Croatian Journal of Education
Vol.21; No.4/2019, pages: 1181-1211
Original research paper
Paper submitted: 05th July 2018
Paper accepted: 15th January 2019
https://doi.org/10.15516/cje.v21i4.3278

Development of the Perception Scale for the Concept of the Integral

Özkan, Ergene[1] and Ahmet Şükrü Özdemir[2]
[1] *Sakarya University, Faculty of Education*
[2]*Marmara University, Atatürk Faculty of Education*

Abstract

Applications for concept teaching in mathematics education essentially affect students' perceptions as regards the concept that is taught, as well as changing their mathematics anxiety and attitude toward mathematics. Therefore, we wished to draw attention to the fact that not enough concept-specific scales related to mathematics education measure variables, such as attitude-anxiety, can be found in professional literature. This research aims to develop a valid and reliable measurement tool in order to measure anxiety-attitude and usefulness perceptions of students for the concept of the integral. The data of this research, in which scale development stages are carried out meticulously, were collected from 565 students who study at mathematics education programs for primary and secondary education at three different public universities in Marmara region of Turkey and have learned about the integral concept in calculus lessons. Experts' opinions for content validity, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) for factorial validity, discriminant and convergent validity analyses for construct validity, criterion validity, internal consistency and composite reliability procedures were performed on the applied scale respectively. As a result of the research, the Perception Scale for the Concept of Integral (PCI Scale) consisting of 20 items and three factors (anxiety, attitude, usefulness) with a 5-point Likert type was developed. It is considered that this research will contribute to professional literature with the thought that there is no scale aiming to measure the perceptions of students towards the concept of the integral in the relevant literature. Considering the lack of concept-based scales in the literature of mathematics education, with this research, the idea of the necessity of development of concept-based scales has also been put forward.

Keywords: *anxiety; attitude; integral; scale development; usefulness*

Introduction

With the influence of technological developments in today's world, education systems are being updated, and educational philosophy, teaching strategies, methods and techniques are changing. In the field of mathematics education, mathematics learning and teaching processes are reformed with the influence of these changes and it is intended to raise individuals who develop a positive attitude towards mathematics and mathematical applications, improve problem-solving skills, gain mathematical thinking and application skills, and can use mathematics effectively and usefully in daily life (MoNE, 2018, p. 10-12). These purposes require that the thought of theoretical difficultness of the concept should not affect the teaching process negatively in the teaching process of mathematical concepts, students should develop a positive attitude towards the concept by assigning meaning to the nature of the concept, and should be aware of use of the concept in daily life (Ryan, 1998). These requirements should be used to make students feel that the concepts taught in Mathematics classes are not difficult and the concepts described as abstract can have daily-life applications. Thus, students showing a positive attitude and low anxiety to the concept will be willing in the teaching process, and this could also enhance success.

Several studies conducted in recent years have revealed that from the elementary school period to the university period some students have reactions against Mathematics lessons such as fear, hatred and anxiety (Betz, 1978; Campbell & Evans, 1997; Di Martino & Zan, 2010; Fennema & Sherman, 1976; Hembree, 1990; Ma & Xu, 2004; Tobias, 1990; Zettle & Raines, 2000). Anxiety in Mathematics lessons implies the tension and fear of mathematics, further hampering the understanding of topics (Fulkerson, Galassi & Galassi, 1984). Research on mathematics learning report that mathematics anxiety causes students to avoid mathematics and have low mathematics performance (Rounds & Hendel, 1980, p. 138). In addition, it is seen that the students who have negative attitudes towards mathematics have performance issues due to anxiety (Tapia, Martha, Marsh, & George. 2004). A decrease in anxiety improves students' attitude to learning in general terms and motivates them (Carraway, 1987; Taylor & Walton, 1997; Vattanapath & Jaiprayoon, 1999). The relationship between anxiety and attitude affects teaching and learning. Researchers have been investigating the effects and results of the phenomenon.

It is a mental and neural state of preparation, occurring after attitudes and experiences, with a directive or dynamic effect on individual's behaviour to objects or situations he/she is interested in (Freedman, Sears & Carlsmith, 1978, p. 278). Accordingly, there is a very high probability for a student to develop positive or negative attitudes to mathematics under the influence of experiences in Mathematics lessons. In research of elementary- and high-school students, attitudes to mathematics are measured by mathematics attitude scales and meaningful differences are seen in their attitudes to mathematics according to different variables (Bandura, 1997; Capar & Tarım, 2015; Elmore & Vasu, 1980; Roberts & Reese, 1987). Failure in understanding or explaining the importance of Mathematics lessons and the use of it in daily life constitutes problems while teaching these lessons.

Perception is about receiving, selecting, acquiring, transforming and organizing information supplied through our senses. It is about vision, hearing, smell, taste, touch, and more (Barber & Legge, 2017, p. 7). Studies about perception (Angier & Povey, 1999; Kung, 2009; Wilson, 2018) are often conducted in the field of mathematics education and in these studies, perception is used as a combination of aspects such as thought, the association of ideas, meaning, and sense. In this research, perception of the concept of the integral is built as a construction including anxiety and attitude of an individual towards the integral concept and awareness level related to using the integral concept in daily life.

The fact that mathematical concepts are regarded as abstract, even though almost every part of our daily life has a lot to do with mathematics (Baki & Bell, 1997, p.34), gives the impression that it is impossible for a student to understand topics via his/her own study. This situation leads to negativities such as students' disbelief in learning mathematical concepts on their own, belief in not having enough intelligence and capacity for it, and difficultness of the concepts. In Mathematics lessons, studies including applications such as the use of material, technology-assisted teaching, visualization, and modelling, especially in the teaching processes of concepts considered by students as difficult, are often observed with the effect of these negativities. For example, research in which software (Sevimli, 2013; Camacho, Depool & Santos-Trigo, 2009; Heid, 2003) such as Computer Algebra System (CAS) and Geogebra, daily life problems, and multiple representations are used (Sealey, 2008), take part in literature in the teaching process of the "integral" concept described as "difficult" by students (Ergene, 2014).

The integral concept expressed to constitute the base for calculus lessons (William & Hall, 2010), is included in curricula of high-school level and all undergraduate and postgraduate levels of higher education. The concept of the integral is a concept of which the application areas are broad, that is, related to several concepts such as limit, derivative, and rate of change, and with which students have a lot of problems in the process of interpretation.

When studies on the concept of the integral are examined, it is seen that the majority of them are done on the level of higher education, conducted within calculus lessons and address students' cognitive difficulties in the process of understanding (Sevimli, 2013). Many researchers have revealed the difficulty in understanding the concept of integral, which is one of the calculus courses (Orton, 1983; Ferrini-Mundi J. & Graham, 1994; Rasslan & Tall, 2002; Ergene, 2014). Finitude in concept-definition-concept images, such as the description of indefinite integral just as the opposite of derivative and of definite integral as the area under a curve, and misconceptions or challenges of contextual problems regarding their use in daily life can be given as examples. It can be thought that these situations cause students to describe the integral concept as difficult, to develop anxiety, reluctance and negative attitude towards the concept and not to be aware of its use in everyday life.

In conclusion, it will be significant in the teaching process of the concept to determine the anxiety and attitude levels of students, which are central to the teaching process

of the integral concept, it being an important concept in the mathematics education field, towards the integral and their perceptions for utility of the integral in daily life. For students whose perceptions for integrals were revealed, teaching processes in different scopes will be designed and existing states of the students will be evaluated from various perspectives. For example, applications enriched with daily life problems related to the concept or teaching processes involving conceptual understanding can be used for a student having high levels of anxiety regarding the integral and thinking that the integral cannot be used in daily life. The solving process of real-life problems is more complicated than that of other types of problems. Actually, this situation may affect the anxiety and attitude levels of students after the problem-solving process. As another example, the teaching process in which the history of the integral is taught to the students with a high level of anxiety about the integral can be planned.

It is observed that virtually all of the attitude and anxiety scales occurring in mathematics education literature are developed for mathematics and Mathematics lessons. The results obtained from these scales paint a general picture considering the content and scope of mathematics and Mathematics lessons. In fact, applications for concept teaching in mathematics education essentially changes students' perceptions towards the concept that is taught, as well as changing their levels for mathematics, such as anxiety and attitude. For example, a researcher performing an application about the integral should prefer a scale prepared for the integral concept rather than a mathematics attitude scale in order to examine how his/her application affects students' anxiety or attitude levels because the application of the researcher has the quality to change their perception against the concept of integral primarily. Therefore, in literature, it is notable that there are not enough concept-specific scales related to mathematics education measure variables such as attitude-anxiety. Due to all these reasons, this research aims to develop a valid and reliable measurement tool in order to measure the anxiety-attitude of students for the integral and the usability of it.

Significance of the Research

It is considered that this research will contribute to professional literature, since international literature lacks a scale that can be used to measure students' perceptions of the integral concept. Also, this research has special significance as it will raise the idea of "the necessity of concept-specific scale development in mathematics education field" with a developed Perception for the Concept of the Integral Scale (PCI scale).

Methodology

The purpose of this study is to develop a PCI scale. Sample and development studies of the scale are presented in this section.

Sample

The research sample consists of 565 students who study at mathematics education programs for primary and secondary education at three different public universities

based in the Marmara region. While determining the sample out of university students who are enroled in mathematics education programs for primary and secondary education, the researchers were careful to pick out the students who took a calculus course in which the integral concept is taught. 191 of the students participated in the sample study at university A, 158 of them study at university B and 216 of them study at university C. Also, 398 of them study Mathematics teaching at primary education program, while 167 of them study Mathematics teaching at the secondary education program. Data taken from students at universities A and B were used for Exploratory Factor Analysis (EFA) and data taken from students at university C were used for Confirmatory Factor Analysis (CFA) in the research process.

Procedure

PCI Scale

Developed within the scope of the research purpose, the PCI scale has a three-factor structure consisting of three dimensions – Anxiety, Attitude, and Usefulness - and comprises 20 items which were finalized following the validation study undertaken with the participation of university students. The scale is a 5-point Likert scale in which the options range from 1 to 5 "I strongly agree (5), I agree (4), neutral (3), I disagree (2), and I strongly disagree (1)". The scores taken from the scale vary from 20 to 100 at this interval. There are 12 reverse-scored items in the scale which are 1, 2, 5, 7, 8, 10, 12, 14, 16, 17, 18, 19

The Process of PCI Scale and Data Analysis

It was decided to develop the PCI scale by using a Likert-type scale based on "scaling with grading totals" model (Judd, Eliot & Kidder, 1991) brought forward by Rennis Likert (1932). The Likert-type scale is practical and gives measurable results at equal-interval scale as the rating level is increased; those were effective reasons in making this decision (Tezbasaran, 2008, p.5).

