Journal of Turkish Science Education, 2022, *19*(1), 288-305.
DOI no: 10.36681/tused.2022.122

Journal of Turkish Science Education
http://www.tused.org
© ISSN: 1304-6020

Investigating the 21st -Century Skills of Undergraduate Students: Physics Success, Attitude, and Perception

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ABSTRACT
This study was performed to figure out the relationship between undergraduate students' 21st-century skills (21CSs), physics academic achievements, attitudes towards physics, and perceptions of physics teaching and learning. The study was carried out with 329 undergraduate students who had taken physics courses from Architecture-Engineering, Education, and Health Sciences Faculties. For collecting data of the study, "Scale of Attitude towards Physics", "Scale of Perception Related to Physics Teaching and Learning" and "Malaysian 21st-Century Skills Instrument" which had adapted into Turkish, were applied to the undergraduate students. Before conducting statistical analysis, the homogeneity and normality tests were applied to the obtained data. All descriptive data of the study which collected using on-line questionnaire form were analyzed by frequency, mean, and percentage. The relationship between variables was analyzed using multiple linear regression testing, as well. Based on the statistical analysis carried out on the obtained data, significant relationship wasn't found between the 21CSs of undergraduate students and their physics success. Contrary to this result, a significant relationship was determined between undergraduate students' 21CSs and their attitudes toward physics, and their perceptions related to physics teaching and learning. Since positive attitudes and perceptions towards physics have positive effects on physics course success, it can be stated that undergraduate students' 21CSs indirectly affect the physics success of undergraduate students.

ARTICLE INFORMATION
Received:
08.04.2021
Accepted:
23.11.2021

KEYWORDS:
Undergraduate student, physics success, 21st-century skills, attitude, perception.

Introduction

Physics is a fundamental science which tries to explain what happens in the environment around us ranging from the fundamental particles to the border of the Universe. Physics education has a crucial importance in higher education (Erkilic, 2020). Regardless of the field of the study, physics has very crucial importance for all basic sciences such as engineering, health, and even social sciences. Physics can be encountered in all areas of life, in natural events in daily life, and in all engineering applications that facilitate our daily life. Developments in the science of physics have an important impact on improvement in different fields of natural sciences, such as biology, medicine, chemistry, astronomy, and engineering (Caliskan, 2007). Therefore, having sufficient knowledge of basic physics subjects will help each individual to understand the events happening around him and produce solutions to the problems he encounters. The developments of physics in the 21st -century have increased technological developments as well. Thus, physics is a key science that enables technological advances (Fishbane et al., 2003). The study carried out by the "European Physical Society" has shown that physics has an important and great effect on the world economy. According to this study, the effects of industrial applications which include physics and physics-based applications on the European economy between 2011 and 2016 can be summarized as follows (Voss et al., 2019):

- *The total revenue of physics-based industries in Europe was € 4.40 trillion each year for the period 2011-2016.*
- *Physics-based industries accounted for 16% of the total turnover of the European business economy.*
- *In 2014, the number of people working in physics-based industries in European countries were 17 million.*

Although the science of physics has such an important place in our daily life, physics has been defined as one of the least popular, most difficult, and a boring lesson that has many abstract equations to be memorized (Oyoo, 2012; Saleh, 2012; Taslidere & Eryilmaz, 2012). Besides, the international exams such as the "Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) show that the science and physics successes are still low, and decrease day by day (Suna et al., 2019; Ullis et al., 2016). Also, it is stated that enrollment in introductory physics courses at the university decreases as well (Council, 2001; Erkilic, 2020). Some factors decreasing students' physics success are related to instructors, insufficient course materials, students, curriculum, insufficient laboratory facilities, economic inadequacies, and insufficient mathematics infrastructure (Vilia & Candeias, 2020; Vysoká & Smetanová, 2016). Except for these factors, it is seen that negative attitudes and perceptions towards science, and physics courses play an important role in students' successes in these fields (Aydin & Cekim, 2017; Erinosho, 2013; Kaur & Zhao, 2017; Veloo et al., 2015). Studies conducted at the primary, secondary, and high school levels show that students' positive attitudes and perceptions towards a course contribute positively to students' success, while their negative attitude and perception negatively affect their success (Ali & Awan, 2013; Bowles-Terry, 2012; Prensky, 2005; Soh et al., 2010). The acquisition of basic science skills is not enough for students to be creative problem-solvers to transfer their knowledge to real-world situations, to generate innovative ideas, and use various resources to face the challenges of modern life. In 21st-century, in parallel with technological developments, the abilities expected from people differ in skills. The skills expected to be found in people in 21st-century are researched by different scientists (Atalay & Anagun, 2016; Binkley et al., 2012; Kan'An, 2018; Lemke, 2002; Murat, 2018). Individuals should be able to use mass media and educational technologies, follow social media, communicate with their environment, and solve problems to find jobs easily, to be successful, and to be happy individuals in information age of 21st-century. Also, they should be able to transfer their knowledge to other fields, open to innovations, aware of their responsibilities, fully self-confident, respectful to themselves and their environment. These skills which should be found in individuals have been defined as "21st-Century Skills (21CSs)" (Murat, 2018). However, an internationally accepted definitive classification of the skills expected from people in the 21st-century has not been made yet. When the relevant literature is examined, the most accepted 21CSs could be given as follows; Inventive Thinking (IT), Effective Communication (EC), High Productivity (HP), Digital Age Literacy (DAL), and Spiritual Values (SV) (Osman et al., 2010).

