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EVALUATION OF TPCK USAGE LEVELS IN MATERIALS DEVELOPED WITH STOP MOTION ANIMATION TECHNIQUE[i]

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Abstract:
During the course of their profession, teacher candidates are required to develop course materials in line with their course content. Development of course materials by teachers using their pedagogical content knowledge and technology is highly important in terms of providing an effective learning environment. The aim of the present study was to determine the extent to which science teacher candidates can use their Technological Pedagogical Content Knowledge (TPCK) while developing their course materials with the incorporation of stop motion animations. During the study, the survey method was used as a quantitative research method. The research population consisted of 62 teacher candidates from the Department of Science Teaching at the Manisa Celal Bayar University during the 2015-2016 academic year. The SPSS 18.0 software package was used for data analysis. Suggestions were made based on the results of the study.

Keywords: course material development, science teacher candidates, self-efficacy, stop motion animation, technological pedagogical content knowledge (TPCK)

[i] This paper is based on the first author's master thesis titled as "*Evaluation of Science Teacher Candidates' Technological Pedagogical Content Knowledge on Material Development Process*" under the supervision of the second author.
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1. Introduction

Students in secondary schools experience the concrete operational stage, which is peculiar to this age group as it is one of the cognitive development periods. Children's thought systems are based on perceptible reality as a characteristic of this period.

Therefore, their highly developed mental skills, which become useful with real objects, do not suffice in the cases that require conceptual thinking (Eripek, 2003). Science courses involve numerous abstract concepts including atoms, molecules, heat, temperature and cells, to name a few. Science teachers cannot provide the students with meaningful learning when they fail to concretize these concepts in their minds. Students need to make sense of scientific concepts on the basis of their real and perceptible experiences. In this case, teaching aids, used during education, play an important role. Especially during science education, the availability of various tools, equipment and materials in the classroom environment can be considered as a prerequisite for effective learning. For this purpose, the use of teaching aids is encouraged especially in science courses. The science education program, based on the inquiry-based learning approach of questioning, stipulates the use of easily accessible, cost-effective and user-friendly tools, equipment, materials and teaching aids which do not pose any safety risk during teaching activities (Ministry of National Education (MoNE), 2013).

During the process of teaching-learning, teaching aids are generally used to support teaching. Well-designed teaching aids enrich the teaching process and facilitate learning. The benefits of teaching aids can be listed as follows:

- They are useful in providing the students with their personal needs;
- They provide learning multimedia;
- Draw attention;
- Facilitate remembering;
- Concretize abstract concepts;
- Save time;
- Enable safe observation;
- Provide consistency among different contents presented at different times;
- Are reusable;
- Simplify the content and make them easily comprehensible (Yalın, 2008).

According to Hackbarth (1996), teaching aids and materials enrich the learning environments, hold the students' attention and motivate them to learn and enable associating previously acquired information to newly learned ones. They also enable students to make connections between the course and real life, allow them to access information and analyze it and help to perceive the information and the outside world, in addition to supporting personal education. The use of teaching aids and materials in education plays an important role in helping the students to reach the goals set for them and in the accomplishment of the conducted education program by providing an effective environment for education. The use of teaching aids prepared in line with instructional technology principles holds great importance (Yanpar-Şahin & Yıldırım, 1999). Material use is also vital during education for the success of science education programs (Karamustafaoğlu, 2005). Science education programs adopt the issue of raising concern about individual differences as a principle. Teaching aids and materials, chosen in consideration of students' individual differences and used in accordance with the characteristics of the subject, will arouse the interest of the students and increase their level of engagement through a more efficient use of time (Öztürk, 2002), resulting in effective learning being accomplished. Teachers need to design effective and interactive learning environments to provide the individuals with skills such as scientific literacy, critical thinking, problem-solving and hypothetical thinking. Acquisition of such skills is possible through the use of modern technological means for an enriched education, in addition to the use of textbooks.

In theory, there is an assumption that the use of materials supports learning; however, in some cases students fail the course despite the use of teaching aids during education. This is generally ascribed to the selection of wrong materials and applications or attributed to the personal experiences of teachers. It is not an easy task for several teachers and teacher candidates with limited experience, to attain the ability to choose appropriate materials and effectively use them during their courses (Yetkin-Özdemir, 2002). Teachers become effective in preparing, developing and utilizing educational materials to the extent that they improve themselves in such areas (Gömleksiz, Kan & Serhatlıoğlu, 2010). In the age of technology, materials are present as virtual objects rather than being tangible. The integration of technology with the process of searching-questioning adopted by science education, is accomplished by taking into account the technological means possessed by schools, teachers and students (MoNE, 2013). The most common multimedia applications used with this integration involve blogs, wikis, social networks, web presentations, online file sharing systems, drawing, animations and video-making tools. Stop motion animation is one of these animation tools.