The process below followed the creation of the pool of items and the validity and reliability studies (EFA-CFA).

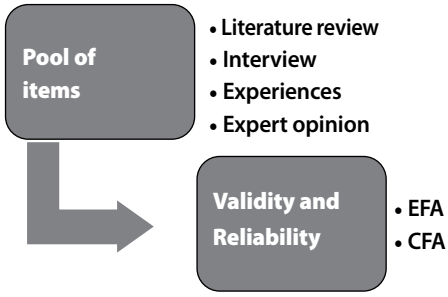

Figure 1. Steps of the PCI Scale Development Process

When views on how to create the pool of items and how many items it would consist of were examined, it was suggested to carry out with literature review, observations, and interviews with the target group (Erkus, 2012, p. 24-41), and it was suggested that, if possible, it should be two to three times the number of items to be used on the scale (Tezbasaran, 2008, p.14-15). In line with these suggestions when creating the pool of items, literature review on the basis of attitude and anxiety concepts, and the use of mathematical concepts in daily life was carried out first. Then, scales related to attitude-anxiety and daily life use and prepared in fields of education and mathematics education were examined. Afterwards, views of randomly selected seven university students who study at mathematics education programs on the concept of the integral were taken. Students were asked to answer (in writing) the questions of: "What do you think about the concept of the integral?" and "How does the concept of the integral make you feel?", and were asked verbally the question of: "What do you do when you encounter the concept of the integral?" Finally, considering the experiences of researchers on integral and undergraduate and graduate experience of the first researcher, the 51-point pool of items was created.

Expert opinion was taken for content validity by explaining the aim of development of the scale and then showing the items in the pool of items to two faculty members who had their PhD degrees in the field of mathematics education and have done research on the integral concept, and to a faculty member who had a Bachelor's degree in the field of mathematics education and a PhD degree in the field of assessment and evaluation. In line with the opinions expressed by three faculty members, eight items that had similar meanings or that were hard to give meaning to were excluded from the pool of items and a draft scale of 43 items was created. Experts' opinions as regards aspect and language validity were taken by showing the scale to an assessment and evaluation expert and to a faculty member who had a PhD degree in the field of Turkish education. In accordance with opinions and criticisms from experts, items of the 43-item draft scale were edited and applied to the sample with the aim of conducting Exploratory Factor Analysis (EFA) for validity and reliability studies.

It was highlighted that the sample to which the draft scale would be applied, should be necessarily suitable to the target population in accordance with the development aim of the scale. The sample consisted of university students who study at mathematics education programs as the development aim of the PCI scale was to reveal university students' perception of the integral concept. It was seen that there were different opinions to determine how many students will be included to sample, for example, saying that it should be at least five times the number of items on the scale (Hair, Black, Babin & Anderson, 2005), that 300 people are enough (Nunnally, 1978, p.276) or that 100 people are too few, 200 people are average, 300 people are sufficient (Comrey & Lee, 1992). Following these recommendations, 349 students were decided to be enough to create a sample. When applying the draft scale, we paid particular attention that students were not on their break time and it was not near the end of the lesson, and

the application aim of the scale was explained to the students. They were asked to answer the scale items carefully. No time restriction was set for the draft form of the scale and the average answer time varied between 15 to 20 minutes.

After applying the draft scale to the sample, the EFA was conducted for validity and reliability studies of items included in the scale by using the IBM SPSS Statistics 20 package program. While conducting the EFA, 10 data cells were excluded by considering Mahalanobis distances (p = 0.05, sd: 20) and z = (-3.00, 3.00) total scores regarding total points. Before performing the EFA, the suitability of data taken from the sample to analysis was examined with the Kaiser-Meyer-Olkin (KMO) and Bartlett sphericity tests. For factorial validity of the scale, while determining items to include in the scale in EFA, it was considered that the eigenvalue of items was 1, factor loadings were at least .30, the items took place at one factor and the items covering two factors had at least .10 difference between them (Buyukozturk, 2013).

In accordance with the determined criteria, 23 items were excluded from the draft scale as a result of the EFA, a 20-item three-factor structure was found, and the final form of the scale, validity and reliability of which were tested, established. After performing the EFA, the CFA was conducted by using the Lisrel 8.7 package program in order to evaluate the fit degree of the scale, the three-factor 20-item structure, and verify it.

There are multiple opinions to determine how many students should be included in the sample to which the final scale would be applied in order to carry out the CFA. For example, it should be at least 5 times the item number according to Lee and Song (2004), while Kline (2005) regards 100 people as too few, 100-200 people as average and more than 200 people as sufficient for the sample. In line with these opinions, and as item number of the final scale is 20, it was decided that 216 students would be enough for the sample. Students to answer the final scale were selected from a different university so that they were different from the students who answered the draft scale. When applying the final scale, we paid particular attention that students were not on their break time and it was not near the end of the lesson, and the application aim of the scale was explained to the students. They were also asked to answer the scale items carefully. No time restriction was set for the final form of the scale and the average answer time varied between 10 to 15 minutes.

Cook's and Leverage values were checked in order to test whether the data set taken from the final form of the scale showed multivariate normal distribution and to identify edge values. It was seen that the data set did not show a multivariate normal distribution and was not an edge value. The ZPRED-ZRESID scatter plot was examined to see whether there were linear relations between variables and it was observed that there were linear relations. Correlation coefficients calculated for the relationship between item scores were examined and it was seen that there was no value greater than 0.80, hence there was no multiple connections problem. After the examination of all these premises, it was determined that the CFA could be conducted. Finally, the convergent and discriminant validities were examined for the validity of the structure of the scale.

To estimate scale reliability, the internal consistency method was used. Cronbach's alpha internal consistency coefficient and composite reliability coefficients were calculated to estimate reliability with the internal consistency method.

Strong and Limited Aspects of the Research

The research is highly strong, as it contains processes that must be applied in scale development and adaptation (**Çü**m & Ko**ç**, 2013), and the validity types (face, content, criterion, construct, convergent, and discriminant validity). However, though some of the reliability analyses were conducted, it is somewhat limited, since it does not have test-retest in terms of consistency, and its validity with item response theory was not checked.

Findings

In this section, findings of validity and reliability studies based on the data obtained from applying the PCI scale to 565 university students are presented.

Exploratory Factor Analysis:

The scale was evaluated via the EFA. Before performing the EFA, it is necessary to determine whether the data set is suitable for factor analysis. The process for this is to perform the Kaiser-Meyer-Oklin (KMO) and Bartlett Sphericity tests. Therefore, before conducting the EFA, the KMO measure of sampling adequacy and Bartlett Sphericity tests were conducted. The KMO ranges from 0 to 1, and the KMO values above 0.5 are acceptable (Field, 2009, p.647). The results exhibited a KMO measure of sampling adequacy of 0.914 (KMO= 0.914), a value greater than 0.70, indicating that the sample size was adequate for factor analysis (Bryman & Cramer, 1999). Bartlett test of sphericity was $p<.001$ indicating that factor analysis was appropriate (Bryman & Cramer, 1999). According to these results, it can be stated that the data were fit for factor analysis. When the items to be included in the instrument were determined as a result of the EFA for the factorial validity of the scale, it was noted that the eigenvalues of the factors constituting the scale items were 1 and above, and the factor loadings were 0.30 and above. In addition, it was also noted that the materials are included in a single factor or that there is at least a 0.10 difference between the factor loadings of the items (Buyukozturk, 2013). After the elimination of these items, the draft scale of 43 items was reduced to 20 items. For the 20-item data set, the KMO value was calculated to be .944 and the Bartlett sphericity test was calculated to be 4283,239 (df=190, p=000) (Field, 2009).

Table 1

The items (original Turkish version), factor structure and factor loads, and explained variance of the scale

Factor	Item No	Items			
Anxiety	1	İntegral en korktuğum matematik konularından biridir. (The integral is one of the most feared mathematics topics for me.)	.762		
	5	İntegral çalışırken gergin olurum. (I am nervous while studying integrals.)	.744		
	7	İntegrale karşı olumsuz duygular beslerim. (I have negative feelings towards the integral.)	.746		
	10	İntegral kelimesini duymak bile beni ürkütüyor. (Even to hear the word integral scares me.)	.824		
	14	İntegral çalışırken kendimi çaresiz hissederim. (I feel helpless while working on the integral.)	.774		
	16	İntegral çalışmak beni sinirlendirir. (Studying the integral makes me angry.)	.774		
	18	İntegral çalışırken kaygılı hissederim. (I feel anxious while studying the integral.)	.797		
	Explained Variance %				**28.08**
Attitude	3	İntegralde yeni bir problemi çözmeye çalışırken kendimi iyi hissederim (I feel good while trying to solve a new problem about the integral.)		.515	
	4	Derste çözümü yarım kalan ya da ödev verilen integral problemleriyle uğraşmak bana zevk verir. (It gives me pleasure to deal with integral problems which remained unfinished in the lesson or given as homework.)		.592	
	6	Boş zamanlarımda integral ile ilgilenirim. (In my spare time I deal with the integral.)		.702	
	9	*İntegral konusu üzerine çalışmayı isterim* (I want to work on the subject of the integral.)		.600	
	11	Karşılaştığım günlük hayat problemlerinde çözümünde integral kullanmak isterim. (I want to use the integral to solve daily life problems I have encountered.)		.620	
	13	*İntegral ile ilgili köşe yazısı, makale, tez araştırmaları okumayı severim.* (I like to read integral-related columns, articles, thesis research.)		.741	
	15	*İntegral ile ilgili problemler çözmekten büyük keyif alırım.* (I really enjoy solving problems about the integral.)		.552	
	20	*İntegral çalışmaya başlayınca bırakmak zor gelir.* (Once I start studying the integral it is hard to leave it.)		.678	
	Explained Variance %				**18.87**

Factor	Item No	Items	
Usefulness	2	*İntegrali iyi bilmek çalışma olanaklarımı artırır.* (Having good knowledge on the integral increases my studying opportunities.)	.652
	8	*İntegral konusunun mesleğime hiçbir katkısı olmadığını düşünürüm.* (I think that the integral has no contribution to my profession.)	.788
	12	*İntegral öğrenmek zaman kaybıdır.* (Integrals are a waste of time to learn.)	.585
	17	*İntegrali anlamaya çalışmak zaman kaybıdır.* (It is a waste of time to try to understand the integral.)	.591
	19	Meslek hayatımda integrali kullanacağımı düşünmem (I do not think that I will use the integral in my occupational life.)	.742
	Explained Variance %		**16.29**

After the EFA, the scale indicates a three-factor structure. The factor loadings of the 20 items in the scale on the factors vary between 0.515-0.824. Three factors in the scale explain 63.24% of the total variance.

