participants such as "*In the case of applying the CFK Survivor game for the issue of unit conversions for °C, °F, °K ...*" were associated with certain concepts and presented in Table 7.

Table 7. Participants' views on the implementation of CFK Survivor

Concept	f	Sample Sentence
It will increase active participation	13	"Even the students not raising a finger in the lesson, dozing off, waiting to leave for home would want to play this game once again. The reason is quite clear, they just want to have fun every time. I mean you would present the temperature unit conversions very complicated and detailed for them, via their favorite thing, the game. In addition, there will be active students completely involved in the process and reaching that information themselves." (P4)
It will increase the permanence level	13	"This game will be quite effective in students' permanent learning. The person learning with joy by doing, seeing, applying never forgets that information. Even when he gets older, every time he remembers this game, he could remember those transformation formulas gained in the game." (P11).
It will save the subject from boredom	13	"No student would want to stay in a closed class for 40 mins. to listen / watch if the best teacher even gave the most important information. Even we, teachers, are looking forward to taking leave off in the meetings with administrators. So, I am sure it would save these 14-15-year-old students from the boredom of the subject." (P3)
It will make students willing	13	"You not only could make the student willing but also have him do thermometer conversions enjoyably. This would enable them to learn very effectively and to participate voluntarily in future physics-related activities." (P2)
It will enable concretization	13	"Each stage requires attention and skill. This would allow students to engage in the game by always keeping their excitement above. Thinking as if they were playing both before and after the game will make them actually learn the CFK conversions joyfully. So, it would be a very comprehensive game making the subject concrete." (P10)
It will raise the perception level	12	"The students are generally happy with everything he does fondly. You would offer them to play the game on a platform similar to the Survivor game he always watches on TV. For having fun, whatever you would give them in the game with that enthusiasm, they could easily gain. Since their perceptions would be extremely open, they could actually learn without even realizing it." (P12)
It will increase the motivation level	12	"Perhaps half of the lesson time is spent motivating the students to the lesson and focus their attention. Therefore, even playing the game itself in the garden would automatically increase their concentration and motivation levels. Moreover, dreaming of playing games, they might come to lessons without a second thought." (P1)
It will increase interest and	11	"Just at the beginning of the heat and temperature subject, we teach these thermometers and conversion calculations between them.

curiosity levels towards the subject / lesson		Thanks to this game, the students might realize that they can do it by devoting themselves to the subject. Because of learning enjoyably, they will also gain self-confidence. They might also wonder about the rest of the subject. After the game ends and they return to the class, their desire and interest towards the subject will continue." (P11)
It will increase academic success	10	"Students whom we almost beg only to write the formulas in their notebook in class, might be prepared for thermometer conversions, perhaps for days to win a bottle cap. They would endeavor to make the right conversion in the fastest way, thinking as "I'll finish the stage before my friends". Is there a chance for such an eager student to fail? Even if his level is low, he could have the formulas down pat on that cardboard to win." (P13)
It will increase excitement and curiosity	10	"Every stage of CFK Survivor was designed so cleverly that the excitement and fun never decreased like the real Survivor. For example, in the first stage, you get excited to solve questions of different colors and get erasers in return. Then the excitement increases even more in the second stage as whether the player drops the right bottles and finds the key. In the third stage, you are waiting for whether he will be able to put the key in the correct box. At the last stage, you wonder whether he will be able to put the wooden block into the correct gap on the board. So, not only the players but also the audience can have fun and learn the relevant subject." (P6)
It will reduce memorization	9	"Believe me, they will know the formulas on those cartoons like their names even when this game comes to their minds even years after school is over. If they learned these in class, they would forget them the next day. But when they remember the game, of course, they will also remember the thermometer conversions." (P13)
It will break the prejudices	9	"In this game, memorizing the concepts or formulas or even being in the classroom isn't necessary. You say, ' <i>Let's go out to the garden together, I will be silent as a referee while you are playing</i> '. Does a student learning a subject like this ever fear physics? Will his prejudice ever remain?" (P9)
It will give the students the opportunity to show themselves	6	"Since the students are in their adolescence period, they see life as a game consisting of only joking, laughing and having fun. They get bored very quickly and always aim to be free and pranksters. This game will offer them both the freedom and fun they want. Thanks to this game, they will show what they can do and we teachers will achieve our goal by getting the subject." (P2)
It will reduce the waste of time	6	"Thanks to this game we will not waste time telling them ' <i>Don't talk!, Sit down!, Listen!</i> ' during the lesson. We won't have a problem with students participating in the lesson anymore." (P7)
It will increase team spirit and a sense of responsibility	5	"The students should act in unison during the game. Because the player will play for his/her group not for himself in the game. For this reason, he/she will want to gradually succeed in the stages with a sense of responsibility. This will keep the adrenaline level high throughout the game and increase team spirit." (P3)
It will facilitate	4	"This game also covers thermometer conversions in the 12 <sup>th</sup> grade

information transfer on future issues	energy unit. Since the students will learn everything by doing and experiencing, they will easily remember this game and therefore the transformation formulas. This will also enable them to grasp the energy issue more easily." (P12).
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All the participants stated that handling unit conversions for  $^{\circ}\text{C}$ ,  $^{\circ}\text{F}$ , K via CFK Survivor game would be stirring and thus the students participating actively will have more effective and permanent learning. However, they drew attention to the possible disturbing situations that may occur due to presumptions like these,

- The game has the winner and loser person,
- Stages in the game require mathematical operations,
- Students have to play with each other regardless of their physical, social, academic success,
- Group leader selection is left to students,
- It is not certain whether group leaders will be competent enough to run their group,
- It is not clear how to control the students waiting their turn or their game is over,
- The duration of the stages / the game, and the setting up times of the platforms for replaying are not limited,
- The students are deeply affected positively or negatively by other students in the game,
- The students are more likely to turn the game into a competition to reach the award,
- No measures are taken for the psychological damage to those who will not be rewarded or lose the game.

After expressing that the game would be gripping and effective, one participant (P5) warned against possible negative situations that might be experienced as:

"Of course, the winners will have fun in the game. However, the losers will necessarily conflict among themselves or with those in the other group and may even fight. After all, not everyone can tolerate losing. They fight all the time even in Survivor on TV. Let's be a little realistic here, they are 14-15 years-old teens and they will try to justify themselves in all kinds of ways. For example, in a class lesson, you can cheer the student when you make a few jokes but joking with the student who lost in the game, will cause more tension.".

In addition, the same participant (P5) drew attention to the situation of the students who do not play in the game as "*Always sitting on the sidelines, won't the 18 students waiting their turn or whose game is over get bored? How will they wait 50-60 minutes while their friends are having fun at the game, enjoying themselves?*".

Another participant (P8) pointed out that the duration of the game should be planned carefully and also made suggestions in this regard as:

"In this game where the player replying to the questions in the fastest way gains an advantage, what will happen if both students cannot answer the questions correctly or if both think for a long time in replying to them? Then the game ends in 3 hours at the earliest. So, I think an upper time limit may be set for Stage 1. Likewise, the players finishing their game will be responsible for making the stages ready again. Maybe the losing student will not like it."

## Evaluations for CFK Survivor on Cognitive, Affective and Psychomotor Skills

Within the scope of the 6<sup>th</sup> question of the interview, the participants were asked about their opinions on what skills the CFK Survivor game can provide to students. According to the evaluations of the participants, this section is organized in three sub-headings: "The Effect of CFK Survivor Game on Cognitive Skills", "The Effect of CFK Survivor Game on Affective Skills" and "The Effect of CFK Survivor Game on Psychomotor Skills".

### *The effects of CFK Survivor on Cognitive Skills*

In the continuation of the 6<sup>th</sup> question of the interview, the participants were directed an extra question as "Do you think this game can provide cognitive skills? Please explain.". Therefore, all 13 participants answered this question elaborately. Their evaluations were associated with the concepts and presented in Figure 1.