1.1 Stop motion animation

Animation is the frame-by-frame photographic process in which the illusion of movement is created (Judge & Hertzfeldt, 2004; Santucci, 2009; Selby, 2009). Stop motion animation exists in two-dimensional and three-dimensional forms (Furniss, 2008; Taylor, 1996; Wells, 2006). Two-dimensional drawings, images, typeface, and collage materials can be photographed and animated; in addition, three-dimensional materials like clay, LEGOs, toys, puppets, people, and household items can be photographed sequentially and animated (Furniss, 2008; Purves, 2010; Taylor, 1996; Wells, 2006).With stop motion animation, unanimated objects are demonstrated as if they are in motion (Yurdigil & Zinderen, 2011). "Stop motion" animated movies are shot with characters designed as animation models on the movie stages made up of fabricated models (Gergin, 2015). Stop motion animation is a genre, in which physical and stationary objects are demonstrated as if they are in motion. In this technique the camera is adjusted to aim at the objects to photograph a single frame. Afterwards each object is incrementally moved to shoot another single frame to obtain a set of frames that demonstrate the objects as if they are in motion, as they are displayed in a fast sequence (24 frames per second). Accordingly, the shooting of the film is accomplished following the montage of the scenes. Basically, this technique resembles the animated cartoon technique; but in stop motion animation, real three dimensional objects, puppet models and real stage designs are used (Sözen, 2012). Since the stop motion animation used for material preparation, is based on the photograph sequencing principle, any individual with a device that is capable of framing the moment (tablet, smart phone, camera, etc.) can easily design new materials using his/her imagination.

Shulman (1987) suggested that teaching proficiencies should include the types of knowledge such as content knowledge, pedagogical knowledge and pedagogical content knowledge. Pedagogical content knowledge (PCK), which was added to the literature by Shulman (1986), is a special combination of content knowledge and pedagogical knowledge. In addition to Shulman's (1987) pedagogical content knowledge concept, Mishra and Koehler (2006) introduced technological knowledge, establishing the framework of Technological Pedagogical Content Knowledge. Science teacher candidates are supposed to have TPCK to provide effective science teaching during the course of their professional lives. During this period, teacher candidates are required to reflect their TPCK in the materials that they develop. In this respect, the present study was conducted in an attempt to determine the extent to which teacher candidates can use their self-efficacy on TPCK while developing materials.

2. Methodology

2.1. Research Model

In this study, carried out to evaluate science teacher candidates' self-efficacy on their technological pedagogical content knowledge, the survey method was used as a quantitative research method. The survey method is a research method by which the opinions of participants on a specific subject or event, or their interests, skills, behaviors etc. are determined. This method is applied to relatively larger samples when compared with other methods (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz & Demirel, 2016).

2.2. Study Group

The study group consisted of 62 teacher candidates in the 3rd grade of the 2015-2016 academic year in the Department of Science Education from Manisa Celal Bayar University.

2.3. Data Collection Tools

Three types of data collection tools were used during the research.

2.3.1. TPCK Self-Efficacy Scale of Science Teacher Candidates regarding the Subject of Material Development

The Technological Pedagogical Content Knowledge (TPCK) self-efficacy scale of science teacher candidates on the subject of material development developed by Balçın and Ergün (2016), was used during the study. The scale was a Likert-type scale with 5 choices and it consisted of 40 items involving eight factors: [*TPCK* (*Technological Pedagogical Content Knowledge*), *TK* (Technological Knowledge), *CKSBS* (Content Knowledge of Sub-Branches of Sciences), *PK* (Pedagogical Knowledge), *CKMBS* (Content Knowledge on Main-Branches of Sciences), *PCK* (Pedagogical Content Knowledge), *TCK* (Technological Content Knowledge), and *TPK* (Technological Pedagogical Knowledge). The KMO (Kaiser-Mayer-Olkin) value of the scale was (.94) and the internal consistency-related Cronbach's alpha value for all 40 items was (.93).