The EFA results, the "anxiety" sub-scale consists of seven items and explains 28.08% of the total variance. The factor loadings of the items in the "anxiety" sub-scale range from 0.744 to 0.824. The "attitude" sub-scale consists of eight items and accounts for 18.87% of the total variance. The factor loadings of the items in the "attitude" sub-scale range from 0.515 to 0.741. The "usefulness" sub-scale consists of five items and accounts for 16.29% of the total variance. The factor loadings of the items in the "usefulness" sub-scale range from 0.585 to 0.788. The findings show that not only the scale can be used as it is, but also that the three-factor structure of the scale can be evaluated as three separate scales.

Confirmatory Factor Analysis

Followed by the EFA, a confirmatory factor analysis (CFA) was conducted to verify and determine the factor structure of the PCI scale. Fit indices obtained after the established method was solved with the CFA, perfect and acceptable fit criteria regarding these indices, and fit indices obtained from the CFA are shown in Table 2.

Table 2

CFA Results of Perception Scale for the Concept of Integral

Fit Index	Perfect Fit Values	Acceptable Fit Values	Values from CFA
χ^2/df	$0 \leq \chi^2/df \leq 2$	$2 \leq \chi^2/df \leq 3$	2.134
GFI	$.95 \leq$ GFI ≤ 1.00	$.90 \leq$ GFI $\leq .95$	.94
AGFI	$.90 \leq$ AGFI ≤ 1.00	$.85 \leq$ AGFI $\leq .90$	.89
CFI	$.95 \leq$ CFI ≤ 1.00	$.90 \leq$ CFI $\leq .95$	.97
NFI	$.95 \leq$ NFI ≤ 1.00	$.90 \leq$ NFI $\leq .95$	.96
RMSEA	$.00 \leq$ RMSEA $\leq .05$	$.05 \leq$ RMSEA $\leq .08$	.073
SRMR	$.00 \leq$ SRMR $\leq .05$	$.05 \leq$ SRMR $\leq .10$	.064

The minimum Chi-square value based on the CFA was χ^2=352.12, df=165, p<0.01, and the ratio of the Chi-square to the degree of freedom was 2.134, indicating a significant deviation from an acceptable fit (Pallant, 2007). It is believed that the deviation was due to the sample size. According to Table 2, fit index values are calculated as RMSEA = .073, GFI = .94, AGFI = .89, CFI = .97, NFI = .96 and SRMR = .064. A review of the other goodness-of-fit values demonstrated that the GFI, AGFI, RMSEA and SRMR values were in the acceptable fit range, and the CFI and NFI values were in the perfect fit range (Bentler & Bonett, 1980; Byrne & Campbell, 1999; Marsh, Hau, Artlet, Baumert & Peschar, 2006; Schermelleh-Engel & Moosbrugger, 2003). These values based on the CFA indicated that the data fit the three-factor structure as specified in the model. These values indicated that the observed factorial of the scale was compatible with the expected factorial. Factor loadings of the three-factor model and path diagram are presented in Figure 2.

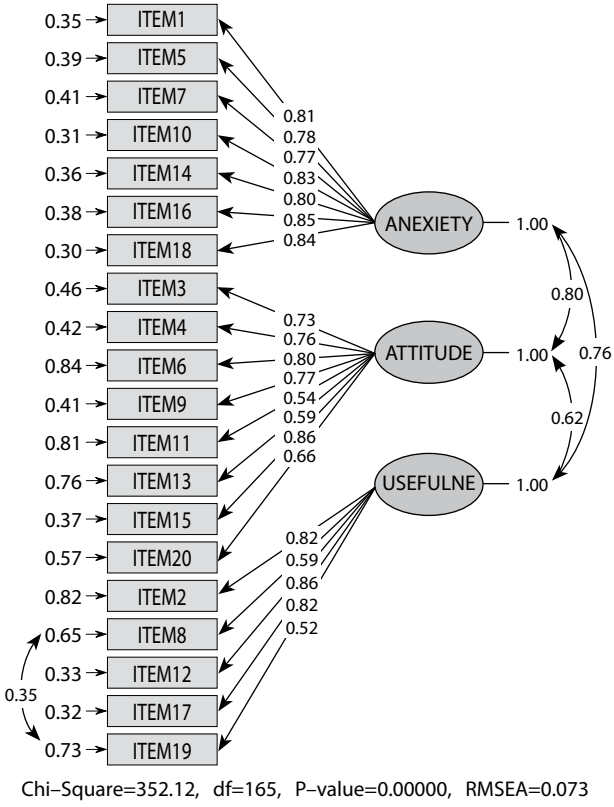

Figure 2. Path diagram and factor loads obtained from CFA regarding PCI scale

As seen in Figure 2, the factor loadings for the anxiety sub-dimension range from 0.77 to 0.85, from 0.54 to 0.86 for the attitude sub-dimension, and from 0.52 to 0.82 for the usefulness sub-dimension. The fact that no red arrows related to t-values are

available means that all items are significant (.05) (Jöreskog & Sörbom, 1996). No red arrows in t-values showed that all items were significant at the level of .05. It was decided to make modifications between items 8 and 19 in accordance with recommendations for modification in the conducted CFA. Modifications done in the model improved χ^2 and fit indexes (Şar, Ayas, & Horzum, 2015).

Construct Validity

Convergent and discriminant validity were for the construct validity that measures the three-factorial structure of the PCI scale. With respect to convergent validity, the average variance extracted (AVE) values were examined. For the convergent validity, the AVE values were as follows: Anxiety: .66, Attitude: .52, Usefulness: .55,. Since the values were greater than .50, the findings indicated an acceptable level of convergent validity (Bagozzi & Yi, 1988). For the discriminant validity, square roots of the AVE values were calculated (see the diagonal values in bold in Table 3). Fornel and Larcker (1981) stated that square root values higher than .50 and higher than the correlations between the other factors in the same column of each factor may be evidence for discriminant validity.

Table 3

CFA Results of Perception Scale for the Concept of the Integral

	Anxiety	Attitude	Usefulness
Anxiety	**.81**		
Attitude	.80	**.72**	
Usefulness	.76	.62	**.74**

Table 3 shows the correlations between the factors, in addition to the square roots of the AVE values. As can be seen in the table, the square root values are the greatest values in their respective columns, except for usefulness. Usefulness, however, is the domain with lower discriminant validity. These findings indicated that the discriminant validity of the instrument was acceptable.

Correlation Values between Factors of the Scale

Correlations between the factors of PCI Scale were examined with Pearson product-moment correlation. The factor correlation values of the scale are given in table 4.

When Table 4 is examined, it can be seen that correlations between total score and factor scores of the scale vary between -.903 and .885, and have a meaningful difference at the level of .01. These findings are qualified to demonstrate that relation and fit between factors of scale are high. Also, a relation in negative level was observed between the anxiety dimension and other dimensions of the scale while a relation in the positive level was observed between the attitude and usefulness dimensions.

Table 4
The factor correlation values of the scale

	Anxiety	Attitude	Usefulness	**Scale**
Anxiety	1			
Attitude	-.674**	1		
Usefulness	-.585**	.543**	1	
Scale	-.903**	.885**	.770**	1

Scale Reliability

The reliability of the integral PCI scale was examined by calculating the Cronbach's alpha internal consistency coefficient and CR alpha coefficient. Table 5 shows the Cronbach's alpha internal consistency and CR alpha coefficients.

Table 5
Reliability coefficients of the scale

Dimensions	N	Cronbach's α	CR α
Anxiety	7	.92	.93
Attitude	8	.87	.89
Usefulness	5	.81	.85
Scale	20	.93	.96

Cronbach's alpha coefficient calculated for the whole scale was .93. The coefficients for the factors were as follows: Anxiety: .92, Attitude: .87, Usefulness: .81, All these values were equal or greater than .81. There is not a certain rule of thumb for judging the Cronbach's alpha coefficients (Cho & Kim, 2015). It can be said that the higher the α coefficient, the more the items have shared covariance and probably measure the same construct. A value of .70 and higher is considered a cut-off point commonly accepted in social sciences (Robinson, Shaver & Wrightsman, 1991). Thus, it can be claimed that the instrument was reliable at an acceptable level.

The CR alpha coefficient calculated for the whole scale was .96. The coefficients for the factors were as follows: Anxiety: .93, Attitude: .89, Usefulness: .85, All these values were equal or greater than .85. Nunnally & Berstein (1994) point out that the coefficient of the CR alpha value should be 0.70 and above. Thus, it can be claimed that the instrument was reliable at an acceptable level. When internal consistency and composite reliability values are examined, it can be said that they produce consistent and reliable data.

Validity and reliability studies about the scale have been completed as a result of these findings.

Analysis of Scores from the Scale

The PCI scale consists of 20 items. A 5-point Likert scale was used with responses ranging from I Strongly agree (5), to I Strongly disagree (1). There are 12 reverse-scored items in the scale which are 1, 2, 5, 7, 8, 10, 12, 14, 16, 17, 18, 19. As there are

seven items in the anxiety sub-dimension, the lowest score that can be taken from this dimension is 7 and the highest score is 35. There are eight items in the attitude dimension. Therefore, the lowest score that can be taken from this dimension is 8 and the highest score is 40. Similarly, there are five items in the usefulness sub-dimension. For this reason, the lowest score that can be received from this dimension is 5 and the highest score is 25. The scale provides adequate fit indices in the CFA; the scale can be used as a whole or just for the sub-scale. Higher scores in sub-scales or overall scale indicate higher perception of the integral.

Discussion and Conclusion

Mathematics that is not limited only to numbers and operations has an unignorably significant place in daily life. It is desired that students attach importance to mathematics as a perceivable, useful, and worth-the-effort field, that they are enthusiastic about learning mathematics and that they enjoy dealing with it. However, students develop a negative attitude, anxiety, or fear towards mathematics in mathematics learning processes and are unaware of the use of mathematics in daily life (Ho, Senturk, Lam, Zimmer, Hong, Okamoto & Chiu, 2000). This situation is more frequently observed in the teaching process of mathematical concepts such as the integral considered "difficult" by students. It is important to identify existing states of students by measuring their anxiety and attitude levels with the aim to increase success in mathematics lessons. One might believe that it would dynamise the teaching processes further to conduct concept-specific evaluations in teaching by going deeper. For example, it will be important for application and assessment to know the effect of difficulty faced in teaching the integral concept and applications performed to overcome them by students learning the concept. The determinations of perceptions of students regarding the integral concept such as anxiety-attitude-daily life uses will contribute to the teaching process of the concept. When literature is examined, it is observed that there is no scale for the integral concept, although there are attitude-anxiety scales for mathematics. Besides, teaching processes are specialised for each concept or segment with innovations in the age of changing and developing technology. This has now brought along the necessity for making concept-specific applications in mathematics education. Therefore, it will be more accurate to use concept-specific scales in the assessment of teaching of a mathematical concept rather than using a "mathematics attitude or anxiety scale".