When the related literature reviewed, it could be seen that many studies about different subjects related to 21CSs, attitude, and perception towards physics, were conducted by various researchers (Pagani et al., 2016; Soh et al., 2010; Zirak & Ahmadian, 2015). When we review the studies in the domestic and international literature, it is seen that studies are generally conducted with primary, secondary, and high school students and teachers. On the other hand, only researches on teacher candidates in the faculty of education are conducted at the university level. In this context, researching the development levels of 21st- century skills of engineer candidates and physiotherapist candidates for the first time at the university level is of great importance in higher education. In addition, the effect of 21CSs on undergraduate students' physics success has not been researched yet. Also, the studies which examined the relationship between students' 21st-century skills, attitude, and perception toward physics are limited to undergraduate level. Therefore, this study is aimed to figure out whether there is a relationship between undergraduate students' 21CSs, their physics success, attitudes, and perceptions towards physics or not.

Literature Review

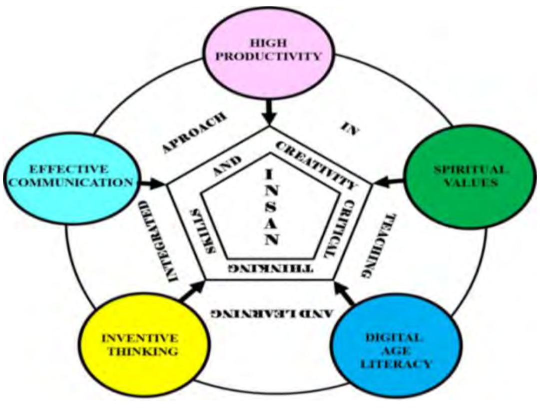
The 21st-century skills (21CSs)

The behaviors and knowledge expected from students in societies have changed compared to the past. Improvements in the 21st-century have significant effects on the education systems, international relations, economic issues, politics, and sports worldwide. The 21st-century's individuals should desire to learn something new and have some skills such as problem-solving, group working and critical thinking, etc. (Alhabahba et al., 2016; Soh et al., 2010; Stuart, 1999). In the 21st-century, students should not be only evaluated on the basis of their answers to test questions. Besides, 21st-century skills such as problem-solving skills, entrepreneurial spirit, and creativity skills should also be evaluated (Soh et al., 2010). 21CSs will be a great support for individuals to survive the challenges of this information age. However, the rigorous definitions and determination methods of 21CSs have not been introduced yet (Agaoglu & Demir, 2020; Barasi & Erdamar, 2021; Cansoy, 2018; Eryilmaz & Uluyol, 2015; Geisinger, 2016; Yavuz et al., 2020). Different scientists (Atalay & Anagun, 2016; Kan'An, 2018; Lemke, 2002; Osman et al., 2010; Vilia & Candeias, 2020; Yavuz et al., 2020; Zorlu & Zorlu, 2021) and some organizations such as International Society for Technology in Education (ISTE), World Economic Forum (WEF), Assessment and Teaching of 21st-Century Skills Framework (ATSC21), Partnership for 21st-Century Skills (P21), The North Central Regional Educational Laboratory (NCREL), American Association of Colleges and Universities (AACU), and METIRI Group have tried to define 21CSs and their assessment rules (Cansoy, 2018). Lemke (2002) has defined 21CSs in four main categories as; IT, EC, HP, and DAL in the project supported by NCREL and METIRI Group. In another project supported by Cisco, Intel, and Microsoft was conducted by Binkley et al. (2012), 21CSs were grouped into four categories as well. Binkley et al. (2012) have organized ten skills and categorized them into four categories. These categories are as follows: Ways of Thinking, Ways of Working, Working, Living in the World.

Alternatively, Osman et al. (2010) were conducted a study which was based on NCREL and METIRI Group's project conducted by Lemke (2002). Osman et al. (2010) have formed "Malaysian 21st-Century Skills Instrument (M-21CSI)" as a part of this study. The 21CSs were categorized into five categories given in Figure1. The spiritual values (SV) category was added to the categories introduced by Lemke (2002).

Figure 1

The Five Categories of "21st-Century Scale Instrument"



Note. (Osman et al., 2010)

Also, Kan'An (2018) was presented a study which was based on the "M-21CSI" of Osman et al. (2010). However, Kan'An (2018) has decreased 5 categories to 3 main categories after conducting statistical analysis. When a general analysis is conducted on these presented studies, it could be stated that the 21CSs are skills that help people to become active, productive, and adaptable persons in the 21st-century (Kan'An, 2018; Kyllonen, 2012; Soh et al., 2010). This study was performed based on the five categories introduced by Osman et al. (2010).

The 21CSs, Affective Characteristics, and Physics Education

Many studies which aimed to determine students' skills required to overcome the challenges in the 21st-century have been performed for two decades (Amin et al., 2020; Kan'An, 2018; Lemke, 2002; Soh et al., 2010; Teo, 2019). Improvements in modern society depend on advanced technology. Physics courses are critical not only for students who want to specialize in physics but for all undergraduate students in higher education, including those who specialize in the arts and humanities (Council, 2001). Many applications were developed by physicists in every field of natural science and engineering (For example, transistors which are semiconductors were developed by physicists. These transistors have been used in many electronic systems including mobile phones, computers, televisions, and space ships, etc.). Graduates of the physics department who have problem-solving skills can work in different technical fields, especially new fields that have not yet turned into an engineering field.