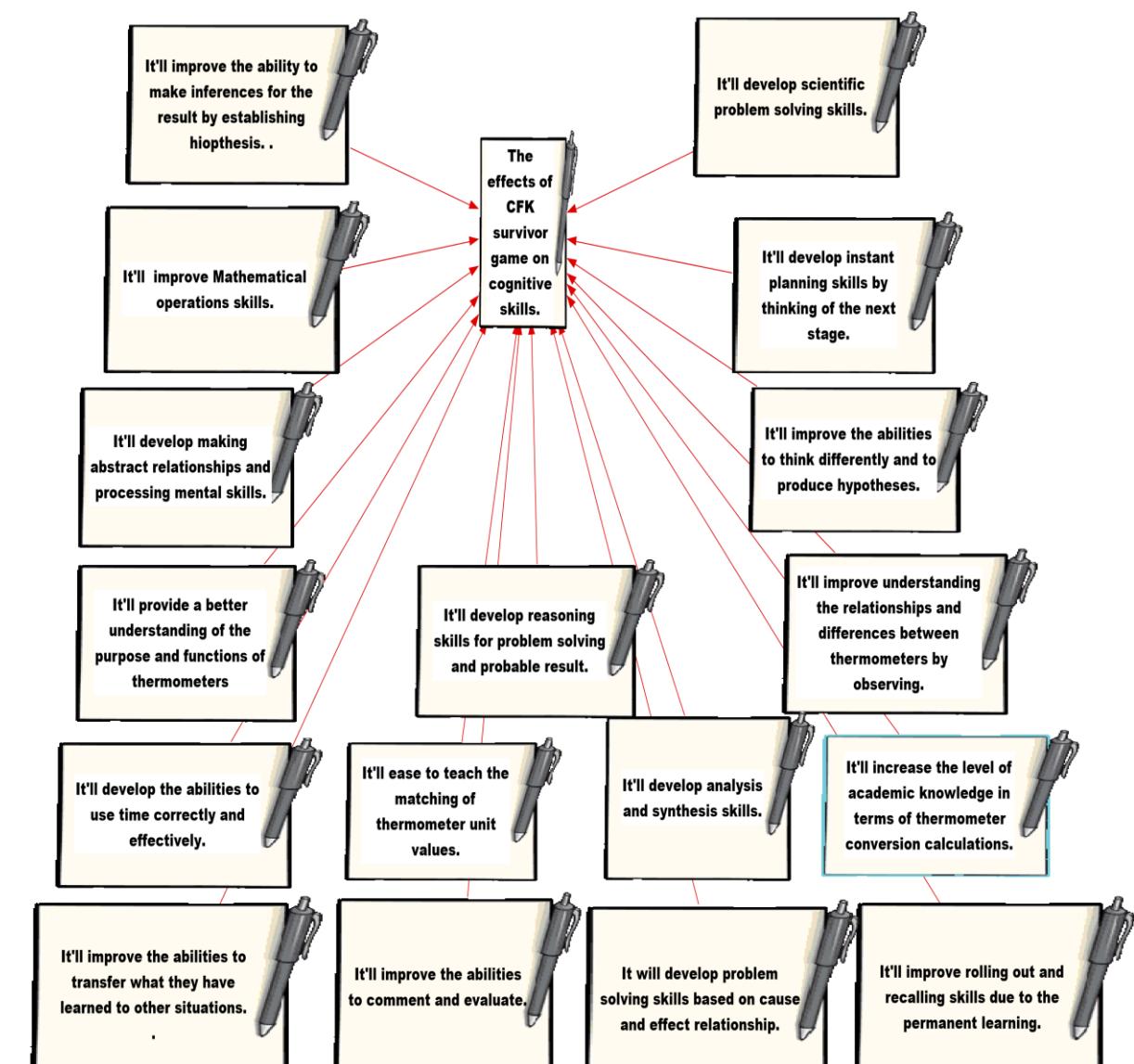


Figure 1. Evaluations for CFK Survivor on cognitive skills

In addition to the evaluations shown in Figure 1, one participant (P13) expressed his views on the cognitive skills that the CFK Survivor game could bring to the students as:

"First of all, it will provide permanent learning and improve the students' information processing and interpretation skills. It will enable them to

comprehend the subject and analyze the thermometer conversions. Since they will play the game themselves, they might also find the opportunity to practice on thermometers. Thanks to the activities in the first and last stages, problem-solving, decision making, inference and evaluation skills could also be developed.”.

Another participant (P10) evaluated the CFK Survivor game in terms of learning the subject as:

“If this subject were handled in the classroom, maybe it would be taught with a few examples. Only a few of them might try to solve those, but the remaining students would count seconds for the lesson to finish without participating in the lesson. However, thanks to this game, the students will get the information themselves. Because they could learn entertainingly, more permanent learning would occur. Also, since each student would solve 4 questions, 80 questions could be solved totally. In this way, the student could learn the subject in a very comprehensive way. It might also be possible to use the prior knowledge that comes from secondary school.”

P9, on the other hand, stated that the game could contribute to the multi-processing skill with her words as:

“Thanks to this game, students could learn much about thermometers and realize that there must be a relationship between them. It is also important for mathematical computing skills. The 1<sup>st</sup> and 4<sup>th</sup> stages are based entirely on problem-solving skills. The students will have to follow the referee and the other player while solving questions in the stages while dropping the bottles, opening the chest and placing the wooden block on the board. Therefore, since they will have to perform more than one operation at the same time, it could also gain them many mental skills.”

One participant (P1) emphasized that the game could appeal to upper-level cognitive skills as:

“First of all, the students should be cognitively conscious of discipline and responsibility from the beginning to the end of the game. After all, it's a matter based on mathematical calculations. For this reason, this is a game that might also gain quick thinking and mental processing skills. While solving the questions in the envelopes correctly, the students could be able to analyze the relationships between Celsius, Fahrenheit and Kelvin thermometers simultaneously. In the 4<sup>th</sup> stage, they will have to make a quick evaluation while placing the chosen wooden block in the right gap.”

Evaluating the game in terms of permanent learning and transferability, one of the participants (P2) said:

“Playing the game with relevant formulas is very important for mathematical process skills. The students' learning the subject by doing and experiencing rather than getting it ready will enable them to code all the information more easily and permanently in mind. I mean when asked about CFK conversions in the future, the students will immediately think of this game, so the retrieval of the information will be faster and without loss. There is also this topic in secondary school units. Thanks to this game, they will be able to transfer what they have learned there and use them while making transactions.”

### *The effects of CFK Survivor on Affective Skills*

In the continuation of the 6<sup>th</sup> question of the interview, the participants were asked an extra question as “Do you think this game can provide effective skills? Please explain.”. All 13 participants answered this question comprehensively. Therefore, their evaluations were associated with the concepts and presented in Figure 2.



Figure 2. Evaluations for CFK Survivor on affective skills

Related to the affective skills that the CFK Survivor game could gain to the students, one participant (P9) expressed his opinions as:

“I think our biggest problem is that the teachers are more willing and striving than students. I mean the students do not make even one percent effort to learn because they do not have the slightest willingness to learn. Since this game could awaken that desire in the student, they would voluntarily attend the class and thus, their self-confidence would be regained. Moreover, it might break their prejudices against physics lessons”.

Another participant (P3) said:

“Students have really great fears about physics. First of all, it seems like they were sitting by force in the classroom. I think the biggest benefit of the game will be that it could relieve physics lessons of boredom, break students' prejudices against physics and make them love the lesson. It might terminate their reluctance and indifference as '*I can't do it anyway!*'. Since the gameplay could increase their willingness and motivation, their perceptions and attitudes would also be affected positively. They might realize that they could be

successful in a subject related to physics and therefore their self-confidence will also increase.”

From a different viewpoint, a participant (P12) expressed his views as:

“This game is also crucial for decision making and evaluation skills. Because the things they do or not do in the game concerns not only him/her but also his/her group. So, this could improve his/her such cognitive skills as taking responsibility, commitment to the group and team spirit. It is also a very important game in terms of sharing with friends, valuing their opinions, and criticizing.”

Another participant (P10) said:

“After finishing the game, the students’ making the stages ready again is also important in terms of responsibility and team spirit. It becomes more of an issue thanks to valuing and belonging to the group, since he/she would play for his/her own group. So, this will be an extra opportunity for introverted students who want to prove themselves.”

All 13 participants implied that the game would have positive features in terms of affective skills. On the other hand, one participant (P5) drew attention to the possible adverse situations that losers might experience as “*Those who are successful in physics could definitely increase their self-confidence. But, as in all the games with a winner and a loser, the loser might be subjected to psychological devastation there.*”. In addition, the same participant stated that the game needs reinforcement activities in gaining effective skills as “*After all, even if the students would learn how to do thermometer conversions with 3-4 minutes of playing and solving 4 questions, they couldn't synthesize it or take it on themselves*”.

#### *The Effects of CFK Survivor on Psychomotor Skills*

In the continuation of the 6<sup>th</sup> question of the interview, the participants were directed an extra question as “*Do you think this game can provide psychomotor skills? Please explain.*”. All 13 participants answered this question in depth. Their evaluations were associated with the concepts and presented in Figure 3.