Scale development is a subject that has certain, rather specific rules and requires expertise (Hambleton & Patsula 1999). Research conducted without considering scale development processes may result in several negative consequences, such as waste of effort and time, scientific errors, or scientific mistakes caused by the use of scales by different researchers. Therefore, scale development should be carried out carefully and by adhering to the set rules (Cohen & Swerdlik, 2010; Crocker & Algina, 1986). In the PCI scale development process, the aim has been to develop a valid and reliable measurement tool by considering scale development steps (Clark & Watson,

1995; DeVellis, 2003). As a result of the research, the Perception for the Concept of Integral Scale consisting of 20 items and three factors (anxiety, attitude, usefulness) with a 5-point Likert type was developed. At different stages of the research, expert opinions have been taken from experts in mathematics education, assessment and evaluation, and Turkish education. Exploratory (EFA) and confirmatory (CFA) factor analysis for factor validity, discriminant and convergent validity analyses for construct validity, criterion validity, internal consistency, and composite reliability have been fully implemented by applying the scale to 349 mathematics education students for the EFA and to 216 mathematics education students for the CFA. The PCI scale can be used as a whole or just for the sub-scale.

As a result of the research, validity and reliability studies that aim to determine students' perception for anxiety-attitude for the integral concept and use of the integral in daily life, have been carried out and an integral PCI scale has been developed. The researchers believe that the development of the PCI scale will be highly significant and have an important place in literature, mainly because it is the first scale in the accessible literature which can be used in the teaching process of the integral and because it will bring forward the idea of need for development of concept-specific scales in mathematics education. In this context, it is thought that this scale can be used in future research, as it will determine perceptions of anxiety, attitude, and use in the daily life of students who are learning the concept of the integral. It is thought that it can be adapted for student groups at the level of secondary education in order to increase the usability and prevalence of the scale. In addition, perception scales of similar scope can also be developed for mathematical concepts such as limits-derivatives-series, which are regarded as difficult by the students, not unlike the integral concept.

Acknowledgement

This work is part of the doctoral dissertation prepared by the first author under the direction of the second author.

References

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the academy of marketing science*, *16*(1), 74-94. https://doi.org/10.1007/BF02723327

Baki, A., & Bell, A. (1997). *Ortaöğretim matematik öğretimi*. Ankara: YÖK

Bandura, A., (1997). *Self-Efficacy: The Exercise of Control*. ABD: W.H. Freeman and Company.

Barber, P. J., & Legge, D. (2017). *Perception and Information*. New York. Routledge. https://doi.org/10.4324/9781315534459

Bentler, P.M., & Bonett, D.G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin, 88*, 588-60. https://doi.org/10.1037/0033-2909.88.3.588

Betz, N. E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of Counseling Psychology*, 25(5), 441-448. http://dx.doi.org/10.1037/0022-0167.25.5.441

Bryman, A. & Cramer, D. 1999. *Quantitative Data Analysis with SPSS Release 8 for Windows.* Routledge.

Büyüköztürk, Ş. (2013). *Sosyal bilimler için veri analizi el kitabı: İstatistik, araştırma deseni, SPSS uygulamaları ve yorum.* (18th ed.). Ankara: Pegem Akademi Yayıncılık.

Byrne, B. M., & Campbell, T. L. (1999). Cross-cultural comparisons and the presumption of equivalent measurement and theoretical structure: A look beneath the surface. *Journal of Cross-Cultural Psychology*, *30*(5), 555-574.

Camacho, M., Depool, R., & Santos-Trigo, M. (2009). Students' use of *Derive* software in comprehending and making sense of definite integral and area concepts. *CBMS Issues in Mathematics Education,* 16, 35-67

Campbell K., & Evans C. (1997). Gender issues in the classroom: A comparison of mathematics anxiety. *Education*, 117 (3), 332-339.

Capar, G., & Kamuran, T. (2015). Efficacy of the Cooperative Learning Method on Mathematics Achievement and Attitude: A Meta-Analysis Research. *Educational Sciences: Theory and Practice*, 15(2), 553-559.

Carraway, C., (1987). *Determining the relationship of nursing test scores and test-anxiety levels before and after a test-taking strategy seminar*. (ERIC Document Reproduction Service No. ED 318 498)

Cho, E., & Kim, S. (2015). Cronbach's coefficient alpha: Well known but poorly understood. *Organizational Research Methods, 18*(2), 207-230. https://doi.org/10.1177/1094428114555994

Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment*, 7(3), 309-319. https://doi.org/10.1037/1040-3590.7.3.309

Cohen R. J., & Swerdlik M.E. (2010). *Psychological testing and assessment*. Boston: McGraw-Hill Companies

Comrey, A. L., & Lee, H.L. (1992). *A first course in factor analysis,* Hillsdale, New Jersey: Erlbaum

Corinne A., & Hilary P. (1999). One Teacher and a Class of School Students: Their perception of the culture of their mathematics classroom and its construction, *Educational Review,* 51:2, 147-160, https://doi.org/10.1080/00131919997588

Crocker, L., & Algina, J. (1986). *Introduction to classical and modern test theory*. New York: Holt, Rinehart and Winston, Inc

Çüm, S. & Koç, N. (2013). Türkiye'de psikoloji ve eğitim bilimleri dergilerinde yayımlanan ölçek geliştirme ve uyarlama çalışmalarının incelenmesi, *Eğitim Bilimleri ve Uygulama*, 12 (24), 115-135

DeVellis, R. F. (2003). *Scale development: theory and applications* (2nd ed. Vol. 26). Thousand Oaks, CA: Sage Publications

Di Martino, P., & Zan, R. (2010). 'Me and maths': towards a definition of attitude grounded on students' narratives. Journal Math Teacher Education. 13:27–48. https://doi.org/10.1007/s10857-009-9134-z

Elmore, P. B., & Vasu, E. S. (1980). Relationship between selected variables and statistics achievement: Building a theoretical model. *Journal of Educational Psychology*, 72, 457–467. https://doi.org/10.1037/0022-0663.72.4.457

Ergene, Ö. (2014). İntegral hacim problemleri çözüm sürecindeki bireysel ilişkilerin uygulama topluluğu bağlamında incelenmesi (Master's thesis). Marmara Üniversitesi in İstanbul.

Erkuş, A. (2012). *Psikolojide ölçme ve ölçek geliştirme-1: Temel kavramlar ve işlemler*. Ankara: Pegem Akademi.

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman Mathematics Attitude Scale: instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education,* 7(5), 324–326. https://doi.org/10.2307/748467

Ferrini-Mundi, J. & Graham, K. (1994) Research in calculus learning: understanding of limits, derivatives and integrals. In J. J. Kaput & E. Dubinsky (eds.),*Research Issues in Undergraduate Mathematics Learnin*g, MAA (Notes 33,pp.31-45). Washington DC: MAA.

Field, A. (2009). *Discovering Statistics Using SPSS: Introducing Statistical Method (3rd ed.).* Thousand Oaks, CA: Sage Publications.

Fornell, C., & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. *Journal of marketing research,* 382-388. https://doi.org/10.2307/3151312

Freedman. J. L., Sears, D. O. & Carlsmith J. M. (1978). *Social Psychology*, (3rd ed) Englewood Cliffs, NJ: Prentice-Hall, Inc.

Fulkerson, K. F., Galassi, J. P., & Galassi, M. D. (1984). Relation between cognitions and performance in math anxious students: A failure of cognitive theory. *Journal of Counseling Psychology, 31*(3), 376-382. https://doi.org/10.1037/0022-0167.31.3.376

Hair, J. F., Jr., Black, W. C., Babin, B. J. & Anderson, R. E. (2005*). Multivariate data analysis* (6th ed.). NY: Prentice Hall

Hambleton, R.K. & Patsula, L. (1999). Increasing the validity of adapted tests: Myths to be avoided and guidelines for improving test adaptation practices. *Journal of Applied Testing Technology*, 1(1), 1-30.

Heid, M. K. (2003). *Theories for thinking about the use of CAS in teaching and learning mathematics.* In J. T. Fey, A. Cuoco, C. Kieran, L. McMullin, & R. M. Zbiek (Eds.), Computer algebra systems in secondary school mathematics education (pp.33-52). Reston, VA: National Council of Teachers in Mathematics.

Hembree, R. (1990). The Nature, Effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education.* 21(1), 33-46. https://doi.org/10.2307/749455

Ho, H., Senturk, D., Lam, A.G., Zimmer, J. M., Hong, S., Okamoto, Y., & Chiu, S. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research in Mathematics Education,* 31(3), 365-379. https://doi.org/10.2307/749811

Judd, C. M., Eliot, E. R, & Kidder, H. (1991) *Research methods in social relations*. New York: Harcourt Brace Jovanovich College PupHshers.

Kline, R. B. (2005*). Principles and practice of structural equation modeling (2nd ed.)*. Guilford Press, New York

Kung, Hsin-Yi, (2009). Perception or Confidence? Self-Concept, Self-Efficacy and Achievement in Mathematics: a longitudinal study. *Policy Futures in Education*. Volume 7 Number 4. 387-397. https://doi.org/10.2304/pfie.2009.7.4.387

Lee, S. Y., & Song, X. Y. (2004). Evaluation of the Bayesian and maximum likelihood approaches in analyzing structural equation models with small sample sizes. *Multivariate Behavioral Research*, 39, 653-686. https://doi.org/10.1207/s15327906mbr3904_4

Ma, X., & Xu, J. (2004). The Causal Ordering of Mathematics Anxiety and Mathematics Achievement: A Longitudinal Panel Analysis. *Journal of Adolescen*ce, 27 (2), 165-179. https://doi.org/10.1016/j.adolescence.2003.11.003

Marsh, H.W., Hau, K.T., Artelt, C., Baumert, J., & Peschar, J.L. (2006). OECD's brief selfreport measure of educational psychology's most useful affective constructs: Crosscultural, psychometric comparisons across 25 countries. *International Journal of Testing, 6*(4), 311-360. https://doi.org/10.1207/s15327574ijt0604_1

Ministry of National Education (MoNE). (2018). *Ortaöğretim Matematik Dersi 9–12 Öğretim Programı*. Talim Terbiye Kurulu Başkanlığı, Ankara.

Nunnally, J.C. (1978), *Psychometric theory,* NewYork: McGraw Hill.

Nunnally, J. C., & Bernstein, I. H. (1994) *Psychometric theory* (3rd ed.). New York, NY: McGraw-Hill, Inc

Orton, A. (1983). Student's Understanding of integration. *Educational Studies in Mathematics*, 14(1), 1-18. https://doi.org/10.1007/BF00704699

Pallant, J. (2007). *SPSS survival manual*. New York, NY: Mc Graw Hill.