As it was stated before, physics forms the basis of many fields, especially engineering sciences and health sciences. The introductory physics courses are crucial for obtaining a 21st-century workforce, and for encouraging scientific literacy. Reviewed studies which showed significant relationships between thinking skills (Niaz et al., 2000; Zirak & Ahmadian, 2015), digital literacy (Pagani et al., 2016), and academic achievement, indicate that undergraduate students should have 21CSs to be successful both in higher education and post-graduation. Therefore, it can be stated that a good knowledge of physics can help the development of 21CSs of students while the development of 21CSs can increase their physics success as well. This idea was proven by the study conducted by Silva (2009). It was explained that 21CSs help students to think critically, to make a decision, to solve the problem, and to think innovatively (Silva, 2009).

Considering physics and its contribution to our daily life, physics is an interesting and enjoyable science. As it was pointed before, it is the basis of many new inventions and an integral part of our daily life. According to students, a large number of subjects included in the physics curriculum and the insufficient content of the methods applied in the physics course, weekly physics course hours, and physics textbooks make it difficult to understand and learn physics topics (Alptekin et al., 2009). Academic achievement is indirectly and directly related to many factors. Affective factors such as students' attitudes and perception towards physics lessons also affect physics education (Kan & Akbaş, 2005).

Students' ability to acquire desired behaviors is closely related to their readiness to learn. One of the basic requirements of being ready to learn is the attitude towards the lesson. Motivation and attitude towards any lesson are important for permanent learning in physics. Emanovský and Gonda (2020) stated that information related to students' attitudes can give some predictions about the teaching process. Alpaslan (2019) stated that appreciating students' views on physics learning would increase students' motivation to learn physics. Therefore, ignoring affective variables such as attitude prevent learning at desired level (Tay & Tay, 2006). Another effective factor that affects learning in physics courses is perception. The perception about teaching and learning physics is defined as intention of the student to discover physics teaching and learning (Osman et al., 2010). The students' perceptions of teaching and learning physics explain their views, and ideas related to teaching and learning physics, whether at school or outside of the school. The relationship between physics success, attitudes (Ali & Awan, 2013), and perceptions (Soh et al., 2010) has been investigated for a long time. Numerous studies have been conducted related to the content and effect of 21CSs. Magno (2003) was figured out that if students have a positive attitude towards physics, they get higher physics grades.

According to Zorlu and Zorlu (2021), improved 21st-century learning skills, could obtain better learning. Eryilmaz and Uluyol (2015), investigated the relationship between 21CSs and FATIH Project. They have figured out that there are direct and indirect relations between 21st–century skills and FATIH Project. They indicated that observing 21CSs in development of existing e-contents and preparation of new e-contents can help FATIH project to reach its goal while providing individuals with 21CSs.

Pana and Escarlos (2017) tried to figure out the effectiveness of contemporary teaching strategies in developing students' attitudes, academic success, and acquisition level of the 21st-century learning skills among seventh grade students. Their results revealed a significant difference between attitude towards learning, academic success, and acquisition of the 21CSs of research groups.

Cansoy (2018) reviewed many reports and studies that have tried to define 21CSs that individuals should acquire. He determined that 21CSs are defined as basic skills in different numbers by different institutions and researchers.

In another study by Colak (2019), the self-efficacy perception levels of science teacher candidates towards 21CSs and the contribution levels of various variables such as university, faculty, undergraduate program and academicians to 21CSs were investigated. As a result of the research, it has been determined that the contribution level of university, undergraduate program, faculty, and academicians to 21CSs are generally at a medium level.

Bao and Koenig (2019) prepared a synthesis about the literature of twenty-first Century skills and physics education. It was tried to define education and research goals that are suggested for future researches in their research. Also, they have given some implications about possible effects of these suggestions on the next generation physics courses.

In research conducted by Agaoglu and Demir (2020), integration of 21CSs into the Turkish National Education system was evaluated based on an activity called "Where are we?" In this research, importance of the activity conducted with fourth-grade students and consisted of preparation, application, and evaluation stages for gaining 21CSs such as creativity, communication, critical thinking, and cooperation to students were emphasized. On the other hand, in this research, the importance of the classroom environment in gaining 21CSs was emphasized, as well.

Yavuz et al. (2020) have investigated the effect of the Science, Technology, Engineering, and Mathematics (STEM) approach on the 21CSs of secondary school students. They carried out a study with 35 students from 7th-grade. As data collection tool, a multidimensional 21CSs scale was applied as pre and post-test. The results of their research showed that the STEM approach has a positive contribution to 21CSs.

Barasi and Erdamar (2021) have carried out a research with 273 teachers of Turkish lesson. They tried to determine main problems during the application of 21CSs as a part of the Turkish secondary school curriculum. As a result of their research, according to Turkish teachers' opinion, the main problems were determined as follows: General, outdated, and repetitive objectives, students' low interest to content, students' lack of problem solving and critical thinking, lack of physical infrastructure of schools, and insufficient examination system to measure 21CSs. Therefore, investigating the affective factors that reduce students' physics success, such as attitude, perception, and their relationship about 21CSs have great importance for solving learning issues in the 21st-century.

Research Questions

The main phenomenon which we focused on was to figure out whether there is an effect of 21CSs on undergraduate students' physics success, attitudes, and perceptions related to physics teaching and learning or not. We are interested in figuring out the relationship between these variables. The research questions we have determined for these purposes are as follows: How is the improvement level of 21CSs of undergraduate students? Is there a significant effect of 21CSs on undergraduate students' physics success? Is there a significant effect of 21CSs on the undergraduate students' attitudes toward physics, and perceptions of physics teaching and learning?