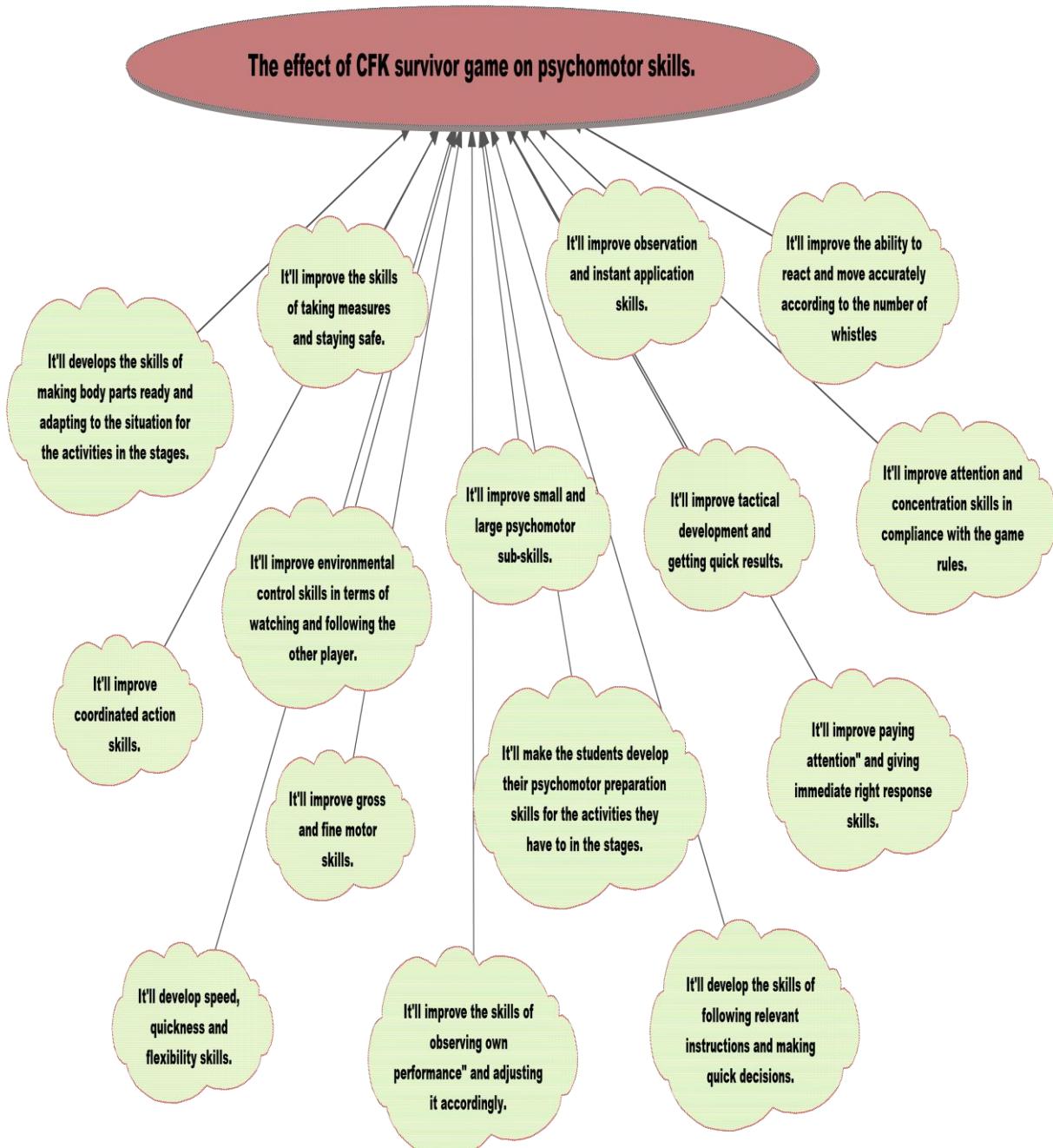


Figure 3. Evaluations for CFK Survivor on psychomotor skills

A participant (P7) expressed his views from the standpoint of psychomotor skills that the CFK Survivor game could provide students several advantages as:

“Concentration and hand-eye coordination to pass the stages would be at the maximum level from the beginning to the end of the game. Since the students could plan their next move in advance, there would be an improvement in terms of using the time to notice and react. First of all, it would be a very important game for small and large muscle coordination. In addition, it would also be vital for their psychomotor skills for their ability to react and act quickly according to the referee's whistles.”.

Another participant (P1) said:

"In terms of psychomotor activity, as the students could play the game themselves, they would be active from start to finish. They wouldn't be passive like sitting at a desk in the classroom and looking at the blackboard passively. It would be effective for hand, arm, leg muscles and the harmony between them. I think speed and quickness would be the key points in this game to finish the stages first. There would also be many points that require attention, such as not pressing the line lines, tilting the bottle of your own color, acting on the referee's whistles. Through those several psychomotor skills could be gained effectively.”.

One of the participants (P2) also expressed his views as:

"Game basically means movement. In other words, the students would actively pass from this table to that table during the game. Therefore, many psychomotor skills, especially hand-arm-leg coordination, could be gained. It would also be important in terms of hand-eye coordination, as the students will have to follow the other player constantly. In addition, they should both give instant responses to the whistles and according to it, they would either go to the other table or do the same task again. This would speed up their perceptions and make their bodies ready to do that job. Not only gaining self-control according to the rules and the order of play but also instant action skills could be listed as the other advantages of this game.”.

Another participant (P4) said:

"This is a game that requires students' hand-arm-leg coordination, rapid movement and instant reaction. Perhaps those who would play later, could make a new tactic for themselves by imitating their friends. This might also improve their analysis and interpretation skills. I think CFK Survivor is a game that could gain high-level skills by evaluating the situation especially when they lose.”.

### Suggestions for Designing an Educational Game for Physics Lesson

As part of the 7<sup>th</sup> question of the interview, the participants were directed an extra question as "*If you had to design an educational game for the physics lesson, what kind of game would you design? Can you explain.*". In this context, all the participants agreed that physics lessons have many suitable topics for educational games. In addition, one participant (P13) emphasized that physics subjects could be concretized thanks to educational games as:

"No matter how much you explain, there are some subjects that cannot be fully coded in mind in physics. I think it would be more logical to design an educational game related to these. For example, even if the students understand such concepts as '*Pressure, Heat, Temperature, Force, Work, Energy, Power, Electrostatics*' they cannot concretize them. Unfortunately, they have to memorize formal information or formulas. So, a few days later or when they pass the exam, they cannot remember them again like the '*Power*' subject. When people are asked what power is, they firstly think of force. According to physics, the man doing a job in a shorter time is more powerful. Suppose that I painted on the chalkboard two men, one big and the other small and started running on a 100 metered road with the same weight sack on their backs. Assume that the big one ran for 3 minutes and the other one for 2 minutes. Then when asked '*Which one is strong?*', perhaps the whole class would say

the big one. But physically, the man who did the same job in 2 minutes is powerful. The inability of students to envisage physics concepts causes such difficulties. So, we can teach these abstract concepts thanks to the relevant educational games.".

All of the participants expressed their opinions on the subjects that educational games could be designed for. Convenient subject suggestions for them were brought together within the framework of certain concepts and presented in Figure 4.

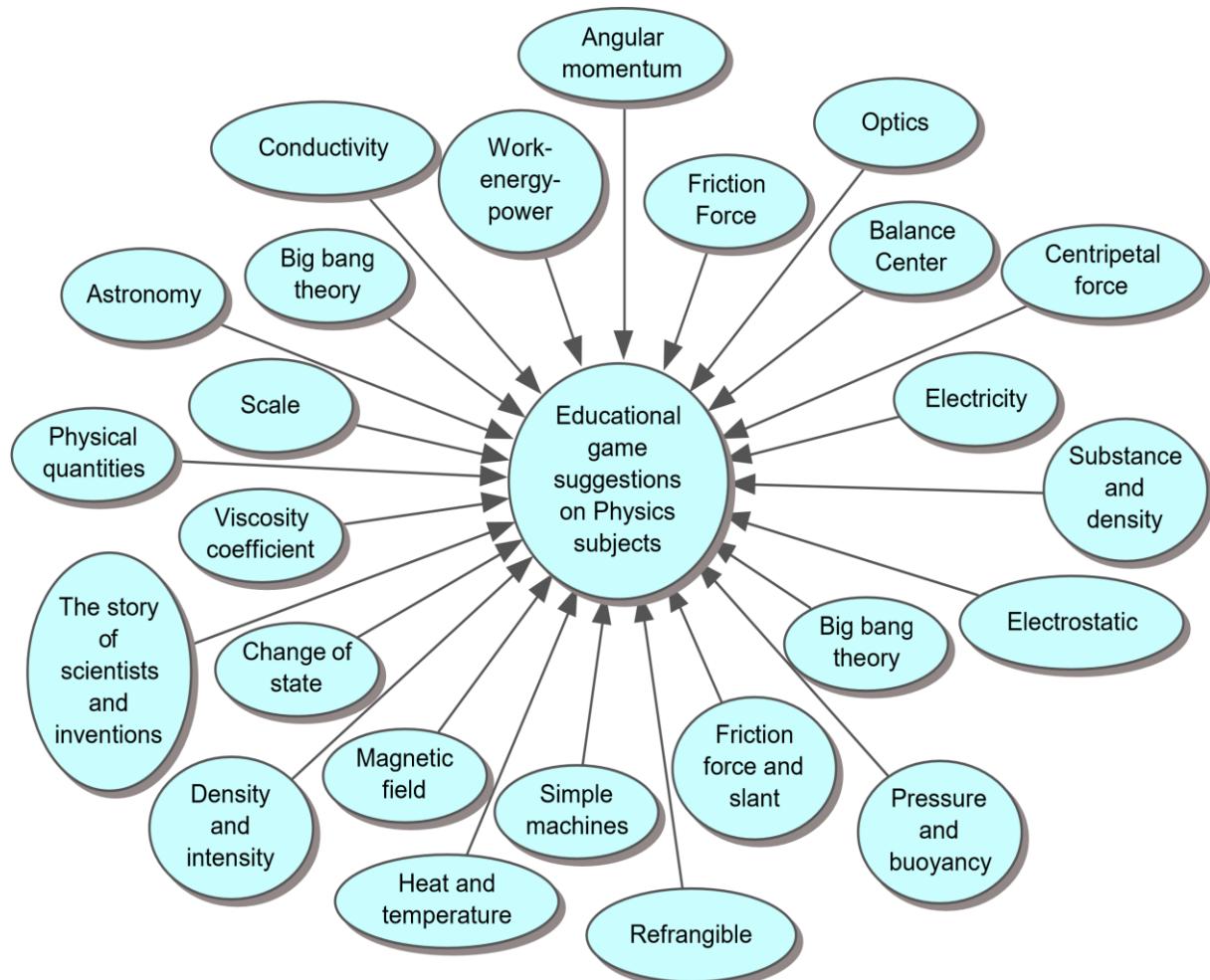


Figure 4. Educational game suggestions on physics subjects

As in Figure 4, Physics is a very rich lesson in terms of educational games. In this context, all participants, asked for an idea for an educational game, made at least 1 suggestion. Therefore, the educational game suggestions of the participants were brought together in the light of certain concepts and presented in Table 8.