2.3.2. Graded Scoring Key for TPCK Assessment during the Material Preparation Process

The graded scoring key, developed by Balçın (2016) to determine the *TPCK* usage level of teacher candidates during material development, was used during the study. The structural validity of the criteria for *TPCK* and its sub-dimensions was ensured through consulting with six content experts, one teaching technologies and material design expert and one linguist. The form was finalized in line with consultations, and a scaled scoring key, consisting of 34 criteria and 5 grades related with the *TPCK* and its 6 sub-dimensions (*CK, PK, TK, PCK, TCK, TPK*), was established.

2.3.3. Material Assessment Form

The material assessment form, developed by Balçın (2016) was used in the study. The criteria for the material to be prepared by stop motion animation were determined primarily in consideration of the pedagogical knowledge that teacher candidates are supposed to possess for material development, and the scale developed for the current research. Another factor, taken into consideration during determination of the criteria for the developed form, was the properties of the developed material. The form was modified and corrected in line with the opinions of six content experts, one teaching technologies and material design expert, and one linguist, and accordingly it was finalized with 31 items and likert type scales with five choices.

2.3.4. Materials Developed by Teacher Candidates

During the research, science teacher candidates were divided into groups and asked to build scenarios and design materials with stop motion animation, by use of the outcomes they received in the Teaching Technologies and Material Design course. The information regarding the content of materials prepared by the groups using stop motion animation is given in Table 1. Some of the designed materials are given in Appendix 1.

Table 1: The grade levels and outcomes of the materials developed with stop motion animation

Group code	N	Outcomes	Grade level
G1	1	Solar system and beyond	7
G2	2	Sense organs	7
G3	3	Systems in our body	7
G4	4	Changes of state	5
G5	5	The systems in our body	6
G6	5	The systems in our body	6
G7	4	Human-environment relationships	7
G8	4	Changes of state	5
G9	2	Earth, Moon and Sun as our life source	6
G10	4	The systems in our body	7
G11	2	The structure and properties of matter	8
G12	4	Living creatures and life	5
G13	3	Understanding matter and the changes of state	5
G14	3	Human-environment relationships	7
G15	2	The systems in our body	6
G16	2	The systems in our body	6
G17	4	Solar system and beyond: The riddle of space	7
G18	2	Solving the riddle of our body	5
G19	2	The systems in our body	7

G20	3	Cellular division and inheritance	8
G21	1	Human-environment relationships	7

Note: N= Number of students

2.5. Data Analysis

2.5.1. Analysis of Data Obtained From the *TPCK* Self-Efficacy Scale of Science Teacher Candidates on the Subject of Material Development

The SPSS (Statistical Package for the Social Sciences) 18.0 software package was used in the analysis of the quantitative data obtained from the scale of the current study. Mean scores were used to evaluate the *TPCK* self-efficacies of the teacher candidates participating in the study group. The score groups, assigned for this scale, are listed in Table 2.

Table 2: The score groups for evaluation of TPCK self-efficacy mean scores of science teacher candidates on the subject of material development

Dimensions	Very low	Low	Medium	Good	Very good
CKMBS	3-5.4	5.41-7.8	7.81-10.2	10.21-12.6	12.61-15
CKSBS	4-7.2	7.21-10.4	10.41-13.6	13.61-16.8	16.81-20
PK	9-16.2	16.21-23.4	23.41-30.6	30.61-37.8	37.81-45
TK	7-12.6	12.61-18.2	18.21-23.8	23.81-29.4	29.41-35
PCK	5-9	9.1-13	13.1-17	17.1-21	21.1-25
TCK	3-5.4	5.41-7.8	7.81-10.2	10.21-12.6	12.61-15
TPK	2-3.6	3.61-5.2	5.21-6.8	6.81-8.4	8.41-10
TPCK	7-12.6	12.61-18.2	18.21-23.8	23.81-29.4	29.41-35
Overall scale	40-72	72.1-104	104.1-136	136.1-168	168.1-200

As shown in Table 2, the group with the lowest mean score is indicated by "very low" which is followed by "low'', "medium", "good" and "very good" according to their respective means scores.

2.5.2. Analysis of the Data with Graded Scoring Keys Obtained to Measure the *TPCK* during Material Preparation

Materials developed by the 62 teacher candidates were evaluated using this graded scoring key. The Likert-type scale defined in this stage are: "I absolutely agree" (5) points, "I agree" (4) points, "I am indecisive" (3) points, "I do not agree" (2) points, and "I do not agree at all" (1) point. Total scores were obtained on assessment of the materials developed by the teacher candidates.