Method

Research Model

The relational survey model was administered in this study. Relational survey model figures out the existence of common variation between two or more variables. Whether variables change together or not in the relational survey model; if there is a change, it is tried to be determined how it happened (Karasar, 2014). In this research, the relational survey model was used to reveal whether there is a relationship between the variables such as 21CSs, physics success, students' attitude towards physics, and their perceptions related with learning and teaching physics.

Research Sample

This study was performed with 329 undergraduate students (199-male and 130-female) who had taken physics courses before, and chosen randomly from Architecture-Engineering Faculty (AEF), Education Faculty (EF), and Health Sciences Faculty (HSF) of a Turkish State University in 2019-2020. More detailed data about participants is given in Table1.

Table 1

The Detailed Data about the Participants of the Research

Faculties	f	%	Departments	f	%
AEF	*163*	*49.5*	Civil Engineering	*33*	*10.0*
			Geomatics Engineering	*29*	*8.8*
			Food Engineering	*31*	*9.4*
			Computer Engineering	*70*	*21.3*
EF	*120*	*36.5*	Physics Education	*22*	*6.7*
			Science Education	*59*	*17.9*
			Primary Education	*39*	*11.9*
HSF	*46*	*14.0*	Physical Therapy and Rehabilitation	*46*	*14.0*
Total	*329*	*100.0*	Total	*329*	*100.0*

As seen in Table1, 49.5% (163 persons) of participants are formed from undergraduate students of AEF, 36.5% (120 persons) of participants are formed from undergraduate students of EF, and 14.0% (46 persons) of participants are formed from undergraduate students of HSF.

Data Collection Tools

In this study, the Turkish version of "Scale of Attitude towards Physics (SATP)", "Scale of Perception Related to Physics Teaching and Learning (SPRPTL)", and "Malaysian 21st-Century Skills Instrument(M-21CSI)" were used as data collection tools. First of all, permission was obtained by e-mail from Malaysian scientists (Soh et al., 2010) for adaptation of the scales from English to Turkish. All of the scales were translated into Turkish. Then Turkish versions of the scales were translated back to English. Original scales and the latest English versions which were translated to English from Turkish were compared with each other. After fixing typos, concept validity of scales was done by getting the opinions of experts in this field. After that, all of the scales were converted to online questionnaires. These online questionnaires were prepared using "Google Forms: Free Online Surveys for Personal Use" platform. After getting relevant permissions, the html link of these online questionnaires was sent to the participants of the research. These online questionnaires were applied to 75 participants as a pilot study in order to check construct validity and reliability analysis of the scales. The more detailed information about the adaptation of the scales, validity, and reliability analysis results can be found in our other studies, as well (Erkilic, 2020; Oral & Erkilic, 2020).

The scales, whose validity and reliability studies were carried out, were applied to 329 undergraduate students as online questionnaires.

Scale of Attitude towards Physics (SATP)

For determining participants' attitudes toward physics course, "Scale of Attitude Towards Physics (SATP)" was administered. SATP was developed by Soh et al. (2010). SATP consisted of a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). It was formed from 14 items. Cronbach's Alpha reliability coefficient value of SATP was determined as 0.95. Kaiser-Meyer-Olkin (KMO) value of SATP was determined as 0.93 as a result of the factor analysis, too. KMO value shows that SATP has a suitable structure for factor analysis. More detailed data about construct validity results of Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA) carried out for the SATP can be seen in our previous studies (Erkilic, 2020; Oral & Erkilic, 2020).

Scale of Perception Related to Physics Teaching and Learning (SPRPTL)

Participants' perceptions related to physics teaching and learning were determined using "Scale of Perception Related to Physics Teaching and Learning (SPRPTL)". Original version of this scale was developed by Soh et al. (2010). SPRPTL consisted of a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5) and consisted of 17 items. The Cronbach's Alpha reliability coefficient value of SPRPTL was determined as 0.85. Kaiser-Meyer-Olkin (KMO) value of SPRPTL was determined as 0.95 as a result of the factor analysis. KMO value shows that SPRPTL has a suitable structure for factor analysis. More detailed data about construct validity results of exploratory and confirmatory factor analysis and reliability analysis carried out for SPRPTL can be seen in our previous studies, as well (Erkilic, 2020; Oral & Erkilic, 2020).

21st-Century Skills Scale (21CSS)

The improvement levels of each 21st-century skill of participants were determined using "Malaysian 21st-Century Skills Instrument (M-21CSI)" developed by Malaysian scientists (Osman et al., 2010). First of all, this instrument was adapted into Turkish by the researchers of this study as explained under data collection tools title. After this process, the instrument's reliability and validity analysis were carried out again. The M-21CSI was a 5-point Likert-type scale. It consisted of 106 items and five sub-dimensions. The exploratory factor analysis was carried out for construct validity of 21CSS. The results of KMO sample adequacy test for a total of 106 items in the scale were determined as 0.949. This KMO value shows that 21CSS is suitable for factor analysis. According to the exploratory factor analysis which carried out for 21CSS, the scale is consisted of five factors and these five factors explain 55.941% of the total variance. This result of total variance shows that the construct validity of 21CSS was sufficient as original version M-21CSI. Also, the detailed data about reliability analysis results of sub-dimensions of 21CSS are given in Table2.