Table 8. Educational game suggestions on physics subjects

Subject	f	Suggestion for Educational Game
Optics	4	"You can teach the refraction of light in optics via a game. Different colored but same sized balls will be given to the students and allowed to line up like a circle in the way they want. Then one student with a mirror comes into the midst of them. Each player will turn towards the ball and whoever has the

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		bigger ball in the mirror wins the game. The logic here is that the image of the light changes when it passes from a highly refractive environment to a less refractive environment or from a less refractive environment to a more refractive environment. So, they can understand that if the light comes perpendicular to the surface, it is unbreakable." (P11)
Balance Center	3	"You may take the students to the park or, if you can, set up a seesaw in the garden. You form two groups and tell them who first touches the ground loses. Let them determine the first players to get on. Then the second and third students get on the seesaw before the others get off. Thus, they can learn by experiencing how the center of balance changes when there are 2 students, 4 students and 6 students on the seesaw successively." (P10)
Electricity	3	"A multimeter is brought to the classroom, and its positive end is connected to a copper plate while the negative end to a zinc plate. Line up the students and let the student in his turn, put one hand on the zinc plate and the other on the copper plate. Therefore, each student's volt values are measured and recorded. So, the one with the highest value wins the electrical current game." (P9)
Electrostatic	3	"Everybody is given papers representing 1, 5 and 10 banknotes. Each player gets enough money to match their own weight. Then the teacher puts on music and the players start dancing. When the music ends, as in the game "Musical Chairs", everyone sits on a chair. All the players exchange their banknotes according to the weight of the right-side player. The standing player is eliminated as he cannot exchange. It continues till two players and one chair remain. Those whose banknotes are more wins the game." (P11)
Friction Force	3	"The students put three stones on top of the different frictional floors and try to drop them with a ball. The same student always throws the ball at the same speed and you successively measure them. Because the surface is different due to the friction force, the distance taken changes. Thus, they can learn what the friction force is and how it affects the subjects." (P1)
Angular momentum	2	"Two students with "a ribbon in their hands" sit on the chairs. I want them to turn first in the same direction then in the opposite direction. I draw attention to the movements on the ribbon according to the rotational speed of the students holding the ribbon. So, they make calculations with simple operations for the angular momentum formula I wrote on the board before." (P2)
Physical quantities	2	"As in the "Super Mario" game, different materials in daily life are put in front of the player wanting to reach gold. To overcome these obstacles, two boxes named scalar and vectorial are placed on both sides of the screen. In the game that gets faster and faster, the players seeing the obstacle momentarily are expected to press the right or left box. Thus, the students will learn both scalar and vectorial classification and have the skills of making quick decisions, attention and operations." (P4)

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Conductivity	2	“Students will be given different items to understand the rate of distribution in the conductor. The students hit the tables to understand the relationship between the intensity of the sound produced and the conductivity levels. In this way, they can concentrate on the relationship between them”. (P8)
Work-energy-power	2	“Form three groups among the students. One handball, football and basketball ball are placed at the starting level for each group. After point A is determined, then point B is determined 100 meters ahead. Boxes are placed at both points in sizes that these balls will fit in. The first students of the groups take the handball balls from point A with the teacher's whistle and take the soccer ball out of the box at point B after throwing the handball ball into the box. The student who takes the soccer ball starts running to point A without waiting for the handball ball to settle in the box. The student reaching point A takes out the basketball after putting the soccer ball in the box. Then the third student picks up the basketball and starts running to point B. As soon as she/he puts the ball in the box, the game is over. Thanks to this game designed for the formula of "Work / Time = Power", they could learn the concept of power and which group is powerful.” (P13)
Density intensity	and 2	“Items for every student such as raw eggs, scrambled eggs, ping-pong balls with different density, such as the "Soaking test" related to density and intensity will be put on a desk. Then they will be immersed in liquids of different densities such as water and sunflower oil. Therefore, by asking the question ‘Which student's belongings float better?’, such a game can be designed for the relation between density and intensity.” (P2)
Big bang theory	1	“In the teaching of Big bang theory, a game can be designed with balloons. For example, each student marks two points with a pencil before inflating his balloon. Then, the students blowing the balloon at different speeds see these two points start diverging. Thanks to the connection of this speed with the speed of the stars in the galaxy diverging from each other, a very nice game can be designed and the subject can be concretized.” (P7)
Astronomy	1	“For example, for astronomy, several rings in the form of circular rings are drawn on the ground. A student takes a flashlight in his hand to symbolize the sun. Other students, symbolizing the planets, begin to move around the sun and around their own axes without leaving that ring, that is, their orbit. Among the players who wanted to turn faster, the one who left the ring was eliminated. The last remaining player wins the orbit game.” (P3)
Scale	1	“To find a scale, two students hold a string or ribbon by the ends. Then you draw two lines parallel to each other on the ground, and the students start walking on that line. As the rope becomes loose or stretched as they walk, students could find the scale.” (P7)
Viscosity coefficient	1	“Open topwater pipes are brought to the classroom to gamify the viscosity coefficient. The students are given five beans each and

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asked to place them to slow the flow of water as they wish. Then an equal amount of water is released into the pipe at the same time. Whichever student's pipe drips on the table last, she/he wins the game. So, after supporting them with formulas to make transactions, they can learn the logic of the viscosity coefficient." (P11)

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As seen in Table 8, the participants made educational game suggestions for such physics subjects as "*Optics, Balance Center, Electricity, Electrostatic, Friction Force, Angular momentum, Physical quantities, Conductivity, Work-energy-power, Density and intensity, Big bang theory, Astronomy, Scale and Viscosity coefficient*".

In the continuation of the 7<sup>th</sup> question of the interview, the participants were posed a question as "*What do you think about making this educational game you designed, available to other teachers?*". All 13 participants stated that they would get support from group teachers before, during and after the game. They also stated that they would make their original game available for other Physics teachers, therefore all students in the same branches could benefit from it. A participant (P13) expressed his views on this subject as:

"If I could develop a game, I would like my colleagues to use it. After all, this is not a state secret. Moreover, there may be something I cannot see, so I would immediately consult them first. After the game, I would also get their evaluations and comments."

Another participant (P12) said:

"If I were to prepare an educational game, I would discuss it in detail with my physicist friends before the game. I would invite them to watch the game when available. In addition, I would make all 9<sup>th</sup> grade students in all branches of our school play this game. At the end of the game, we would also evaluate it all together. Therefore, I think that there should always be qualified communication and cooperation among teachers in the educational process not only for educational games but also for everything."

One of the participants (P10) expressed his views as:

"If I designed such an educational game as a physicist, I would apply it to all classes I lecture anyway. I would want my other physicist friends to do it and even encourage them. I would do this cooperatively by taking their opinion. Therefore, for many eyes would evaluate it, possible mistakes could quickly be prevented in terms of skills and acquisition in the field. After the game, with colleagues, we could discuss and evaluate the game as '*How did it happen? What was missing? How can we do it better? What else can we design an educational game?*'. Since the students would play the game, I think they should make better and more effective evaluations. So, I would take their opinions because they must be regarded meticulously.".

Thus, the participants' evaluations and suggestions for educational games that can be designed on Physics subjects were received. In addition, during the educational game process, their opinions about the pre-game, during and after the game were determined in effective communication and cooperation with colleagues and students.

## DISCUSSION, CONCLUSION AND SUGGESTIONS

It was decided to design an educational game for "*The students make calculations related to the temperature units.*" acquisition within the scope of the 9<sup>th</sup> grade Physics lesson "*Heat and Temperature*" unit. Therefore, the "CFK Survivor" game, aiming to learn the temperature unit conversion calculations of the Celsius, Fahrenheit and Kelvin thermometer types, was developed under the acquisition explanation as "*Unit conversions for °C, °F, K are provided to be done*". During the development of the game stages, CFK Survivor's being able to gain targeted behaviors, being suitable for the age and level of the students, being easy to understand and applicable, not time-consuming in terms of playing the stages and making them ready again and allowing students to learn by participating with interest and enthusiasm were minutely regarded.

Due to the Covid-19 epidemic the schools were closed, so it was not possible to implement this game. Then, 13 physics teachers working in private educational institutions and attending 9<sup>th</sup> grade classes online were consulted to determine the effects of the CFK Survivor game on unit conversions for °C, °F, K.

Describing educational games in their own words, the participants stressed that the use of educational games in physics lessons would be greatly positive, such as "*increasing active participation, increasing permanence, providing concretization, increasing motivation, making lessons enjoyable, reducing memorization and breaking prejudices*". Educational games can establish a strong link between practice and learning by transforming abstract concepts and information into concrete experiences (Varışoğlu, Şeref, Gedik & Yılmaz, 2013). On the other hand, they also expressed their hesitations on educational games such as "*being time-consuming, having little effect without reinforcement and not being applicable for all subjects*". Since educational games may not be suitable for all subjects and learning styles, the level of the knowledge of all participants cannot be evaluated precisely and they also require more time. (Pehlivan, 2014) Their views stand with these statements.

All 13 teachers pointed out that they had not used educational games or teaching techniques with games by then but would like to use them if possible. Despite their willingness, they expressed their concerns about designing or using educational games as "*intensive curriculum, insufficient course hours, expectations of administration / parents / students, being quite a time consuming, being required too much effort, being costly*".

All 13 participants emphasized that the CFK Survivor game was easily understood thanks to not only supporting the rules and gameplay with visuals but also presenting them item by item. In addition, evaluating the game in terms of teachers and students, the participants expressed their views as "*Students will get less mentally tired, Teachers will get more mentally tired, Lower-level students will have more difficulty, Teachers will get more physically tired, Students will get more physically tired, Teachers will have more difficulty, Teachers will have less difficulty, Students will have less difficulty*".