The results obtained from the *TPCK* graded scoring key were specified as total scores. The minimum possible score was defined as 34 and the maximum possible score was defined as 170. Materials were evaluated by two researchers, and the mean scores were separately evaluated for each item of the assessment tool. The score groups of *TPCK* graded scoring key, developed for evaluation of the materials designed by science teacher candidates, are given in Table 3.

Table 3: Score groups for evaluation of the mean scores of TPCK graded scoring key

Dimensions	Very low	Low	Medium	Good	Very Good
CK	3-5.4	5.41-7.8	7.81-10.2	10.21-12.6	12.61-15
PK	6-10.8	10.81-15.6	15.61-20.4	20.41-25.2	25.21-30
TK	3-5.4	5.41-7.8	7.81-10.2	10.21-12.6	12.61-15
PCK	9-16.2	16.21-23.4	23.41-30.6	30.61-37.8	37.81-45
TCK	4-7.2	7.21-10.4	10.41-13.6	13.61-16.8	16.81-20
TPK	3-5.4	5.41-7.8	7.81-10.2	10.21-12.6	12.61-15
TPCK	6-10.8	10.81-15.6	15.61-20.4	20.41-25.2	25.21-30
Total	34-61.2	61.21-88.4	88.41-115.6	115.61-142.8	142.81-170

As seen in Table 3, the group with the lowest score was denoted as “very low”, which was followed by “low”, “medium”, “good” and “very good”, in ascending order.

2.5.3. Analysis of the Data Obtained From the Material Assessment Form

The materials designed by the 62 teacher candidates were evaluated with this form. The specified Likert-type scales are: “I absolutely agree” (5) points, “I agree” (4) points, “I am indecisive” (3) points, “I do not agree” (2) points, and “I do not agree at all” (1) point. Total scores were obtained by assessment of the materials designed by the teacher candidates. The least possible score was 31 and the maximum score was 155. The materials were assessed by two researchers, and mean values were calculated for each item in the assessment tool. The results obtained from the material assessment form were specified as total scores. The score groups in Table 4 were used to determine the extent to which teacher candidates reflected their *TPCK* on the materials that they developed.

Table 4: Score groups for evaluation of the mean TPCK scores obtained from the material assessment form

	Very low	Low	Medium	Good	Very good
Material *TPCK* score	31-55.8	55.81-80.6	80.61-105.4	105.41-130.2	130.21-155

2.5.4. Evaluation of the Materials Developed by the Teacher Candidates

The materials prepared by 21 groups comprising the 62 teacher candidates in the Teaching Technologies and Material Design course, by use of stop motion animation, were evaluated by two researchers using the *TPCK* graded scoring key and the material assessment form. The number of students in the evaluated groups, average *TPCK* self-efficacy score, the assessment scores and levels of the materials were compared.

3. Results

3.1. The Results for the TPCK Self Efficacy Levels of the Science Teacher Candidates on the Subject of Material Design

An answer was sought for the question: *"What is the TPCK self-efficacy level of science teacher candidates on the subject of material development?"* Average scores, standard deviations, minimum and maximum scores for 8 sub-dimensions, that define the *TPCK* self-efficacy levels of teachers on the subject of material development, are given in Table 5. The score groups in Table 2 were taken as a basis for evaluation of the mean scores.

Table 5: TPCK self-efficacy levels of science teacher candidates on the subject of material development

Dimensions	$\overline{X}$	S	Minimum	Maximum	Level
CKMBS	12.42	1.90	3.00	15.00	Good
CKSBS	14.25	3.37	4.00	20.00	Good
PK	37.15	4.93	9.00	45.00	Good
TK	27.28	5.20	7.00	35.00	Good
PCK	21.62	2.93	5.00	25.00	Very good
TCK	10.99	2.48	3.00	15.00	Good
TPK	8.61	1.41	2.00	10.00	Very good
TPCK	28.97	4.66	7.00	35.00	Good
Overall scale	161.28	18.42	40.00	200.00	Good

Note: $\overline{X}$=Mean; S=Standard deviation

As shown in Table 5, the sub-dimensions of the *TPCK* self-efficacy scales of science teacher candidates on material development, were evaluated as: *CKMBS* ($\overline{X}$ = 12.42) "good"; *CKSBS* ($\overline{X}$ = 14.25), "good" ; *PK* ($\overline{X}$ = 37.15), "good"; *TK* ($\overline{X}$ = 27.28), "good"; *PCK* ($\overline{X}$ = 21.62), "very good"; *TCK* ($\overline{X}$ = 10.99), "good"; *TPK* ($\overline{X}$ = 8.61), "very good"; *TPCK* ($\overline{X}$ = 28.97), "good"; and overall scale was evaluated as ($\overline{X}$ = 161.28), "good".