Table 2

Detailed Data about Sub-Dimensions of 21CSS

Parts of Scale	Sub-dimensions of Scale	Item Numbers	(Osman et al., 2010)	Current Study
			Cronbach's Alpha	Cronbach's Alpha
A	DAL	*24*	*0.88*	*0.93*
B	IT	*42*	*0.92*	*0.96*
C	EC	*15*	*0.74*	*0.94*
D	HP	*18*	*0.89*	*0.92*
E	SV	*7*	*0.78*	*0.96*

Note. As it is seen in Table2, reliability values of all sub-dimensions of 21CSS were determined as over 0.90. This result indicates that the reliability value of 21CSS was sufficient.

Data Analysis

The statistical analysis of this study was done via SPSS 22.00 program. Before performing a statistical analysis, it is necessary to determine whether collected data are normally distributed. If data are normally distributed, parametric tests are used in the analysis, and if data do not fit for normal distribution, non-parametric tests are used.

Normality analysis is evaluated by statistical (Shapiro-Wilks, Anderson-Darling, Kolmogrorov-Smirnov, etc.), measures of central tendency (Mode, median and mean), skewness and kurtosis or graphical (P-P plot, Detrendet normal Q-Q plot, Box plot, Steam and leaf, etc.) methods (Tabachnick & Fidell, 2013).

In this study, skewness and kurtosis values were used to test the normality of the data. Tabachnick and Fidell (2013) stated that if the skewness value is greater than 3 and the kurtosis value is greater than 10 in a data analysis, there will be a problem with the normality of that data. Also, Tabachnick and Fidell (2013) stated that even if the kurtosis value is above 20, this would create an even more serious problem regarding the normal distribution of the data. Based on these suggestions about skewness and kurtosis in data analysis, since the skewness values of the data obtained in this study were less than 3 and the kurtosis values were less than 10, it was accepted that the data showed a normal distribution. In addition, while searching for answers to each problem, homogeneity analysis of the variables were also made with Levene's test.

As a result of these preliminary analyzes made in the research, multiple linear regression test was used as a parametric test for analysis of the relationship between variables. Frequency, percentage, and mean were used in analysis of descriptive data obtained from the on-line questionnaire. In the study, EFA and KMO were used in analysis of whether the scales in the questionnaire form were suitable for validity analysis, while Cronbach's Alpha correlation analysis was used in reliability analysis. Data obtained in this research was tested at $p < .05$ significance level.

Results

The results obtained for each sub-problems of the research were presented in this part of the study. First question of this study was aimed to figure out the improvement level of undergraduate students' 21CSs. Therefore, online form of 21CSS was conducted on 329 undergraduate students. Development levels of scales were determined according to the determination criteria given in Table3. If the mean score of any scale is over 3.40, that scale and its sub-dimensions were accepted as developed.

Table 3

Development Level Determination Criteria of the Scales

Mean Range	Development level
1.00-1.80	Very low
1.80-2.60	Low
2.60-3.40	Medium
3.40-4.20	High
4.20-5.00	Very high

The obtained data about undergraduate students' 21CSs is given in Table4.

Table 4

The Data about Development Level of Undergraduate Students' 21CSs

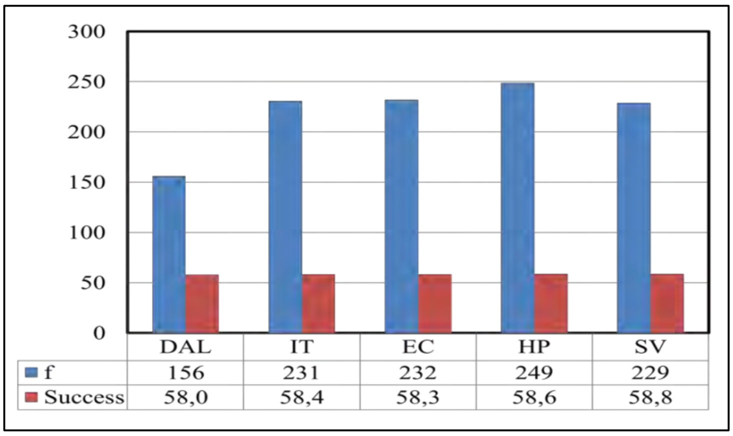
Sub-dimensions	*Mean Value*
DAL	*3.28*
IT	*3.61*
EC	*3.62*
HP	*3.75*
SV	*3.71*

From the findings given in Table4, it was seen that the development level of the DAL sub-dimension is at medium level (3.28) while all other sub-dimensions were found as high level. Also, development level of HP sub-dimension was determined as the most developed 21st-century skill (3.75) of undergraduate students.

The second question of the study was aimed to find out the effect of 21CSs on undergraduate students' physics success. The undergraduate students whose 21CSS's sub-dimensions have mean values of "high" and "very high" were evaluated as developed skills. As a result of this evaluation, the frequency (number), and physics success scores of these undergraduate students are given in Figure 2.

Figure 2

The Frequency of Undergraduate Students Who Have Advanced 21CSs and Mean Scores of Undergraduate Students' Physics Success



According to the data in Figure 2, there are 156 undergraduate students who have developed DAL, and physics course mean scores of these students was determined as 58.0 points. Frequency of other sub-dimensions groups and their physics course mean scores are as follows: IT (231 students, 58.4 points), EC (232 students, 58.3 points), HP (249 students, 58.6 points), and SV (229 students, 58.8 points). The results of the multiple linear regression analysis conducted to determine whether students' 21CSs affect their physics course success or not are given in Table5.