The whole participants said that the game would be suitable for the relevant acquisition and could meet it. In this context, 2 participants stated that the game would meet the gain alone without the need for any other activity. On the other hand, 11 participants emphasized that before or after the game, some reinforcing activities should be done as "*Solving extra questions in the class, Giving homework as intensifier questions / tests, Replaying the game, Giving time to prepare students by announcing the game time in advance, Giving a project / term paper, Making a quiz or oral exams*".

For such reasons as ““*It will increase active participation, It will increase permanence level, It will save the subject from boredom, It will make students willing, It will enable concretization, It will raise the perception level, It will increase the motivation level, It will increase interest and curiosity levels towards the subject / lesson, It will increase academic success, It will increase excitement and curiosity, It will reduce memorization, It will break the prejudices, It will give the students the opportunity to Show themselves, It will reduce the waste of time, It will increase team spirit and sense of responsibility, It will facilitate information transfer on future issues*”, 11 participants stated that teaching unit conversions for °C, °F, °K via CFK Survivor educational game would be more enjoyable therefore, the students participating actively, could have more effective and permanent learning. Educational games can establish a strong link between practice and learning by transforming abstract concepts and information into concrete experiences (Varışoğlu, Şeref, Gedik & Yılmaz, 2013). Because educational games provide the opportunity to learn by doing and experiencing actively in real-like environments also ensure social interaction with their own rules (Gee, 2014). The students, whose communication and interaction with each other increase, may also show positive behaviors in obeying the rules thanks to educational games (Yıldız, Şimşek, & Araz, 2016). Active participation in the learning process is the main factor in educational games. The students learning by doing and experiencing can thus gain effective and permanent learning. The evaluations of the participants are in line with these statements in the literature.

On the other hand, the participants drew attention to possible disturbing situations that may arise as “*having winners and losers; stages' requiring mathematical operations; students' playing with each other without paying attention to their physical, social, academic achievement; leaving students to select group leader; group leaders' being skillful or unskillful to manage their groups; controlling of the students waiting for their turn or finishing it; not foreseeing playing time of the stages, the whole game and preparation time of the platforms for replay; players' being positively or negatively affected by other students during the game; the possibility of the students turning the game into a competition to reach the award; the psychological devastation that those who cannot get a reward or who lose it can suffer mentally.*”. Because some educational games are competition-based, gaining awards or winning feelings may be predominating. These cases may lead to negative situations such as disappointment, aggression and loss of control for the losers (Canbay, 2012). Participants' hesitations about possible negative situations that may arise in the implementation of the game support these statements.

All participants draw attention that the CFK Survivor game would be effective in terms of gaining a large number of cognitive, affective and psychomotor skills expressed in Figures 1, 2 and 3. Thanks to educational games, many skills such as learning, sharing, helping each other, cooperation, decision making, ranking, organizing, respecting the rights of others are unwittingly learned and adopted (Çoban & Nacar, 2006). By virtue of the active participation of the students, high-level skills such as quick thinking, strategic thinking, ratiocination, rapid decision-making, taking responsibility and problem solving can be gained through educational games (Gürcan, Özhan & Uslu, 2008). As stated in the figures, the evaluations of the participants on the cognitive, affective and psychomotor skills to be acquired by the students through the CFK Survivor game jibe with these statements in the literature. All participants also stated that this game would positively affect the teaching of the subject and increase academic success level. The findings of Karamustafaoglu and Kaya (2013) and Boz

(2018) that learning through educational games increase academic success is in the same direction with these statements.

The fact that the games are interesting is very important in gaining and developing the intended knowledge, skills, behaviors and values. Thus, educational games make it possible to learn the subject in a more interesting and enjoyable way in the learning environments where students can have a good time (Yıldız, Şimşek & Araz, 2016). The student moving more comfortably and independently in the game reflects her/his inner world more realistically while playing. Educational games are important for many acquisitions as strategic thinking, tactical development, planning, discussion, numerical processing, data processing (Kirriemur & McFarlane, 2004). In addition, educational games are effective in providing such skills as comprehension, thinking and acting together, making decisions, respecting the rights of others, being honest and obeying the rules (Hazar & Altun, 2018). The opinions and evaluations of the participants about educational games match up with these statements in the literature.

According to them, thanks to the reinforcement of the rules and gameplay of the CFK Survivor game with figures, the students and teachers might have fewer difficulties. In addition, if the game could be supported with the relevant posters, pictures, videos or simulations, the subject would be more easily concentrated by the students. Giving preparing time to the students by telling the game time in advance would also be crucial for meeting the acquisition. Based on the obtained data, processing the subject of unit conversions for  $^{\circ}\text{C}$ ,  $^{\circ}\text{F}$ ,  $^{\circ}\text{K}$  via CFK Survivor could

- increase the active participation,
- make the students eager,
- increase their perception levels by concretizing the concepts,
- increase their motivation and attention levels to the lesson,
- increase their excitement and curiosity about the subject/lesson,
- decrease memorization,
- provide the students with the opportunity to show themselves,
- increase team spirit and sense of responsibility,
- facilitate the transfer of knowledge for further subjects.

In this context, it is expected that the prejudices of the students whose willingness and motivation levels might increase by means of concentrating the subject, against physics and its other subjects would be terminated. Because the students can focus their attention on that subject, they become willing to learn by switching from passive to active (Hazar, 1996).

Therefore, both their problem-solving skills could be improved, and their academic success would increase. The students involved in learning and developing positive attitudes, become more inquiring thanks to their more selective receptors and increased motivation (Kıldan, 2001).

In addition, their ability to obey the rules and express themselves would improve thanks to many skills such as commitment, team spirit, respecting others, being open to criticism, and taking responsibility. Specific learning goals can be achieved through educational games dragging students as if they were having a genuine experience (De Freitas, 2006).

They could also gain several positive acquisitions such as hand-eye coordination, speed and quickness, flexibility, rapid decision making and responsiveness, fast processing, fine and coarse muscle development, and coordinated movement skills. In addition to such psychomotor characteristics as strength, endurance, quickness, dynamism, flexibility, several mental skills such as keeping in memory, matching, classification can be acquired through educational games (Aral, Gürsay & Köksal, 2000).

It was stated that the CFK Survivor game would be sufficient for the intended acquisition, and thanks to the acquisition of many cognitive, affective and psychomotor skills, the students could gain enjoyable and permanent learning. Cognitive behaviors as knowledge and skills aimed in the courses taught at schools within the scope of the curriculum psychomotor behaviors as coordination and affective behaviors as attitudes, interests, values can be acquired (Gündüz, 1998). These statements in the literature tally with the evaluations of the participants.

The students involved in learning and developing positive attitudes, become more inquiring thanks to their more selective receptors and increased motivation (Kıldan, 2001). In other words, since they can focus their attention on that subject, they become willing to learn by switching from passive to active (Hazar, 1996). Specific learning goals can be achieved through educational games dragging students as if they were having a genuine experience (De Freitas, 2006). In addition to such psychomotor characteristics as strength, endurance, quickness, dynamism, flexibility, several mental skills such as keeping in memory, matching, classification can be acquired through educational games (Aral, Gürsay & Köksal, 2000). Cognitive behaviors as knowledge and skills aimed in the courses taught at schools within the scope of the curriculum psychomotor behaviors as coordination and affective behaviors as attitudes, interests, values can be acquired (Gündüz, 1998). These statements in the literature tally with the evaluations of the participants on the acquisition of many cognitive, affective and psychomotor skills and such other factors, emphasized above, as academic success.

#### *Suggestions Based on Research Findings*

- Educational games should be planned in a detailed way to be suitable for the purpose of teaching and to be flexible enough to the changes according to the necessities.
- In order to avoid confusion, the educational games' layout should be established by providing such factors as the selection of the playground and its arrangement; the preparations of the platforms; the provision and preparation of the materials and tools.
- The rules / gameplay of the educational games should be clear and the roles of the players / leaders should be explained in detail.
  - To distinguish the groups, different colored jersey sort t-shirts signs can be used.
  - Educational games should be backed up with visual and audio materials for concentrating easily.
  - Various measurement tools for evaluating the teaching via educational game applications should be developed.
  - School administrators, teachers and students should be in effective cooperation and communication in the educational game process.
  - Such activities as interviews, debates, symposiums, and essay writing should be held to increase the impact and permanence of the educational games.
  - In terms of such factors such as heat, light, sufficient space, tools and materials, the schools, classes, school gardens and other places should be designed for educational games and other physical activities.

- Physics curriculum should be revised in view of the methods and the duration for the subjects.
- The physics textbooks should be revised and more activities such as educational games should be added.
- The necessary developments and arrangements should be made in the physics curriculum and textbooks prepared under this program, to support the teaching activities via educational games.

### *Suggestions for Further Researches*

- New educational games can be developed on other physics subjects where students have difficulty in participating, motivating, or understanding.
- New educational games can be developed for the relevant 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grade physics subjects.
- A more comprehensive study can be done with experimental and control groups on educational games.
- New longitudinal research can be done for educational games on appropriate topics.

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## ANNEX 1. CFK SURVIVOR

**Table A. General information on CFK Survivor educational game**

Grade	Unit	Subject	Acquisition	Playing Area	Game Type	Number of Players	Playing Time
9	Heat and Temperature	Celsius, Fahrenheit and Kelvin Conversions	F.9.5.1.3. Makes calculations about temperature units.	Playground (indoor sports hall in overcast days)	Group	20	2 lesson hours (80 mins.)