Rasslan, S. & Tall, D. (2002). Definitions and images for the definite integral concept. In Cockburn A., Nardi, E. (Eds.). Proceedings of the 26th PME, 4, 89-96. Orton, A. (1983). Student's Understanding of integration. *Educational Studies in Mathematics*, 14(1), 1-18. https://doi.org/10.1007/BF00704699

Ryan, J. (1998). Teacher devolopment and use of portfolio assesment strategies and ımpect on ınstruction in mathematics. (Doctoral dissertation). Standford University in USA.

Roberts, D. M., & Reese, C. M. (1987). A comparison of two scales measuring attitudes toward statistics. *Educational and Psychological Measurement*, 47, 759–764. https://doi.org/10.1177/001316448704700329

Robinson, J. P., Shaver, P. R. & Wrightsman, L. S. (1991). *Measures of personality and social psychological attitudes.* CA: Academic Press, San Diego

Rounds, J.B. & Hendel, D.D. (1980). Measurement and Dimensionality of Mathematics Anxiety. *Journal of Counseling Psychology*, 27 (2), 138-149. https://doi.org/10.1037/0022-0167.27.2.138

Schermelleh-Engel, K., & Moosbrugger, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research Online, 8*(2), 23-74

Sealey, V. (2008). *Calculus Students' Assimilation Of The Riemann Integral Into A Previously Established Limit Structure.* (Doctoral dissertation). Arizona: Arizona State University in USA.

Sevimli, E. (2013). *Bilgisayar Cebiri Sistemi Destekli Öğretimin Farklı düşünme Yapısındaki Öğrencilerin İntegral Konusundaki Temsil Dönüşüm Süreçlerine Etkisi.* (Doctoral dissertation). Marmara Üniversitesi in İstanbul.

Şar, A. H., Ayas, T., & Horzum, M. B. (2015). Developing the smart phone addiction scale and its validity and reliability study. *Online Journal of Technology Addiction & Cyberbullying*, 2(3), 1–17.

Tapia, M., & Marsh, G. E. (2004). The relationship of math anxiety and gender. *Academic Exchange Quarterly*, 8(2), 130-134.

Taylor, K., & S. Walton. (1997). Co-opting standardized tests in the service of learning. *Phi Delta Kappan* 66–70.

Tezbaşaran, A. (2008). *Likert tipi ölçek hazırlama kılavuzu*. Ankara: Türk Psikologlar Derneği Yayınları.

Tobias, S. (1990). Math anxiety: an update. NACADA Journal, 10 (1), 47-50. https://doi.org/10.12930/0271-9517-10.1.47

William L., & Hall, Jr. (2010). Student Misconceptions of the Language of Calculus: Definite and Indefinite Integrals. In Proceedings of the 13th Annual Conference on Research in Undergraduate Mathematics Education. From http://sigmaa.maa.org/rume/crume2010/Archive/Hall.pdf

Wilson, S. (2018). Understanding Maths Anxiety In Pre-Service Teachers Through A Quality Of Life Framework. *International Journal of Child, Youth and Family Studies*. 9(4): 168–187. https://doi.org/10.18357/ijcyfs94201818646

Vattanapath, R., & K. Jaiprayoon. (1999). An assessment of the effectiveness of teaching test-taking strategies for multiple-choice English reading comprehension test. *Occasional Papers* 8: 57–71.

Zettle, R. & Raines, S. (2000). The relationship of trait and text anxiety with mathematics anxiety. *College Student Journal*, 34 (2), 246.

Özkan Ergene
Department of Mathematics Education
Faculty of Education
Sakarya University,
54300 Hendek, Sakarya, Turkey
ozkanergene@gmail.com

Ahmet Şükrü Özdemir
Atatürk Faculty of Education
Marmara University
34722 Kadıköy, Istanbul, Turkey
ahmet.ozdemir@marmara.edu.tr

Razvoj percepcijskih ljestvica za pojam integrala

Sažetak

Primjene konceptualnoga poučavanja u nastavi Matematike utječu na učeničku percepciju glede samog pojma koji se poučava, kao i na promjene u pogledu njihovog straha od matematike i stavu o matematici. Stoga se u literaturi naglašava činjenica da ne postoji dovoljno ljestvica za pojedine pojmove, a koji se tiču mjerljivih varijabli u nastavi Matematike kao što su stavovi ili strah od matematike. Cilj ovoga istraživanja jest razviti valjan i pouzdan alat za mjerenje stavova, straha i korisnosti u odnosu na učeničke percepcije pojma integrala. Podatci korišteni u ovome istraživanju, u kojemu su pomno odijeljene razvojne faze ljestvice, prikupljeni su od 565 studenata odgojno-obrazovnih programa matematike za osnovnu i srednju školu na tri različita javna sveučilišta u turskoj regiji Marmara, a koji su u svojoj nastavi Matematike učili o pojmu integrala. Primijenjena ljestvica potvrđena je sljedećim: stručnim mišljenjima o sadržajnoj valjanosti, eksplorativnom faktorskom analizom (EFA) i konfirmativnom faktorskom analizom (CFA) za faktorsku valjanost, analizom diskriminantne i konvergentne valjanosti za konstruktnu i kriterijsku valjanost te postupcima interne konzistencije i kompozitne pouzdanosti. Istraživanjem smo razvili Percepcijsku ljestvicu za pojam integrala (PCI ljestvicu) koja sadrži 20 tvrdnji i tri faktora (strah, stav, korisnost) s Likertovom ljestvicom od 5 stupnjeva. Smatramo da će ovo istraživanje doprinijeti postojećim saznanjima na ovome području s obzirom da u relevantnoj literaturi trenutačno ne postoji neka druga ljestvica za mjerenje učeničkih percepcija o pojmu integrala. Zbog manjka pojmovno temeljenih mjernih ljestvica u literaturi o nastavi Matematike, ovim istraživanjem također se promiče ideja o nužnosti razvoja pojmovno temeljenih mjernih ljestvica.

Ključne riječi: *integral; korisnost; razvoj mjerne ljestvice; stav; strah*

Uvod

Zahvaljujući utjecaju tehnološkoga razvoja u suvremenome svijetu, odgojno-obrazovni sustavi također se razvijaju, a odgojno-obrazovna filozofija, strategije poučavanja kao i metode i tehnike se mijenjaju. U nastavi Matematike, procesi učenja i poučavanja reformiraju se zbog utjecaja navedenih promjena te je namjera obrazovati pojedince koji imaju pozitivan stav prema matematici i primjeni matematike, koji imaju bolje vještine rješavanja problema, i koji su usvojili matematički način razmišljanja te vještine primjene, i koji mogu učinkovito i korisno upotrebljavati matematiku u svakodnevnome

životu (MoNE, 2018, str. 10-12). Ovi ciljevi pretpostavljaju da promišljanje o teorijskim poteškoćama nekog matematičkog pojma ne bi trebalo negativno utjecati na nastavni proces, da bi učenici trebali razviti pozitivan stav prema tom pojmu te biti svjesni njegove primjene u svakodnevnom životu (Ryan, 1998). Navedene pretpostavke trebale bi se koristiti tako da učenici imaju dojam da pojmovi koji se uče u matematici nisu teški te da oni pojmovi koji se opisuju kao apstraktni imaju primjenu u svakodnevnome životu. Dakle, učenici koji u nastavnom procesu iskazuju pozitivan stav i nisku razinu straha od nekog pojma, bit će spremniji sudjelovati, što bi moglo pozitivno utjecati na konačnu uspješnost.

Nekoliko istraživanja provedenih posljednjih godina pokazala su da od osnovne škole pa sve do fakulteta neki učenici na matematiku reagiraju strahom, mržnjom i tjeskobom (Betz, 1978; Campbell & Evans, 1997; Di Martino & Zan, 2010; Fennema & Sherman, 1976; Hembree, 1990; Ma & Xu, 2004; Tobias, 1990; Zettle & Raines, 2000). Strah od matematike podrazumijeva napetost i bojazan, što onemogućuje razumijevanje obrađenih tema (Fulkerson, Galassi & Galassi, 1984). Istraživanja o učenju matematike tvrde da zbog straha od matematike učenici izbjegavaju matematiku te bilježe lošiji uspjeh (Rounds & Hendel, 1980, str. 138). Nadalje, vidljivo je da oni učenici koji imaju razvijen negativan stav prema matematici, imaju problema s uspjehom upravo zbog straha od matematike (Tapia, Martha, Marsh, & George, 2004). Smanjenje straha poboljšava učenički stav prema učenju općenito te ih motivira (Carraway, 1987; Taylor & Walton, 1997; Vattanapath & Jaiprayoon, 1999). Odnos između straha i stava odražava se i na učenje i na poučavanje. Znanstvenici već dugo istražuju učinke i posljedice ovoga fenomena.

Riječ je, naime, o stanju mentalne i neuralne pripreme, do kojega se dolazi nakon usvojenih stavova i iskustava, a s izravnim i dinamičkim učinkom na ponašanje pojedinca prema predmetima ili situacijama koje ga zanimaju (Freedman, Sears & Carlsmith, 1978, str. 278). Slijedom toga, vrlo je visoka vjerojatnost da će neki učenik razviti ili pozitivan ili negativan stav prema matematici na osnovi iskustava s nastave Matematike. U istraživanjima stavova osnovnoškolskih i srednjoškolskih učenika, stavovi prema matematici mjere se ljestvicama stavova prema matematici te su primjetne značajne razlike u stavovima prema matematici prema različitim varijablama (Bandura, 1997; Capar & Tarım, 2015; Elmore & Vasu, 1980; Roberts & Reese, 1987). Nemogućnost shvaćanja ili objašnjavanja važnosti nastave Matematike te njezine svakodnevne uporabe predstavlja problem u samom poučavanju.

Percepcija je primanje, selekcija, usvajanje, transformacija i organizacija informacija koje dobivamo osjetilima. Tiče se vida, sluh njuha, okusa, dodira i još mnogo toga (Barber & Legge, 2017, str. 7). Znanstvena istraživanja percepcije (Angier & Povey, 1999; Kung, 2009; Wilson, 2018) često se provode upravo na području nastave Matematike i u tim istraživanjima „percepcija" se koristi kao kombinacija apekata kao što su promišljanje, veza između ideja, značenja i osjetila. U ovome istraživanju, percepcija

pojma integrala gradi se kao konstrukt koji uključuje strah i stav pojedinca o pojmu integrala te razinu osviještenosti prema uporabi integrala u svakodnevnome životu.