Table 5

Multiple Regression Analysis Related to Undergraduate Students' 21CSs, and Their Physics Success

Variables	*B*	*Std. Error*	*β*	*t*	*p*	*Pearson correlation (r)*
Constant	*58.991*	*5.814*	*-*	*10,147*	*0.000*	*-*
DAL	*0.156*	*1.881*	*0.006*	*0.083*	*0.934*	*-0.009*
IT	*0.679*	*2.369*	*0.026*	*0.287*	*0.774*	*-0.009*
EC	*-3.232*	*2.141*	*-0.140*	*-1.510*	*0.132*	*-0.052*
HP	*1.309*	*1.839*	*0.058*	*0.712*	*0.477*	*0.007*
SV	*0.836*	*1.563*	*0.041*	*0.535*	*0.593*	*0.001*
$R = 0.086$, $R^2 = 0.007$, $F(5,323) = 0.482$, $p = 0.790$						

Regression analysis data given in Table5 shows the effect of participants' 21CSs (DAL, IT, EC, HP, and SV) on their physics course success. Also, the data given in Table5 presents relationship between undergraduate students'21CSs, and their physics course success as well. The equation which indicates the effect of students' 21CSs on their physics course success could be written as follows: Undergraduate students' physics success = *58.991 - 3.232*EC + 1.309*HP + 0.836*SV + 0.679*IT + 0.156*DAL*. Regression coefficients obtained for each sub-dimensions indicates the relative importance on undergraduate students' physics success. Regression coefficients obtained for each sub-dimensions of participants' 21CSs were obtained as follows; *EC (B = -3.232), HP (B = 1.309), SV (B = 0.836), IT (B = 0.679),* and *DAL (B = 0.156).* On the other hand, the results of Table5 also showed that there was not a significant relationship between 21CSs of undergraduate students, and their physics success (*$R = 0.086$, $R2 = 0.007$; $F [5,323] = 0.482$, $p = 0.790 > 0.05$*).

The third question of this study was aimed to examine whether there was an effect of undergraduate students' 21CSs on their attitudes toward physics courses, and their perceptions of physics teaching and learning, or not. The obtained data about this question are given in Table 6 and Table7. Multiple linear regression analysis results about the relationship between undergraduate students' 21CSs, and their attitudes toward physics are presented in Table6.

Table 6

Multiple Regression Analysis Data Related to Undergraduate Students' 21CSs and Their Attitudes Toward Physics

Variables	*B*	*Std. Error*	*β*	*t*	*p*	*Pearson correlation (r)*
Constant	*0.819*	*0.206*	*-*	*3.975*	*0.000*	*-*
DAL	*0.182*	*0.067*	*0.166*	*2.724*	*0.007*	*0.477*
IT	*0.412*	*0.084*	*0.358*	*4.907*	*0.000*	*0.562*
EC	*0.064*	*0.076*	*0.063*	*0.843*	*0.400*	*0.475*
HP	*0.013*	*0.065*	*0.013*	*0.203*	*0.840*	*0.420*
SV	*0.068*	*0.055*	*0.076*	*1.224*	*0.222*	*0.415*
$R = 0.590$, $R^2 = 0.348$, $F(5,323) = 34.414$, $p = 0.000$						

Regression analysis data given in Table 6 shows the regression equation which predicts undergraduate students’ attitudes toward physics course. This equation can be given as follows: Undergraduate students' attitudes toward physics = *0.819 + 0.412*IT + 0.182*DAL + 0.068*SV + 0.064*EC + 0.013*HP*. This equation indicates the effect of improvement level of undergraduate students’ 21CSs on their attitudes towards physics course. According to the regression coefficients, relative importance order of predictor variables of 21CSs sub-dimensions on students' attitudes towards physics are as follows; *IT (B = 0.412), DAL (B = 0.182), SV (B = 0.068), EC (B = 0.064)* and *HP (B = 0.013).*

On the other hand, the results of Table 6 showed that there was a significant relationship between 21CSs of undergraduate students, and their attitudes towards physics course as *well* (*R = 0.590, R2 = 0.348; F [5,323] = 34.414, p = 0.000 <0.05).*

Multiple linear regression analysis results about the relationship between undergraduate students' 21CSs and their perceptions of physics teaching and learning are presented in Table 7.

Table 7

Multiple Regression Analysis Data Related to Undergraduate Students’ 21CSs, and Perceptions of Physics Learning and Teaching

Variables	*B*	*Std. Error*	*β*	*t*	*p*	*Pearson correlation (r)*
Constant	*0.703*	*0.194*	-	*30.626*	*0.000*	-
DAL	*0.401*	*0.063*	*0.385*	*60.393*	*0.000*	*0.564*
IT	*0.205*	*0.079*	*0.188*	*20.601*	*0.010*	*0.498*
EC	*0.011*	*0.071*	*0.011*	*0.147*	*0.883*	*0.437*
HP	*-0.030*	*0.061*	*-0.032*	*-0.481*	*0.631*	*0.373*
SV	*0.114*	*0.052*	*0.134*	*20.180*	*0.030*	*0.427*
$R = 0.601$, $R^2 = 0.361$, $F(5.323) = 36.485$, $p = 0.000$						

Regression analysis data given in Table 7 shows the regression data which predicts undergraduate students’ perceptions of physics teaching and learning. The equation which predicts undergraduate students’ perceptions of physics teaching and learning can be written as follows: Undergraduate students’ perceptions related to physics teaching and *learning = 0.703 +0.401*DAL + 0.205*IT + 0.114*SV - 0.030*HP + 0.011*EC*. This equation indicates the effect of improvement level of undergraduate students' 21CSs on their perceptions of physics teaching and learning. Also, the results of Table 7 show that there is a significant relationship between 21CSs of undergraduate students, and their perceptions of physics teaching and learning too (*R = 0.601, R2 = 0.361; F [5,323] = 36.485, p = 0.000 <0.05*).