**Table B. Materials required for CFK Survivor educational game.**

Piece	Material	Piece	Material
60	Fastener	1	Teacher table
20	Wooden rectangular block	1	Board (60x120 cm in size)
14	Student desk	1	Ruler (100 cm long)
20	Wooden lath (each 60 cm long)	1	Red colored water glass
10	0.5 l water bottle cap (Red)	1	Blue colored water glass
10	0.5 l water bottle cap (Blue)	1	Red colored handkerchief
6	Oversized student eraser	1	Blue colored handkerchief
4	Cardboard paper in different colors	1	Board pen
3	0.5 l filled water bottle with red cap	1	Scissors
3	0.5 l filled water bottle with blue cap	1	Liquid glue
2	Wooden chests with keys	1	Packing tape
2	Referee whistle in different tones	1	Game box (small cardboard box)
2	Piece of nylon rope (each 60 cm long)		

### 1. PREPARATION OF THE GAME

Packing tape is stuck on the floor to determine the audience area. 9 student desks are placed in the audience area for the players waiting their turn, and the spectators to sit. In addition, the floors of the audience area and playgrounds are made clean and tidy.

#### 1.1. Preparation of Stage 1

- 1 metered packing tape is properly stuck on the ground to mark the starting line. 3 student desks (one meter apart) are lined side by side 1 meter ahead of this line (Figure 1).
- The white cardboard measured with a ruler, is cut into four equal parts with scissors. Celsius, Fahrenheit and Kelvin temperature unit conversion formulas are written on 3 white cardboards as " $^{\circ}\text{F} = 1.8^{\circ}\text{C} + 32$ ", " $\text{K} = ^{\circ}\text{C} + 273$ " and " $^{\circ}\text{F} = 1.8 (\text{K}-273) + 32$ " and they are taped to the corners of student desks in a way that they do not fall (Figure 2).

- 5x10cm pieces are cut from yellow, green and purple cardboards. 15 questions in the form of “ $X_F=...c$ ”, “ $X_c=....F$ ” on yellow cardboards (Celcius-Fahrenheit/Fahrenheit-Celcius), 20 questions as “ $X_K=....c$ ”, “ $X_c=....K$ ” on green cardboards (Celcius-Fahrenheit / Fahrenheit-Celcius), and 25 questions as “ $X_F=...K$ ”, “ $X_K=....F$ ” on purple cardboards (Celcius-Kelvin / Kelvin-Celcius) are written ( $X$  = temperature value). Colored cardboards are turned over and stacked on the tables as in Figure 2. In addition, two pencils and erasers are placed on each table.

### **1.2. Preparation of Stage 2**

- In order to determine the 1-meter throwing line (the area 1 meter next to the table with purple cardboards) 1 meter of tape is stuck on the floor (Figure 1).
- A student bench is placed 3 meters from the throwing line (Figure 3).
- 3 red and 3 blue capped bottles filled with 0.5-liter water are stacked side by side on the table as in Figure 3.

### **1.3. Preparation of Stage 3**

- So as to be placed in the spaces in the temperature unit panel, correspondence values of the units not given in the panel, are written on 20 wooden blocks in terms of Celsius, Fahrenheit and Kelvin with a wooden pen (Figure 6).
- Prepared wooden blocks are scrambled up and placed randomly in 2 wooden chests, 10 in each, and they are locked (Figure 4).
- Wooden chests are placed on a student desk with a 50 cm gap between them, as shown in Figure 4.
- The keys of the wooden chests are taken and hidden randomly, as one under the bottles with a red cap and one under the bottles with blue cap, on the table with 6 bottles in the second stage (Figure 3).

### **1.4. Preparation of Stage 4**

- The temperature units' panel is measured with a ruler and markings are made with a pencil at equal intervals with 20 equal divisions on the long side and 3 equal divisions on the short side. According to the markings, 20 laths are fastened to the short sides of the board and thus 20 equal lines are created on the board. In reference to the markings, 3 equal columns are formed on the panel by stretching and fastening 2 pieces of rope to the long sides. Cardboards on which the formulas Celsius, Fahrenheit and Kelvin are written, are affixed to the heads of the columns. Thus, as in Figure 6, the temperature units panel consisting of 60 equal divisions in which temperature units in Celsius, Fahrenheit and Kelvin will be written on each line is prepared.
- Corresponding units of two of Celsius, Fahrenheit and Kelvin are written on cardboards and pasted in a way that 1 space is left in each line of the temperature board. Therefore, one for the temperature unit not given in each row, a total of 20 answer (wooden block) spaces are created, (Figure 6).
- The temperature units' panel is placed on the teacher's table and two panel alignment lines are drawn on the floor on both sides of the table (Figure 5).
- Next to the table where the board is located, a game box is placed to throw yellow, green and purple colored answered cards (Figure 5).

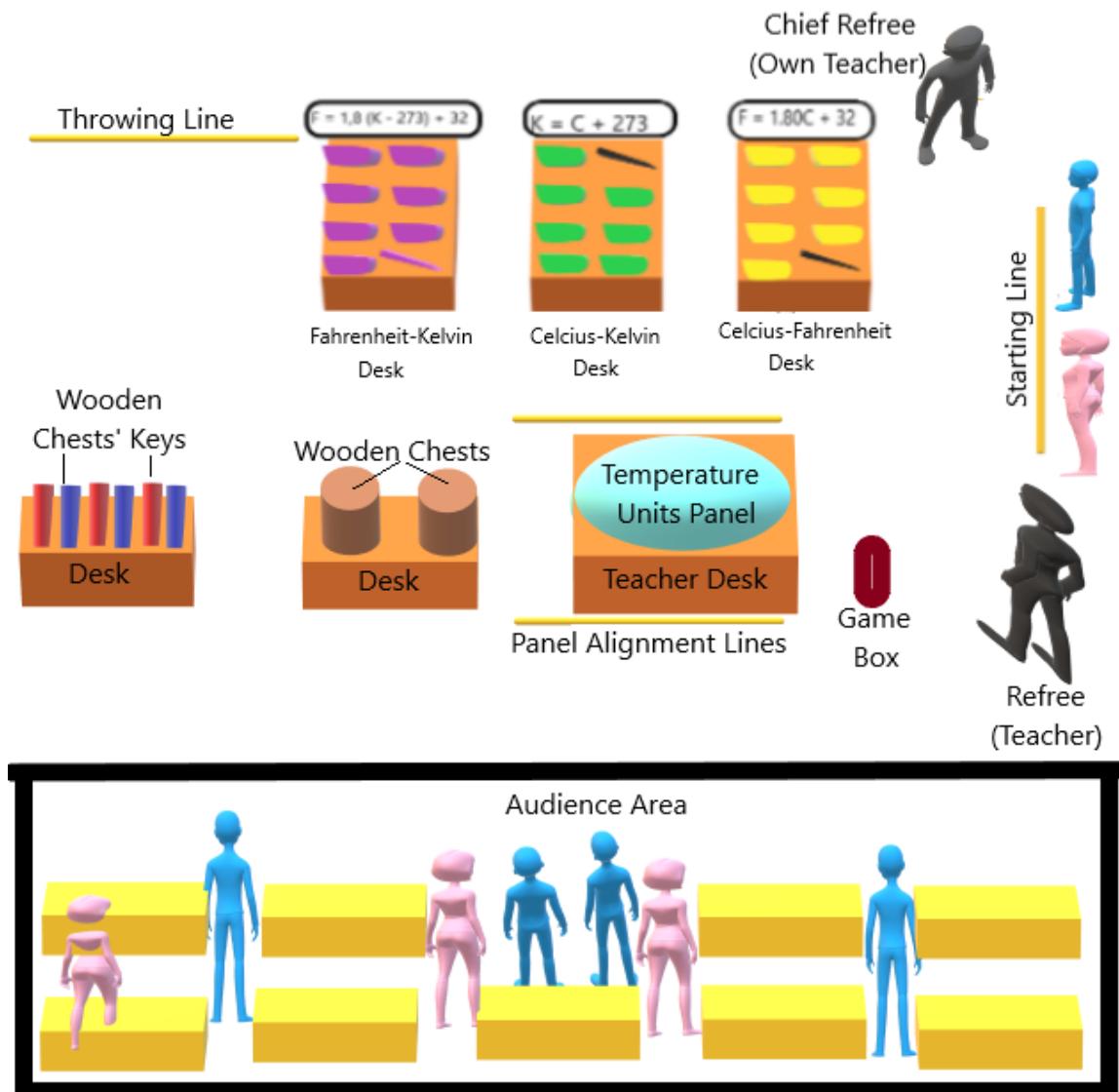


Figure 1. Preparation stages of the CFK Survivor game

## 2. GAME RULES

1. CFK Survivor game consists of 4 stages. It starts from the 1<sup>st</sup> stage and all the stages are played, respectively. Next stages cannot be passed before the previous stage is fully completed.
2. Two referees conduct the game. The same referee follows and controls the same player from the start of the 1<sup>st</sup> stage to the end of the 4<sup>th</sup> stage. Referee whistles mean as;
  - 3 whistles (start / end whistle): it means the game has started in the 1<sup>st</sup> stage and the round is over in the 4<sup>th</sup> stage. Only the chief referee may whistle 3 times.
  - 2 whistles (rejection whistle): It means that the answers given to the questions on the cards are wrong in the 1<sup>st</sup> stage and the questions have to be solved again, and also in the 4<sup>th</sup> stage the gap where the wooden block is placed is wrong and it must be replaced. Both referees can whistle twice.
  - 1 whistle (confirmation whistle): It means that the answers given to the questions on the cards in the 1<sup>st</sup> stage are correct and you can switch to the next table. Both referees can whistle once.
3. Nobody can enter the playground except two referees and two players. The other players must watch the game as an audience in the place reserved for them outside the playing area until their turn. They may cheer and support their group mates in the game, but they cannot interfere with the referee decisions, players or the game in any way.
4. The group leaders play the first game. The players cannot step on the starting line in front of the class door. The game starts with 3 whistles of the referee after the players receive the handkerchiefs in the color of their group (Figure 1).
5. In the first stage, each player has to choose 3 cards and answer the questions in them correctly. The first players can choose 1 yellow, 1 green and 1 purple cardboard. Since the yellow cards will run out, the next players must select 2 green 1 purple cards and the last remaining players 1 green 2 purple cards (Figure 2).