3.2. The Results Obtained From the Graded Scoring Key for Assessment of *TPCK* during Material Development

An answer was sought for the question: "*To what extent can the science teacher candidates use their TPCK self-efficacies while developing their materials?*" The results, obtained from *TPCK* graded scoring key, are shown in Table 6.

Table 6: The results obtained from the TPCK graded scoring key

Dimensions	$\bar{X}$	Minimum Score	Maximum score	Level
CK	11.28	7.5	15	Good
PK	23.11	18	29.5	Good
TK	14.30	11	15	Very good
PCK	35.34	27	45	Good
TCK	15.80	10.5	19.5	Good
TPK	14.25	10.5	15	Very good
TPCK	24.52	16	30	Good
Total score	139.53	103.00	169.00	Good

Note: $\bar{X}$=Mean

As indicated by the results given in Table 6, and based on the data given in Table 3, *TPCK* self-efficacy usage levels of teacher candidates during material design, were found to be at a the "good" level in the *CK, PK, PCK, TCK* and *TPCK* dimensions, whereas it was found to be at a "very good" level in the *TK* and *TPK* dimensions.

3.3. The Results Obtained From the Material Assessment Form

The results based on the scores obtained from material assessment form, are given in Table 7.

Table 7: The results obtained from the material assessment form

	$\bar{X}$	Minimum score	Maximum score
Score	129.81	91.50	154.00

Note: $\bar{X}$=Mean

As indicated by the results, given in Table 7, and based on the data given in Table 4, the teacher candidates were found to have developed their materials at a "good" level.

3.4. Results for Correlation

The results of the correlation between the total score for the *TPCK* self-efficacy scale of teacher candidates for material development, and the *TPCK* graded scoring key total score are given in Table 8.

Table 8: The correlation between the total score obtained from the scales of teacher candidates and the total scores of the TPCK graded scoring key

		Scale total score	**TPCK graded scoring key total score**
Scale total score	Pearson correlation coefficient	1	.066
	p		.602
	N	62	62

Note: p=Significance value; N=Number of students

According to the results given in Table 8, there is no statistically significant relation between the *TPCK* self-efficacy scores of the science teacher candidates on the subject of material development and the scores obtained upon TPCK-based evaluation of the materials ($p > .05$). The results for the correlation between the scores obtained from the teacher candidates' scales, and the total score obtained from the material assessment form are given in Table 9.

Table 9: Correlation between the total score obtained from the teacher candidates' scales, and the total score obtained from the material assessment form

		Scale total score	**Total score from material assessment form**
Scale total score	Pearson correlation coefficient	1	.090
	p		.476
	N	62	62

Note: p=Significance value; N=Number of students

According to the results given in Table 9, there is no statistically significant relation between the *TPCK* self-efficacies of the science teacher candidates on the subject of material development, and the scores they received from the materials they developed ($p > .05$).

3.5. Comparison of the Results Obtained From All Data Collection Tools

The group and total score-based comparisons of the results obtained from all data collection tools are given in Table 10.

Table 10: Comparison of group materials based on the data obtained from data collection tools