Discussion

The relationship between undergraduate students' 21CSs, their attitudes towards physics, and their perceptions of physics teaching and learning were investigated in this study. The development level of the DAL sub-dimension of undergraduate students' was determined as medium while the other subdimensions' (IT, EC, HP, and SV) development levels were determined as high. This result of study is in good agreement with related literature (Akman, 2019; Bozkurt & Çakır, 2016; Karakas, 2015; Zehra & Kozikoglu, 2019). It was stated that “educational environments play a role as essential as education programs” for developing 21CSs of students (Agaoglu & Demir, 2020). Also, Putranta et al. (2021) has figured out that smartphone usage has a significant impact on students’ higher order thinking skills (HOTS) in physics learning. Results of this research which showed that most of the participants’ 21CSs are at a high level is in good agreement of with this expression. Therefore, the main reason for students' having developed 21CSs may be due to today's mass media such as computers, tablets, smartphones, and the internet, and following current developments in the world using these tools. This result is related to the fact that learning environments have an important effect on the development of students' 21CSs. For example, Erdogan (2019) had trained pre-service science teachers using Lego education sets. Results of his study showed that some 21CSs of pre-service science teachers were affected by learning environments designed using robot sets. Therefore, because those students can access different information from YouTube, Facebook, Twitter, Instagram, and WhatsApp using internet connection via these tools in a short time, so their skills, which are defined as 21CSs, also improve.

According to results of multiple regression analysis regarding the effect of 21CSs development levels of undergraduate students on their physics course success, it was observed that 21CSs explain about 0.7% of students' physics success. Also, the t-test results of the significance of the regression coefficients indicated that none of the sub-dimensions of 21CSs were a significant predictor of physics success. On the other hand, according to the correlation coefficients, a negative and insignificant relationship was found between students' physics success, and their DAL, IT, and EC skills, while a positive and insignificant relationship was found between their HP, and SV skills as well. It can be stated that none of the sub-dimensions of 21CSs have a significant effect on undergraduate students' physics success. Therefore, according to the data obtained for first question of this study, we can state that none of the sub-dimensions of 21CSs directly have a significant effect on undergraduate students' physics success. Besides, opposite findings have been seen in the literature. For example, in the research conducted with 96 middle school 8th-grade students in Jordan by Kan'An (2018), it is stated that the development level of 21CSs of students is an important predictor of students' academic success. Similarly, it has been stated in many studies that academic success is in a positive relationship with 21CSs such as digital-age literacy, critical thinking, and inventive thinking (Bowles-Terry, 2012; Pagani et al., 2016; Prensky, 2005; Zirak & Ahmadian, 2015). The main reason for the dissimilarity between results of our study and literature may be the fact that participants of our study were undergraduate students while participants of studies in the literature were students from primary and secondary schools.

The regression analysis showed that all of the sub-dimensions of 21CSs of undergraduate students explained about 35% of students' attitudes towards physics. This means that about 35% of the undergraduate students' attitudes towards physics arise depending on 21CSs. Also, t-test results given in Table 6 indicate that the variables of DAL were positive and significant predictors of undergraduate students' attitudes toward physics. According to this data, it is clear that relationship between students' attitudes toward physics, DAL, and IT is significant at $p < 0.05$ level. Therefore, it can be stated that DAL and IT sub-dimensions make significant contribution to undergraduate students' attitudes toward physics courses. On the other hand, according to correlation coefficients, it is seen that there is a positive, significant, and moderate relationship between the students' attitudes toward physics and their 21CSs (DAL, IT, EC, HP, and SV). This finding is in good agreement with findings obtained in the study carried out by Soh et al. (2010) in Malaysia. In their study, Soh et al. (2010), have found a positive and strong relationship ($r = 0.62$) between the overall average of 21CSs and students' attitudes toward physics. However, they found that there was a weak and medium level relationship between the sub-dimensions of 21CSs and their attitudes toward physics. Correlation coefficient values such as 0.55, 0.46, 0.30, 0.30, and 0.43 were obtained between the sub-dimensions of 21CSs such as DAL, IT, EC, HP, and SV, and students' attitudes toward physics, respectively.

The results of multiple linear regression analysis given in Table7 have figured out a significant relationship between undergraduate students' 21CSs, and their perceptions of physics teaching and learning. These results indicate that 36% of perceptions related to physics teaching and learning of undergraduate students depend on their 21CSs. It was seen that especially IT, DAL, and SV sub-dimensions of the 21CSs were found as positive and significant predictors of perceptions related to physics teaching and learning as well. On the contrary of this result, there was not found a significant effect of the development level of EC and HP sub-dimensions on undergraduate students' perceptions of physics teaching and learning. Correlation coefficient values obtained between undergraduate students' perceptions of physics teaching and learning, and the DAL, IT, EC, HP, and SV sub-dimensions of their 21CSs were such as 0.30, 0.40, 0.27.0.25, and 0.55, respectively. This result is consistent with some results in related literature (Havik & Westergård, 2020; Soh et al., 2010). Similarly, a positive and moderate relationship (r = 0.58) between the students' mean values of 21CSs and their perceptions about physics teaching and learning was figured out by Soh et al. (2010). Also, weak and medium relationships between the sub-dimensions of 21CSs and their perceptions about physics teaching and learning were explained in their study. Havik and Westergård (2020) conducted a study that investigated the students' perceptions about classroom interactions. They have figured out that perceiving high-quality classroom interactions supply more engagement of students in school.