6. In the first stage, the one whistle of the referee indicates that the player's response is correct and could move on to the next table. If the player's answer is wrong, the referee whistles twice and she/he has to solve the question repeatedly until finding the correct answer. The referees take the solved yellow, green and purple question cardboards and throw them into the game box. They also give 3 large erasers to the players finishing the first stage.

7. In the second stage, the throwing line cannot be stepped on. If the bottle full of water under which the chest key is found on the first shot, there is no obligation to shoot again. When the wrong shot is made or the bottle of the other group is dropped, the erasers are picked up the ground again and the game continues. The player finding the key her/his or the other player's dropping the water bottles, moves to stage 3.

8. In stage 3, after opening the correct wooden chest, the player can only take 1 wooden block in it. The randomly selected wooden block cannot be left back or replaced.

9. In stage 4, the player, thinking she/he has placed the wooden block in the correct gap on the board, lifts the group's icon-colored handkerchief in the air. After the check, if the gap where the block is placed is correct, the referee blows his whistle 3 times and the game is over and that player wins that round. If the gap she/he placed is not correct, the referee blows his whistle twice and the player takes his second chance. If he/she still doesn't find the right gap, then she/he takes her/his 3<sup>rd</sup> and last chance. Still the player placing the block in the wrong space for the third time is eliminated from the game.

10. The player winning the round is given 1 bottle cap in the icon color of his/her group (red or blue). Only the winner in the 10<sup>th</sup> round will be given 2 bottle caps. Caps collected as winning the tours are put in the glass of the group's icon color. The group with the most caps in their glass at the end of the 10<sup>th</sup> round wins the game.

### **3. GAME PLAY:**

The CFK Survivor game consists of 4 stages. It starts from the 1st stage and all stages are played respectively. Next stages cannot be passed before the previous stage is completed.

- 1<sup>st</sup> Stage; answering questions on yellow, blue and purple cartons,
- 2<sup>nd</sup> Stage; knocking over the right water bottle with oversized erasers and finding the key under it,
- 3<sup>rd</sup> Stage; opening the correct wooden chest with the key and selecting a wooden block from inside the box,
- 4<sup>th</sup> Stage; placing the received wooden block in the correct gap in the temperature units' panel.

The chief referee of the game is the teacher of the physics lesson. A second physics teacher working at the school is also asked to act as a referee. The referees (physics teachers) divide the players (students) into two groups of ten people. Once their group is determined, the players choose the group leaders and the color (red or blue) that represents their group. They develop a game strategy led by the group leaders and determine their playing orders accordingly. Determining the playing order of the players is especially important in terms of the 1<sup>st</sup> and 4<sup>th</sup> stages (not being able to choose from yellow cards and having less / more gaps in the temperature units panel) and the 10<sup>th</sup> round (giving 2 bottle caps).

#### **3.1. Gameplay of Stage 1**

At the beginning of the game, the players are given handkerchiefs in their group's icon color (red or blue). Both players stand side by side on the starting line (Figure 1). When the chief referee whistles three times, they arrive at the "Celsius-Fahrenheit" table with yellow cartons. They each select one of the question cardboards on the table and read the question below by turning it over. After calculating by looking at the white formula cardboards attached to the head of the table, they show their cardboards to the referee. The player whose answer is correct goes to the "Celsius-Kelvin Table" with green cardboards after the referee whistles once. Likewise, by choosing a green cardboard she/he does the calculations on it. If the answer is correct, the referee whistles once again and she/he arrives at the "Fahrenheit-Kelvin Table" with purple cardboards. So, by choosing a purple cardboard, she/he does the calculations on it. If the answer is correct, the referee whistles one more time and gives the player three oversized erasers. If the answers are wrong, the referee will whistle twice and the player cannot move to the next table until he finds the correct answer. Thus, the 1<sup>st</sup> stage is completed (Figure 2).

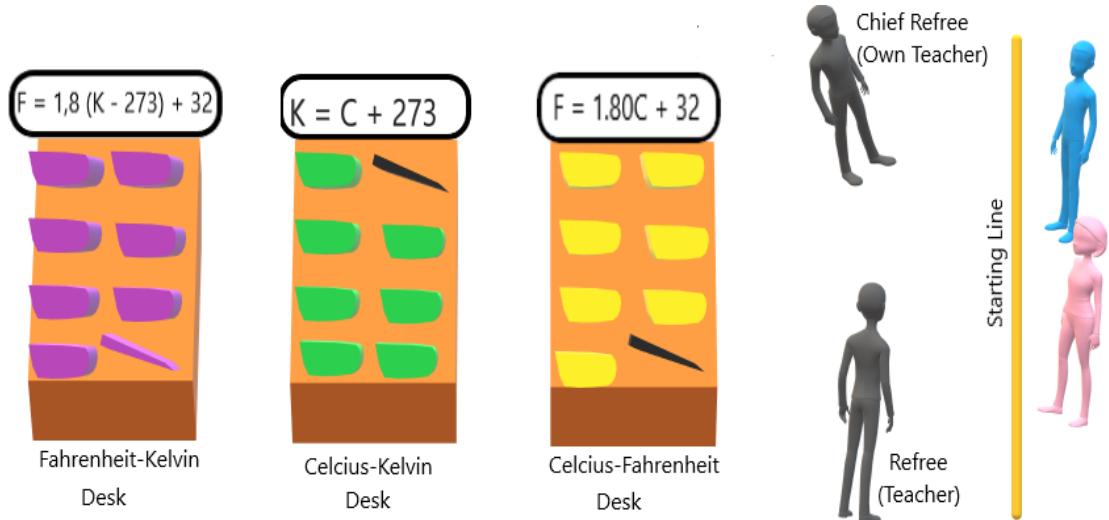


Figure 2. CFK Survivor Stage 1

In the first stage, each player has to choose 3 question cardboards and answer the questions written on them correctly. The first players can choose 1 yellow, 1 green and 1 purple cardboard. Since the yellow cartons will run out, the next players have to choose 2 green 1 purple cartons and the last remaining players have to choose 1 green 2 purple cartons.

Although all 21 questions on yellow, green and purple cards are prepared at "medium difficulty" level, the questions on the yellow card (as the Celsius-Fahrenheit conversion calculations can be made relatively easier and faster) can be an advantage for first players. On the other hand, the next players' being obliged to choose from green and purple cardboards may also be a disadvantage for them. In addition, finishing the first stage fast can give players an advantage before throwing bottles in the second stage.

### 3.2. Gameplay of Stage 2

After finishing the first stage, the players taking their oversized erasers from the referees, arrive at the throwing point without stepping on the throwing line next to the table with purple cardboards (Figure 1). By throwing 3 erasers, they try to drop the water-filled bottles in group colors standing 3 meters away. When the bottle with the key under it is dropped, there is no need for another shot. So, the player finding the key, no matter if she/he or the other player drops, under the right bottle passes to the third stage. However, if she/he cannot drop the right bottle in all 3 shots, or drops the other group's bottles, the player can take her/his erasers again and shoot until finding the right bottle (Figure 2).

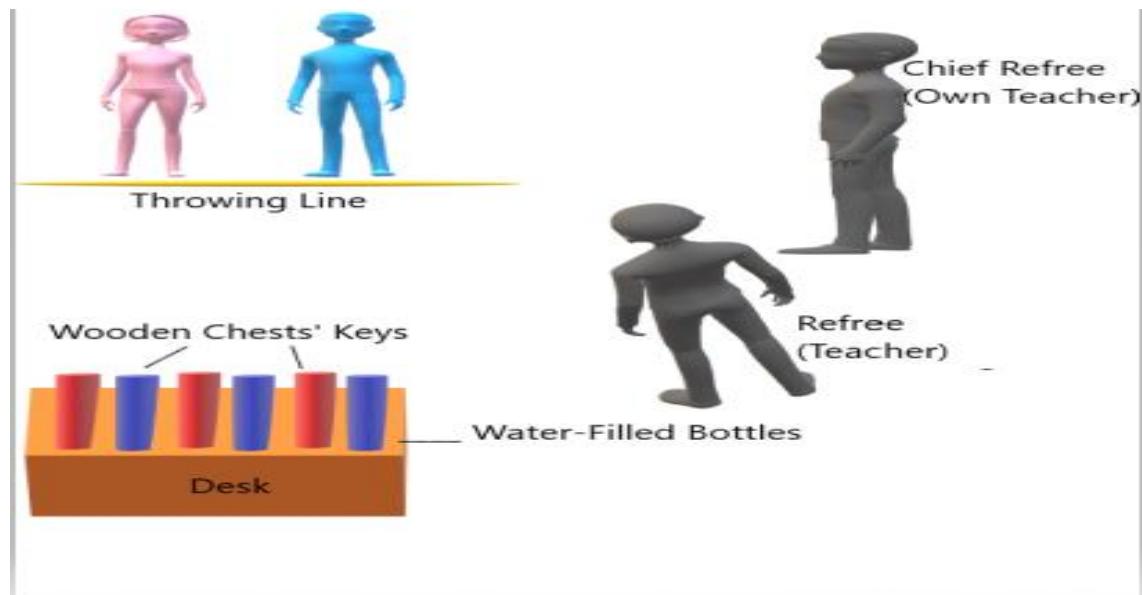


Figure 3. CFK Survivor stage 2

At this stage, the players dropping the bottle with the key under the first shot gives them an advantage in terms of speeding up. On the other hand, it would be a disadvantage for them to find the key in the next shots or to drop the other group's bottles.