Činjenica da se matematičke pojmove smatra apstraktnima premda nas matematika okružuje u gotovo svakome dijelu našega svakodnevnog života (Baki & Bell, 1997, str. 34) odaje dojam da je učenicima nemoguće samostalnim učenjem razumjeti matematičke pojmove. Ovakva situacija vodi do negativnih fenomena kao što su učenička nevjerica glede samostalnoga učenja matematičkih pojmova te vjerovanje da nisu dovoljno inteligentni ili sposobni pojmiti teške pojmove. U nastavi Matematike istraživanja koja proučavaju primjenu kao što je uporaba materijala, digitalizirane nastave, vizualizacije i modeliranja, osobito u nastavnom procesu u kojemu se obrađuju pojmovi koje učenici doživljavaju teškima, vrlo se često proučavaju učinci tih negativnih stavova. Primjerice, istraživanja u kojemu se koriste softveri (Sevimli, 2013; Camacho, Depool & Santos-Trigo, 2009; Heid, 2003) kao što su *Computer Algebra System* (CAS) ili *Geogebra*, odnosno svakodnevni problemi i višestruki prikaz (Sealey, 2008) u literaturi pokazuju da učenici opisuju pojam integrala kao težak (Ergene, 2014).

Pojam integrala izražen kao temelj nastave Matematike i računanja (William & Hall, 2010) zastupljen je u kurikulima srednje škole te na dodiplomskoj i poslijediplomskoj razini visokoga obrazovanja. Pojam integrala ima široku primjenu, a povezan je s drugim pojmovima kao što su međa, derivacija te stopa promjene, a s razumijevanjem kojih učenici i studenti imaju poprilično problema.

Kada se pomnije prouče znanstvena istraživanja pojma integrala, jasno je da je većina provedena na razini visokoga obrazovanja, u sklopu nastave Matematike te da predstavlja kognitivne poteškoće u procesu razumijevanja (Sevimli, 2013). Brojni znanstvenici bavili su se poteškoćama u shvaćanju pojma integrala, koji je neizostavno zastupljen u matematičkim kolegijima. Kao primjeri mogu poslužiti slike pojam-definicija-pojam, kao što su opis neodređenoga integrala kao i suprotnost derivacije funkcije i određenoga integrala kao područje ispod krivulje te pogrešno poimanje ili izazovi kontekstualnih problema koji se tiču uporabe u svakodnevnome životu. Vrlo je lako izvesti zaključak da zbog ovakvih situacija učenici i studenti opisuju pojam integrala kao težak te osjećaju strah, oklijevanje i razvijaju negativan stav o tom pojmu te nisu svjesni njegove uporabe u svakodnevnome životu.

Da zaključimo, za nastavni proces ovoga pojma bit će značajno utvrditi učeničke strahove i stavove, koji su središnji u nastavi pojma integrala, pojma vrlo važnoga na području nastave Matematike, o integralu, kao i njihove percepcije o uporabi integrala u svakodnevnome životu. Za učenike čije su percepcije integrala utvrđene, nastavni proces će se prilagoditi, a postojeća stanja učenika i studenata vrednovati iz različitih perspektiva. Primjerice, primjeri s problemima iz svakodnevnoga života u vezi s ovim pojmom ili nastavni proces koji uključuje pojmovno shvaćanje, mogu se primijeniti na učenike koji iskazuju visoku razinu straha prema integralu te smatraju da se on ne može koristiti u svakodnevnome životu. Proces rješavanja svakodnevnih problema puno je složeniji od ostalih vrsta problema. Zapravo bi ova situacija procesa rješavanja

problema mogla utjecati na razinu straha i stavove studenata. Kao još jedan primjer, kod učenika i studenata s visokom razinom straha od integrala može se planirati nastavni proces u kojemu se poučava povijest integrala.

Utvrđeno je da se gotovo sve ljestvice poznate u relevantnoj literaturi koje se tiču stavova i straha o poučavanju matematike razvijaju upravo za matematiku i nastavu Matematike. Rezultati dobiveni tim ljestvicama oslikavaju općenitu sliku u pogledu sadržaja i opsega matematike i nastave Matematike. U biti, primjena pojmovno temeljene nastave Matematike esencijalno mijenja učeničku percepciju pojma koji se poučava, kao i njihovu razinu straha i stav o matematici. Primjerice, znanstvenik koji provodi aplikaciju integrala trebao bi preferirati ljestvicu pripremljenu baš za pojam integrala, a ne ljestvicu stavova o matematici želi li proučiti kako ta aplikacija utječe na učenički strah ili stavove jer već i samo provođenje istraživanja može promijeniti percepciju o pojmu integrala. Stoga je primjetno da u literaturi nema dovoljno pojmovno određenih ljestvica vezanih uz nastavu Matematike kojima bi se mjerile varijable kao što su stavovi i strah. Zbog svih navedenih razloga, cilj ovoga istraživanja jest razviti valjan i pouzdan mjerni alat za mjerenje učeničkih stavova i strahova koji se tiču integrala i njegove korisnosti.

Važnost istraživanja

Smatramo da će ovo istraživanje doprinijeti postojećoj literaturi s obzirom na to da u međunarodnoj relevantnoj literaturi nema ljestvice kojom bi se mjerila učenička percepcija pojma integrala. Također, ovo istraživanje ima poseban značaj jer će osvijestiti ideju „nužnosti razvoja pojmovno temeljene ljestvice na području nastave Matematike" i to razvojem Percepcijske ljestvice za pojam integrala (PCI ljestvice).

Metodologija

Svrha ovoga istraživanja jest izraditi PCI ljestvicu. U ovome dijelu predstavljen je uzorak i razvojne faze ljestvice.

Uzorak

Uzorak korišten u istraživanju sastoji se od 565 studenata nastavničkoga smjera matematike za osnovnoškolsko i srednjoškolsko obrazovanje pri tri različita javna sveučilišta u regiji Marmara. Pri utvrđivanju uzorka sveučilišnih studenata nastavničkoga smjera matematike za osnovnoškolsko i srednjoškolsko obrazovanje, voditelji istraživanja pazili su da odaberu studente koji su slušali kolegij u kojemu je bio zastupljen pojam integrala. Na sveučilištu A u istraživanju je sudjelovao 191 student, njih 158 na sveučilištu B i 216 na sveučilištu C. Važno je napomenuti da njih 398 studira matematiku za osnovnu školu, dok ih 167 studira matematiku za srednju školu. Podatci izvedeni za studente sveučilišta A i B korišteni su za eksplorativnu faktorsku analizu (EFA), a podatci izvedeni za studente sveučilišta C za konfirmativnu faktorsku analizu (CFA) znanstveno-istraživačkoga procesa.

Postupak

PCI ljestvica

Razvijena prema svrsi ovoga istraživanja, PCI ljestvica ima trofaktorsku strukturu, odnosno sastoji se od tri dimenzije: strah, stav i korisnost, a sadrži 20 tvrdnji koje su finalizirane nakon studije valjanosti u kojoj su sudjelovali sveučilišni studenti. Ljestvica je u biti Likertova ljestvica od 5 stupnjeva s rasponom odgovora od 1 do 5: „U potpunosti se slažem (5), Slažem se (4) Neutralan sam (3) Ne slažem se (2) Nimalo se ne slažem (1)". Brojčani rezultati ljestvice variraju od 20 do 100. Ljestvica sadrži i 12 tvrdnji s obrnutim bodovanjem, a to su 1, 2, 5, 7, 8, 10, 12, 14, 16, 17, 18 i 19.

Postupak izrade PCI ljestvice i analiza podataka

Odlučeno je razviti PCI ljestvicu u obliku Likertove ljestvice temeljene na modelu „ljestvice s bodovanjem" (Judd, Eliot & Kidder, 1991) koji je osmislio Rennis Likert (1932). Likertova ljestvica je praktična te daje mjerljive rezultate na ljestvici jednakih intervala kako se povećava razina ocjene; to su bili razlozi za odabir ove ljestvice (Tezbasaran, 2008, str. 5).

Postupak koji slijedi nastao je nakon stvaranja skupa tvrdnji te studija valjanosti i pouzdanosti (EFA-CFA).

Slika 1.

Nakon što su proučena razmišljanja o tome kako uobličiti skup tvrdnji i od koliko tvrdnji će se ljestvica sastojati, predložen je pregled literature, opservacije i intervjui s ciljnom skupinom (Erkus, 2012, str. 24-41) te je predloženo da bi se ljestvica, ako je to moguće, trebala sastojati od dva do tri puta većeg broja tvrdnji od onoga koji će se upotrijebiti na konačnoj ljestvici (Tezbasaran, 2008, str. 14-15). U skladu s navedenim naputcima za kreiranje skupa tvrdnji, prvo je izvršen pregled literature na temelju pojmova stavova i straha te uporabe matematičkih pojmova u svakodnevnom životu. Zatim su pregledane postojeće ljestvice o temi stavova i straha te uporabe u svakodnevnom životu osmišljene za područje odgoja i obrazovanja te nastave Matematike. Nakon toga ispitana su stajališta sedam slučajno odabranih sveučilišnih studenata nastavničkoga smjera matematike o pojmu integrala. Studenti su zamoljeni da pismeno odgovore na sljedeća pitanja: „Što misliš o pojmu integrala?", „Kako se osjećaš u vezi s integralima?" te verbalno „Što napraviš kad se susretneš s pojmom integrala?". Zatim, imajući u vidu iskustva znanstvenika o integralima te dodiplomsko i poslijediplomsko iskustvo prvog autora ovoga članka, osmišljen je skup od 51 tvrdnje.

Mišljenje stručnjaka radi sadržajne valjanosti dobiveno je tako da je cilj razvoja ljestvice objašnjen, a tvrdnje pokazane dvojici kolega koji imaju doktorat s područja nastavničkoga smjera matematike i istraživali su pojam integrala te jednom kolegi koji ima završen dodiplomski studij iz nastavničkoga smjera matematike i doktorat s područja vrednovanja i ocjenjivanja. U skladu s mišljenjima koja su kolege izrazili, osam tvrdnji sličnoga značenja, odnosno one koje su bile teško razumljive, isključeno je s popisa te

je izrađen prijedlog ljestvice od 43 tvrdnje. Mišljenja stručnjaka u pogledu lingvističke, odnosno jezične valjanosti dobivena su tako što je ljestvicu pregledao stručnjak za vrednovanje i ocjenjivanje te kolega s doktoratom na području nastavničkoga smjera turskog jezika. U skladu s njihovim mišljenjima i kritikama, ljestvica od 43 tvrdnje uređena je i primijenjena na uzorku s ciljem provedbe eksplorativne faktorske analize (EFA) da bi se potvrdila valjanost i pouzdanost.