Group code	**N**	***TPCK* self-efficacy scale total score**	**Scale score level**	**Material assessment form score**	**Material assessment form score level**	***TPCK* graded scoring key score**	***TPCK* graded scoring key score level**
G1	1	169	Very good	125	Good	149.50	Very good
G2	2	168.50	Very good	113	Good	119.50	Good
G3	3	159.03	Good	132	Very good	141.50	Good
G4	4	164.50	Good	91.50	Medium	103	Medium
G5	5	151.22	Good	128	Good	132	Good
G6	5	164.74	Good	154	Very good	169	Very good
G7	4	152.10	Good	135	Very good	131	Good
G8	4	159.75	Good	145.50	Very good	154	Very good
G9	2	150.50	Good	93	Medium	111	Medium
G10	4	162	Good	139.50	Very good	153	Very good
G11	2	167	Good	112	Good	117.50	Good
G12	4	161.48	Good	106	Good	114	Medium
G13	3	162.33	Good	143	Very good	152.50	Very good
G14	3	173.11	Very good	144.50	Very good	158	Very good
G15	2	172.13	Very good	134.50	Very good	150.50	Very good
G16	2	157	Good	139.50	Very good	159	Very good
G17	4	157.50	Good	146	Very good	148	Very good
G18	2	156	Good	144	Very good	156.50	Very good
G19	2	164.50	Good	125	Good	134	Good
G20	3	147.33	Good	115	Good	130	Good
G21	1	167.26	Good	145	Very good	163	Very good

Note: N=Number of students

As indicated by the results obtained from all data collection tools, TPCK self-efficacies of teacher candidates and the corresponding level of the materials developed by them varied, as in the case of the group with "very good" TPCK self-efficacy level which developed "good" materials, or in the case of the group with "good" TPCK self-efficacy level which developed "very good" materials, or in the case of the group with "good" TPCK self-efficacy level which developed "medium" materials. There were cases in which the corresponding level of the materials developed by the teacher candidates matched and did not match with their self-efficacy levels.

4. Discussion, Conclusion and Recommendations

In the present study, which was carried out to determine the extent to which science teacher candidates used their technological pedagogical content knowledge while developing materials with stop motion animation, the teacher candidates were found to be at a "very good" level for the *TPK* and *PCK* sub-dimensions, and at a "good" level for the *CKMBS, CKSBS, PK, TK, TCK, TPCK* sub-dimensions of the *TPCK* self-efficacy scales. Graham et al. (2009) reported that the *TPCK* component with highest self confidence level was *TK,* which was followed by *TPK, TPCK and TCK,* whereas Cox (2008) reported that primary school teachers had strong *TPK* and weak *TCK*. In their study, Taşar and Timur (2010) reported that, science teacher candidates did not have sufficient *TPCK* self-efficacies. In Terpstra's (2009) research, which was conducted to examine the *TK, TCK, TPK*, and *TPCK* developments of teacher candidates, teacher candidates' *TPK* development levels were found to be higher than their *TCK* development levels. Avcı (2014) found that the *TPCK* scale of science teacher candidates was at a "good" level for all sub-dimensions. Timur (2011) reported that the *PK* confidence of teacher candidates were very low, and at a theoretical knowledge level. In the current study, the *TPK* levels of teacher candidates were found to be at a similar level with those reported in the literature.

After the evaluation of the extent to which teacher candidates used their *TPCK* self-efficacies on material development, using the graded scoring key, they were found to be "good" at the *CK, PK, PCK, TCK* and *TPCK* sub-dimensions, and "very good" at the *TK* and *TPK* sub-dimensions. In general, teacher candidates were found to use their technology related knowledge at a very good level while developing their materials, while their deficiency in other sub-dimensions was ascribed to the lack of content knowledge and pedagogical knowledge. The results obtained by the graded scoring key indicated that, the teacher candidates reflected their significant *TCK* self-efficacy on material development as well.

The materials developed by the teacher candidates were evaluated based on the criteria included in the material assessment form, and the developed materials were found to be at a "good" level among the specified levels. Based on the criteria for evaluation of the developed materials, the teacher candidates could not reflect their content knowledge and pedagogical knowledge on the developed materials, although they had "very good" technological knowledge.

As a result of the study no correlation was found between the *TPCK* self-efficacies of the teacher candidates with the *TPCKs* for the materials that they developed. As seen in Table 10, the *TPCK* self-efficacies of the teacher candidates and corresponding level of the materials developed by them varied, as in the case of the group with "very good" *TPCK* self-efficacy level which developed "good" materials, in the case of the group with "good" *TPCK* self-efficacy level which developed "very good" materials, or in the case of the group with "good'' *TPCK* self-efficacy level which developed "medium" materials. There were cases in which the corresponding level of the materials developed by the teacher candidates either matched or did not match with their self-efficacy levels.

In this context, regardless of their *TPCK* self-efficacy levels, all the teacher candidates were supposed to possess *TPCK* skills during the course of material preparation, and to use these skills while designing the materials.