The statistical analysis obtained for second question showed that none of sub-dimensions of 21CSs have significant effect on undergraduate students' physics success. However, the statistical analysis obtained for third question of this study showed that 21CSs of undergraduate students have a significant effect on their attitudes towards physics courses and perceptions of teaching and learning physics as well. Many types of research which have been conducted in the literature figured out that positive and negative perceptions of physics course affect students' attitudes towards physics course, and their physics course success too (Chanthala et al., 2017; Hariwangsa Panuluh et al., 2019; Setyani et al., 2017). Therefore, the following conclusion can be drawn from these results: More improved 21CSs of undergraduate students will help an increase in undergraduate students' attitudes toward physics, and their perception of physics teaching and learning. Also, improvement in the 21CSs of students can indirectly affect their physics course success. It is extremely important for undergraduate students and graduated students in engineering, health, education, or any other field to have improved 21CSs. In conclusion, it can be said that undergraduate students with advanced 21CSs can be more successful in courses such as physics courses that require abstract and advanced thinking. Also, the development of 21CSs of undergraduate students may increase their success in other courses similar to physics. For this reason, it is very important to develop the 21CSs of undergraduate students.

On the other hand, it can be said that having advanced 21CSs of undergraduate students will also help them to get a job easily after graduation and be successful after graduation. Increasing amount of physicists in different industries and the significant transition of physics graduates in other fields also support this result (Voss et al., 2019). In this context, it could be concluded that having 21CSs can play an important role in becoming successful and happy persons too. Because after graduation having improved 21CSs in every aspect of daily life will help undergraduates to use different software, educational technologies and mass media more easily, to make sense of many events happening around them, and to use many tools used in the field of health as well. Persons who have improved 21CSs can find solutions to the problems they face in daily life more easily, communicate easily with their friends, have sufficient self-confidence, and be more productive individuals.

The rapid development in information and communication technologies causes new changes in every aspect of our daily life. These new developments enable individuals to reach information faster and find an alternative way of solutions to the problems they encounter in their daily lives. In the century we live in, what matters is not how people acquire information, but how they analyze and use the information they have acquired in their economic and social lives. Therefore, in 21st-century, behaviors expected from individuals have also changed. Individuals are expected not only to know but also to be lifelong learners, critical, thinking, questioning, innovative and adaptable to innovations, working in collaboration and problem solving, that is, having 21CSs (Atalay & Anagun, 2016).

Developing 21CSs and adapting these skills to the education systems of countries will primarily improve students' attitudes towards physics courses and their level of perception about physics learning and teaching. As result, the academic success of undergraduate students is expected to increase even more. Because studies on these issues reveal that there is a positive relationship between individuals' positive attitude and their perceptions towards a course and their success in that course (Aydin & Cekim, 2017; Bowles-Terry, 2012; Kan'An, 2018; Kaur & Zhao, 2017; Prensky, 2005; Veloo et al., 2015; Vilia & Candeias, 2020; Vysoká & Smetanová, 2016).

Conclusions

Physics is one of the most important natural sciences which enable us to learn about nature. Physics enables us to obtain the essential knowledge necessary for future technological advances that enable the world to evolve in every aspect. Therefore, Physics, besides contributing to the technological infrastructure, plays an important role in training the necessary trained personnel to provide these technological advances.

According to the statistical analysis of this study, the obtained results were summarized as follows:

1) IT, HP, EC, and SV sub-dimensions of 21CSs of undergraduate students were determined as a high level, while the DAL sub-dimension was determined at medium level.
2) A direct significant effect of undergraduate students' development levels of 21CSs was not found on physics success of undergraduate students.
3) A significant effect of undergraduate students' development levels of 21CSs was found on their attitudes toward physics.
4) A significant effect of undergraduate students' development levels of 21CSs was found on their perceptions of physics teaching and learning.

Physics is a crucial science in the educational system and it will always have a key role in the progress of countries and the world as well. Therefore, physics education problems should be researched and solved. According to the results obtained in this study the following recommendations can be given;

1) This study was carried out with undergraduate students of architecture, engineering, education, and health sciences faculties. Thus, similar studies should be performed with undergraduate students enrolled in different fields.
2) No consensus has yet been reached on exactly what skills the so-called 21CSs cover. Therefore, these skills are being defined in different ways by many sources. These skills should be defined in a way that is acceptable to all.
3) The effect of the development levels of 21CSs on different courses other than physics should be investigated.

Acknowledgments

This article was produced from the master of sciences thesis entitled: "Investigation of 21st-Century Skills' Effect on Physics Success". Also, this article was presented as an oral presentation at Global Conference on Education and Research (GLOCER 2021) which was virtually held in Florida, USA on June 8-10, 2021. Only the abstract of the study was published in the proceedings book.

Disclosure statement

No potential conflict of interest was reported by the authors.

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