Naglašeno je da bi uzorak na koji će se primijeniti ova probna ljestvica nužno trebao biti prikladan za ciljanu populaciju, a u skladu s razvojnim ciljem ljestvice. Uzorak se sastojao od sveučilišnih studenata sa studija nastavničkoga smjera matematike budući da je razvojni cilj PCI ljestvice otkriti percepciju sveučilišnih studenata u vezi s pojmom integrala. Nametnula su se dva različita viđenja kako odrediti koliko studenata uključiti u uzorak, primjerice da bi trebalo biti najmanje pet puta više od broja tvrdnji na ljestvici (Hair, Black, Babin & Anderson, 2005), da je 300 ljudi dovoljno (Nunnally, 1978, str. 276) ili da je 100 osoba nereprezentativno, 200 prosječno, a 300 reprezentativno (Comrey & Lee, 1992). U skladu s navedenim preporukama, odlučeno je da će 349 studenata biti dovoljno za uzorak. Prilikom provjere ove probne ljestvice, pazilo se da je studenti ne rješavaju za vrijeme odmora ni pred kraj sata, a studentima je objašnjen cilj ove ljestvice. Zamoljeni su da pažljivo odaberu odgovore. Nije im zadano vrijeme rješavanja probne ljestvice, a prosječno vrijeme rješavanja variralo je od 15 do 20 minuta.

Nakon primjene probne ljestvice na uzorku, proveden je EFA radi provjere valjanosti i pouzdanosti tvrdnji uključenih u ljestvicu uporabom programa IBM SPS Statistics 20. Tijekom provedbe EFA, s popisa je isključeno 10 tvrdnji zbog Mahalanobisove udaljenosti ($p = 0.05$, sd: 20) i $z = (-3.00, 3.00)$ te u pogledu ukupnoga broja bodova odnosno rezultata. Prije provedbe EFA, prikladnost podataka uzetih iz uzorka radi analize provjerena je Keiser-Meyer-Olkin (KMO) testom i Bartlettovim testom sferičnosti. Kod faktorske valjanosti ljestvice, a prilikom određivanja tvrdnji koje će se uključiti u konačnu ljestvicu tijekom EFA, svojstvena vrijednost tvrdnji uzeta je kao 1, faktorsko opterećenje najmanje .30, tvrdnje koje su zauzimale jedan faktor i one koje su pokrivale dva faktora imale su najmanje .10 razlike (Buyukozturk, 203).

U skladu s određenim kriterijima, a kao rezultat EFA, iz probne ljestvice isključene su 23 tvrdnje, osmišljena je trofaktorska struktura s 20 tvrdnji te utvrđen konačni oblik i izgled ljestvice provjerene valjanosti i pouzdanosti. Nakon EFA, proveden je i CFA uporabom programskoga paketa Lisrel 8.7 radi procjene usklađenosti trofaktorske ljestvice s 20 tvrdnja te njezine potvrde.

Postoje različita viđenja kako odrediti koliko studenata uključiti u uzorak na koji će se primijeniti konačna ljestvica da bi se izvršila CFA. Primjerice, trebalo bi biti najmanje pet puta više od broja tvrdnji na ljestvici, tvrde Lee and Song (2004), dok Kline (2005) smatra da je 100 osoba nereprezentativno, 100-200 prosječno, a više od 200 reprezentativno. U skladu s navedenim preporukama, a kako se na konačnoj ljestvici nalazi 20 tvrdnji, odlučeno je da će 216 studenata biti dovoljno za uzorak. Studenti

koji su rješavali konačnu ljestvicu bili su odabrani s različitoga sveučilišta kako bi se razlikovali od studenata koji su popunjavali probnu ljestvicu. Prilikom primjene konačne ljestvice, pazilo se da je studenti ne rješavaju za vrijeme odmora ni pred kraj sata, a studentima je objašnjen cilj ove ljestvice. I oni su zamoljeni da pažljivo odaberu odgovore. Nije im zadano vrijeme rješavanja konačne ljestvice, a prosječno vrijeme rješavanja variralo je od 10 do 15 minuta.

Provjerene su Cook i Leverage vrijednosti radi utvrđivanja pokazuje li skup podataka iz konačnog oblika ljestvice multivarijatnu normalnu distribuciju te radi određivanja rubnih vrijednosti. Pokazalo se da skup podataka iz konačnog oblika ljestvice ne pokazuje multivarijatnu normalnu distribuciju niti rubnu vrijednosti. Ispitan je i ZPRED-ZRESID dijagram razmještaja radi provjere postojanja linearnih odnosa među varijablama te je utvrđeno da linearni odnosi postoje. Korelacijski koeficijent izračunat za odnos između tvrdnji također je pregledan te je utvrđeno da ne postoji vrijednost iznad .80, dakle nisu utvrđeni problemi s višestrukim poveznicama. Nakon provjere svih navedenih premisa, utvrđeno je da se može provesti CFA. Na kraju su provjerene konvergentna i diskriminantna valjanost radi utvrđivanja valjanosti strukture ljestvice.

S ciljem procjene pouzdanosti ljestvice provedena je metoda interne konzistencije. Izračunati su Cronbachov alfa koeficijent interne konzistencije i kompozitne pripadnosti radi procjene pouzdanosti uporabom metode interne konzistencije.

Jake strane istraživanja i njegova ograničenja

Ovo se istraživanje smatra vrlo jakim jer sadrži procese koji se moraju primijeniti kod razvoja i adaptacije ljestvice (Çüm & Koç, 2013), kao i tipove valjanosti (izgled, sadržaj, kriterije, konstrukt, konvergentna i diskriminantna valjanost). Međutim, iako su provedene određene analize pouzdanosti, njegovo ograničenje donekle nalazimo u činjenici da nije proveden test i ponovljeni test u pogledu konzistencije, a nije provjerena ni valjanost teorijom odgovora na tvrdnje.

Rezultati

U ovome dijelu predstavljeni su rezultati studije valjanosti i pouzdanosti nakon primjene PCI ljestvice na 565 sveučilišnih studenata.

Eksplorativna faktorska analiza

Ljestvica je procijenjena koristeći EFA. Prije provedbe EFA, potrebno je odrediti je li skup podataka prikladan za faktorsku analizu, što se utvrđuje Kaiser-Meyer-Oklin (KMO) testom i Bartlettovim testom sferičnosti. Stoga su prije provedbe EFA provedeni KMO i Bartlettov test. Raspon KMO je od 0 do 1, a vrijednosti KMO iznad 0.5 smatraju se prihvatljivima (Field, 2009, str. 647). Rezultati su pokazali KMO mjeru prikladnosti uzorka od 0.914 (KMO = 0.914), vrijednost veću od 0.70, ukazujući da je veličina uzorka prikladna za faktorsku analizu (Bryman & Cramer, 1999). Bartlettov test sferičnosti pokazao je rezultat $p<.001$, što ukazuje da je faktorska analiza prikladna

(Bryman & Cramer, 1999). Prema navedenim rezultatima, može se zaključiti da su podatci prikladni za faktorsku analizu. Nakon što su tvrdnje koje će se uključiti u instrument utvrđene kao posljedica EFA za faktorsku valjanost ljestvice, primijećeno je da su svojstvene vrijednosti faktora u koje su raspoređene tvrdnje na ljestvici 1 i više, a faktorska opterećenja 0.30 i više. Nadalje, zapaženo je da su materijali uključeni u pojedine faktore ili da između faktorskih opterećenja tvrdnji postoji razlika od najmanje 0.10 (Buyukozturk, 2013). Nakon eliminacije navedenih tvrdnji, ljestvica od 43 tvrdnje reducirana je na 20. KMO vrijednost za skup podataka od 20 tvrdnji izračunata je na .944, a Bartlettov test sferičnosti na 4283,239 (df = 190, p = 000) (Field, 2009).

Tablica 1.

Nakon EFA, struktura ljestvice je utvrđena kao trofaktorska. Faktorska opterećenja 20 tvrdnji na ljestvici po faktorima varira od 0.515 do 0.824. Tri faktora ljestvice objašnjavaju ukupnu varijancu od 63,24 %.

Prema rezultatima EFA, skup „strah" sadrži sedam tvrdnji i čini 28,08 % ukupne varijance. Faktorska opterećenja tvrdnji u tom skupu raspona su od 0.744 do 0.824. Skup „stav" sadrži osam tvrdnji i čini 18,87 % ukupne varijance. Faktorska opterećenja tvrdnji u tom skupu raspona su od 0,515 do 0,741. Skup „korisnost" sadrži pet tvrdnji i čini 16,29 % ukupne varijance. Faktorska opterećenja tvrdnji u tom skupu raspona su od 0,585 do 0,788. Rezultati pokazuju ne samo da se ljestvica može koristiti u postojećem obliku, nego se i njezina tri faktora mogu sagledavati kao tri zasebne ljestvice.

Konfirmativna faktorska analiza

Nakon EFA, provedena je konfirmativna faktorska analiza radi provjere i utvrđivanja faktorske strukture PCI ljestvice. Indeksi prikladnosti dobiveni nakon ustanovljene metode riješeni su uporabom CFA, kao savršeni i prihvatljivi kriteriji u vezi s tim indeksima, što je prikazano u tablici 2.

Tablica 2.

Najniža Hi-kvadrat vrijednost na temelju CFA bila je $\chi^2 = 352.12$, df =1 65, $p < 0.01$, a odnos Hi-kvadrata prema stupnju slobode 2,134, što ukazuje na značajnu devijaciju od savršenoga (Pallant, 2007). Smatramo da je takva devijacija posljedica veličine uzorka. Prema tablici 2., indeksi prikladnosti su RMSEA = .073, GFI = .94, AGFI = .89, CFI = .97, NFI = .96 i SRMR = .064. Pregledom drugih vrijednosti koje se tiču prikladnosti, GFI, AGFI, RMSEA i SRMR vrijednosti u prihvatljivom su rasponu, dok su CFI i NFI vrijednosti u rasponu savršene prikladnosti (Bentler & Bonett, 1980; Byrne & Campbell, 1999; Marsh, Hau, Artlet, Baumert & Peschar, 2006; Schermelleh-Engel & Moosbrugger, 2003). Navedene vrijednosti temeljene na CFA ukazuju na to da podatci odgovaraju trofaktorskoj strukturi kako je specificirano u modelu. Te vrijednosti ukazuju da je zabilježeni faktorijal ljestvice kompatibilan s očekivanim faktorijalom. Faktorska opterećenja trofaktorskoga modela i dijagram slijeda prikazani su na slici 2.