Some of the recommendations proposed in line with the results of this study, are as follows:

- The results of the study indicated that, teacher candidates are able to combine their pedagogical knowledge with their technological knowledge, but they failed to associate their technological knowledge with their content knowledge. Accordingly, it was concluded that, the teacher candidates' *TPCK* self-efficacies were not at a "very good" level, and they failed to reflect these skills in the materials that they designed. In this respect, the teacher candidates are required to draw upon technology in content courses during their undergraduate education, and to associate their improved *TCK* with their pedagogical knowledge with a view to reflect them upon the materials that they designed. The content of the courses such as Special Teaching Methods I-II and Teaching Technology and Material Design should be reorganized in line with *TPCK*, and technologically aided classrooms should be established in faculties of education (Babacan, 2016).
- Teacher candidates should be provided with technological materials or aided with the use of techniques (such as stop motion animation, slow motion animation, etc.) while developing their teaching aids.
- Projects could be launched to improve the *TPCK* self-efficacies of teacher candidates on material development.
- Teacher candidates could be allowed to develop interactive teaching models for their *TPCK* development.
- Use of smart phone applications by teacher candidates could be encouraged for improvement of their *TPCK*.

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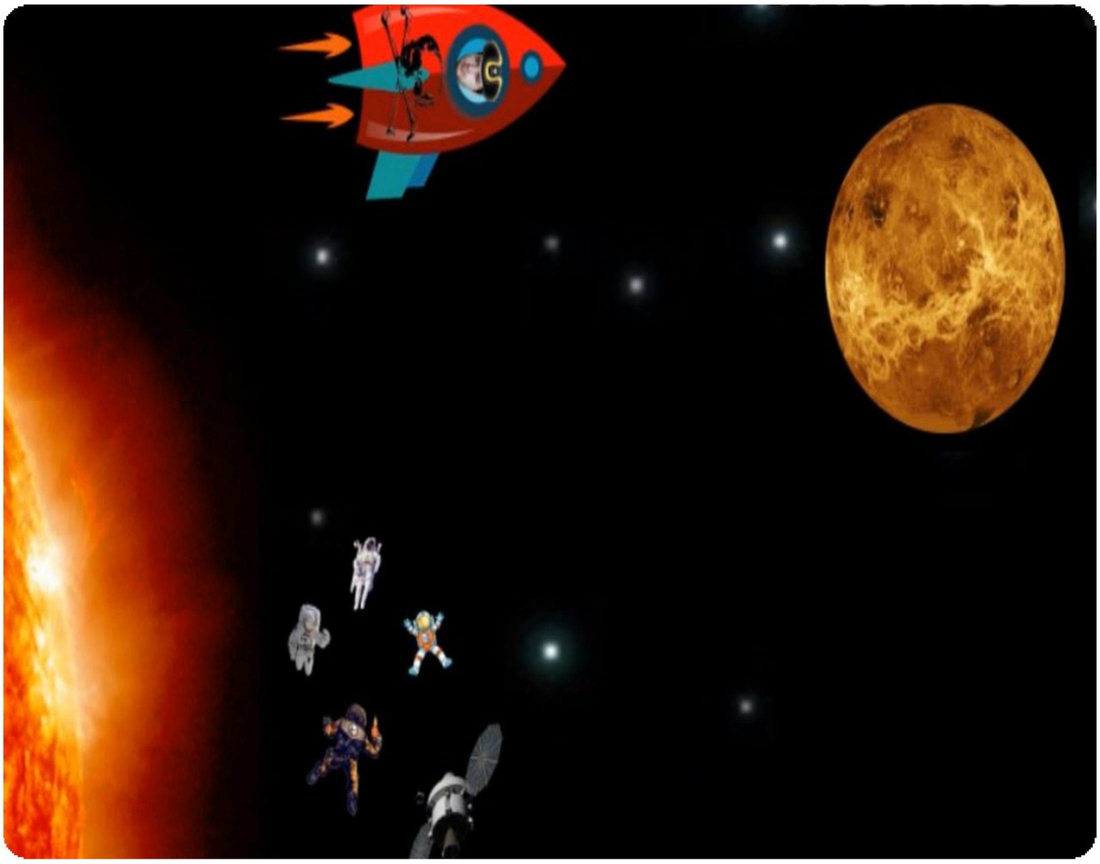
6. Appendices

Appendix 1: Some of the Materials Prepared by Teacher Candidates Using Stop Motion Animation.




Böö!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