### 3.3. Gameplay of Stage 3

The player receiving the key tries to find the correct one among the 2 wooden chests on the table as in Figure 4. After opening the chest, she/he randomly selects a wooden block with corresponding values in Celsius, Fahrenheit or Kelvin. The player can only select 1 wooden block and cannot leave back or change what he bought. Thus, the third stage is completed.

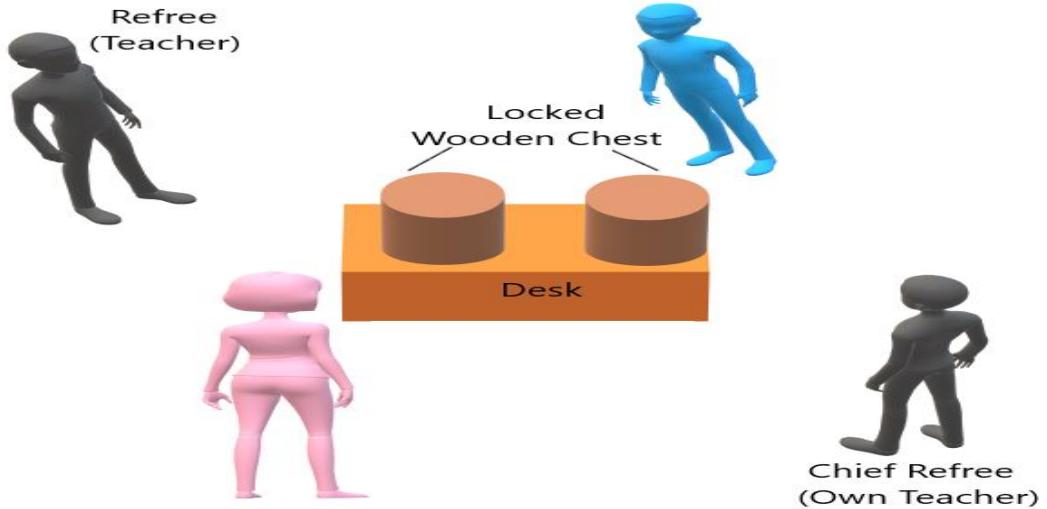


Figure 4. CFK Survivor stage 3

In the 3<sup>rd</sup> stage, which is shorter than the other stages, panic or excitement to find and unlock the right wooden chest, which is suitable for the key, can cost her/him time. So, this may cause a disadvantage in the fourth stage.

### 3.4. Gameplay of stage 4

With the wooden blocks, the players come to the temperature units' panel without stepping the alignment band on the floor, touching the board or the table as in Figure 5.

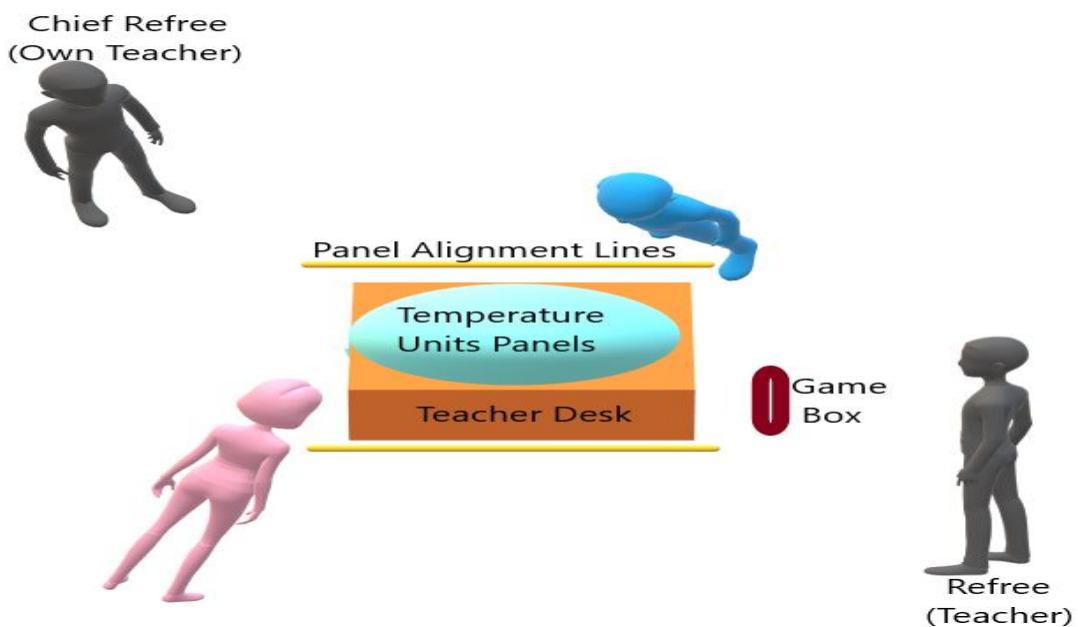


Figure 5. CFK Survivor stage 4

The players place the wooden blocks in the appropriate gap of the 20 spaces in the temperature units' panel as shown in Figure 6. The player thinking, she/he has placed the wooden block in the correct gap on the board, lifts up the group's icon-colored handkerchief. If the gap where the block is placed is correct after the referee check, the referee whistles 3 times and the first round is finished.

If the wooden block is not placed correctly on the board, the referee whistles twice and the player is given a second chance to find the right gap. So, if it is true, the referee whistles 3 times and the player becomes the winner of the round. However, if she/he doesn't place it correctly again, the referee whistles 2 times and the player is given the third and last chance. If the gap in her/his last chance is correct, the referee whistles 3 times and she/he becomes the winner of the round. But if it is not correct, the player failing to use all 3 chances, is eliminated from the game.

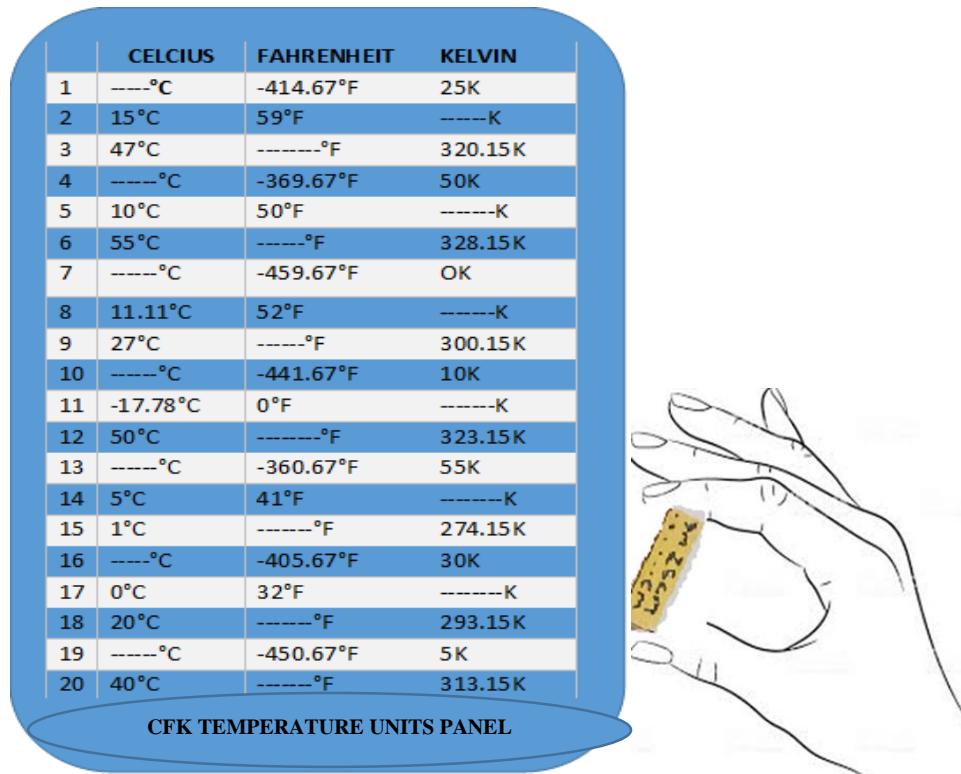


Figure 6. Placing the wooden block in the temperature units' panel

Therefore, the player finishing the fourth stage first wins that round and is given 1 bottle cap in the icon color of her/his group (no cap is given to the player who finishes the game in second place or fails to finish). The winners of the first 9 rounds are given 1 bottle cap in the group's icon color (red or blue), while only the winner in the 10<sup>th</sup> round is given 2 bottle caps. Caps collected as winning the rounds are put in the glass of the group's icon color. At the end of the 10<sup>th</sup> round, the group with the most caps in their glass wins the game.