Kako je vidljivo na slici 2., faktorska opterećenja za skup „strah" u rasponu su od 0.77 do 0.85, za skup „stav" od 0.54 do 0.86 te za skup „korisnost" od 0.52 do 0.82. Činjenica da nema crvenih strelica povezanih s t-vrijednostima znači da su sve tvrdnje bitne (.05) (Jöreskog & Sörbom, 1996). Izostanak crvenih strelica u t-vrijednostima pokazuje da su sve tvrdnje bitne na razini .05. Odlučeno je provesti modifikacije između tvrdnji 8 i 19 u skladu s preporukama nakon provedene CFA. Te modifikacije poboljšale su χ^2 i indekse prikladnosti (Şar, Ayas, & Horzum, 2015).

Slika 2.

Konstruktna valjanost

Konvergentna i diskriminantna valjanost određene su za konstruktnu valjanost kojom se mjeri trofaktorska struktura PCI ljestvice. Prema konvergentnoj valjanosti proučene su vrijednosti prosječne ekstrahirane varijance (AVE) koje su iznosile kako slijedi: strah: .66, stav: .52, korisnost: .55. Kako su vrijednosti bile više od .50, rezultati upućuju na prihvatljivu razinu konvergentne valjanosti (Bagozzi & Yi, 1988). Za diskriminantnu valjanost, izračunati su korijeni AVE vrijednosti (vidi dijagonalne vrijednosti tamno otisnute u tablici 3.). Fornel i Larcker (1981) ustvrdili su da vrijednosti korijena više od .50 i više od korelacija između ostalih faktora u istom stupcu svakoga faktora mogu poslužiti kao dokaz diskriminantne valjanosti.

Tablica 3

U tablici 3 prikazane su korelacije među faktorima, uz korijene AVE vrijednosti. Kao što se vidi iz tablice, vrijednosti korijena najveće su vrijednosti u svojim zasebnim stupcima, osim u stupcu korisnosti. Međutim, korisnost je domena s najnižom diskriminantnom valjanosti. Takvi rezultati upućuju na zaključak da je diskriminantna valjanost ovoga instrumenta prihvatljiva.

Korelacijske vrijednosti između faktora ljestvice

Korelacije između faktora PCI ljestvice proučene su Pearsonovom produkt-moment korelacijom. Vrijednosti korelacije faktora ljestvice prikazane su u tablici 4.

Kada se prouči tablica 4, jasno je da korelacije između ukupnoga rezultata i faktorskih rezultata ljestvice variraju između -.903 i .882 te da postoji značajna razlika na razini .01. Takvi rezultati dovoljan su dokaz da su međuodnosi i sklad između faktora ljestvice na visokoj razini. Također, negativan omjer uočen je između dimenzije straha i ostalih dimenzija ljestvice dok je pozitivan odnos primijećen između dimenzija stava i korisnosti.

Tablica 4

Pouzdanost ljestvice

Pouzdanost integralne PCI ljestvice testirana je izračunom Cronbachova alfa koeficijenta interne konzistencije i CR alfa koeficijenta. U tablici 5 prikazani su Cronbachov alfa koeficijent interne konzistencije i CR alfa koeficijent.

Tablica 5

Cronbachov alfa koeficijent za cijelu ljestvicu iznosi .93. Koeficijenti su prema faktorima kako slijedi: strah: .92, stav: .87, korisnost: .81. Sve te vrijednosti više su ili jednake .81. Nema nekog općeg pravila za procjenu Cronbachova alfa koeficijenta (Cho & Kim, 2015). Moglo bi se reći da što je alfa koeficijent veći, to će više tvrdnje imati zajedničkih kovarijanci te vjerojatno mjeriti isti konstrukt. Vrijednost od .70 i viša smatra se pragom koji je općeprihvaćen u društvenim znanostima (Robinson, Shaver & Wrightsman, 1991). Stoga se može izvesti zaključak da je pouzdanost ovoga instrumenta na prihvatljivoj razini.

CR alfa koeficijent za cijelu ljestvicu iznosi .96. Koeficijenti su prema faktorima kako slijedi: strah: .93, stav: .89, korisnost: .85. Sve te vrijednosti više su ili jednake .85. Nunnally & Berstein (1994) naglašavaju da bi koeficijent CR alfa vrijednosti trebao biti iznad .70. Stoga se može izvesti zaključak da je pouzdanost ovoga instrumenta na prihvatljivoj razini. Kada se usto prouče vrijednosti interne konzistencije i kompozitne pouzdanosti, može se reći da daju dosljedne i pouzdane podatke.

Kao rezultat ovih saznanja, dovršene su i studije valjanosti i pouzdanosti ljestvice.

Analiza rezultata ljestvice

PCI ljestvica sadrži 20 tvrdnji. Ljestvica je u biti Likertova ljestvica od 5 stupnjeva s rasponom odgovora od 1 do 5: „U potpunosti se slažem (5), Slažem se (4) Neutralan sam (3) Ne slažem se (2) Nimalo se ne slažem (1)". Ljestvica sadrži i 12 tvrdnji s obrnutim bodovanjem, a to su 1, 2, 5, 7, 8, 10, 12, 14, 16, 17, 18 i 19. Kako skup „strah" sadrži sedam tvrdnji, najniži rezultat koji se može dobiti u ovoj dimenziji je 7, a najviši 35. U dimenziji „stav" osam je tvrdnji. Tako je najniži mogući rezultat 8, a najviši 40. Slično tome, u dimenziji „korisnost" pet je tvrdnji. Stoga je najniži mogući rezultat u toj dimenziji 5, a najviši 25. Prema CFA, ljestvica bilježi zadovoljavajuće indekse prikladnosti, a može se koristiti u cjelini ili u dijelovima, zasebnim dimenzijama. Viši rezultati za pojedine podljestvice ili cijelu ljestvicu upućuju na višu percepciju integrala.

Rasprava i zaključak

Matematika koja nije ograničena samo na brojke i operacije ima nezanemarivo značajno mjesto u svakodnevnom životu. Poželjno bi bilo da učenici i studenti pridaju vrjednost matematici kao području koje je opipljivo, korisno i vrijedno truda, da iskazuju entuzijazam za učenje matematike te da uživaju baveći se njome. Međutim, učenici i studenti razvijaju negativne stavove, tjeskobu ili strah prema matematici u procesu učenja i nesvjesni su uporabe matematike u svakodnevnom životu (Ho, Senturk, Lam, Zimmer, Hong, Okamoto & Chiu, 2000). Ova situacija češće je primjetna u nastavnom procesu matematičkih pojmova kao što su integrali, a koje učenici i studenti smatraju „teškima". Važno je identificirati postojeća stanja kod studenata mjerenjem njihove razine straha i stavova s ciljem postizanja boljeg uspjeha u nastavi Matematike. Stoga je lako pomisliti kako bi se nastavni proces dodatno dinamizirao

provedbom sadržajno specifičnih procjena nastave, odnosno njezinim produbljivanjem. Primjerice, za primjenu i procjenu bilo bi vrlo važno poznavati učinak teškoća s kojima se suočavamo kod poučavanja pojma integrala kao i postupke kojima ih učenici i studenti koji proučavaju taj pojam premošćuju. Odredbe o percepciji studenata u vezi s pojmom integrala kao što su strah-stav-uporaba u svakodnevnom životu doprinijet će nastavnom procesu vezanom uz taj pojam. Prilikom proučavanja literature, primijećen je izostanak ljestvice za pojam integrala iako u matematici postoje ljestvice vezane uz stavove i strah. Osim toga, nastavni procesi specijalizirani su za svaki pojedini pojam ili tek djelić u vremenu inovacija, neprestane mijene i tehnološkoga razvoja, što nam je donijelo nužnost pojmovno specifičnih aplikacija u nastavi Matematike. Stoga je točnije koristiti pojmovno određene ljestvice za vrednovanje nastave matematičkoga pojma umjesto uporabe „matematičke ljestvice o stavovima ili strahu".

Razvoj ljestvice predmet je koji prati određena vrlo specifična pravila te zahtijeva stručnost (Hambleton & Patsula, 1999). Istraživanje provedeno bez uzimanja u obzir proces razvoja ljestvice može za rezultat imati nekoliko negativnih posljedica, kao što su gubitak truda i vremena, znanstvene omaške, znanstvene pogreške uzrokovane uporabom ljestvice od strane trećih znanstvenika-istraživača. Stoga se razvoju ljestvice mora pristupiti pomno te pratiti zadana pravila (Cohen & Swerdlik, 2010; Crocker & Algina, 1986). Kod procesa razvoja PCI ljestvice, cilj je bio izraditi valjan i pouzdan mjerni alat praćenjem koraka u razvoju ljestvice (Clark & Watson, 1995; DeVellis, 2003). Na osnovi rezultata našega istraživanja proizašla je Percepcijska ljestvica za pojam integrala koja se sastoji od 20 tvrdnji i tri faktora (strah, stav, korisnost) u obliku Likertove tablice od pet stupnjeva. U različitim fazama istraživanja, zatraženo je mišljenje stručnjaka s područja metodologije matematike, vrednovanja i procjene te metodologije turskog jezika. U potpunosti su primijenjene eksplorativna (EFA) konfirmativna (CFA) faktorna analiza za faktornu valjanost, analizu diskriminantne i konvergencijske valjanosti za konstruktnu valjanost, kriterijsku valjanost, internu konzistentnost i kompozitnu pouzdanost primjenom ljestvice na 349 studenata nastavničkoga smjera matematike za EFA i 216 studenata nastavničkoga smjera matematike za CFA. PCI ljestvica može se koristiti kao cjelina ili se mogu koristiti njezini dijelovi.

U sklopu istraživanja provedene su studije valjanosti i pouzdanosti s ciljem utvrđivanja studentske percepcije, odnosno stava i straha glede pojma integrala te uporabe integrala u svakodnevnom životu, pri čemu je razvijena PCI ljestvica. Autori su uvjereni da će razvoj ove PCI ljestvice biti vrlo značajan te zauzeti važno mjesto u literaturi, uglavnom zato što je riječ o prvoj ljestvici u dostupnoj literaturi koja se može koristiti u nastavnom procesu integrala te će se njome potaknuti prihvaćanje ideje o potrebi razvoja pojmovno temeljenih ljestvica u metodologiji matematike. U tom kontekstu, mišljenje je autora da se ova ljestvica može koristiti u budućim istraživanjima jer će se njome odrediti percepcije studenata koji uče pojam integrala vezane uz strah, stav i uporabu u svakodnevnom životu. Autori također smatraju da se ona može prilagoditi srednjoškolskim učenicima kako bi se povećala uporabljivost

i rasprostranjenost ljestvice. Osim toga, percepcijske ljestvice sličnoga tipa mogu se osmisliti i razviti i za druge matematičke pojmove kao što su derivacije, koje učenici i studenti smatraju teškima, baš kako opisuju i pojam integrala.

Napomena

Ovaj rad dio je doktorske disertacije prvog autora pod mentorstvom drugog autora.