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Self-Confidence Scale for Interdisciplinary Teaching

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Abstract

The importance of interdisciplinary education is a well-known fact in today's world. However, do educators feel sufficiently prepared to implement such an approach? Identifying this aspect among pre-service science teachers (PSTs), who are the educators of the future, will be an important step in terms of improvement efforts. Building upon this premise, the research aims to develop a valid and reliable measurement tool for assessing the self-confidence of pre-service teachers in Elementary Science, Biology, Physics, and Chemistry Education Programs. In order to determine the scale construct validity, a two-stage process was undertaken. In the first stage, an exploratory factor analysis (EFA) was conducted with a sample comprising 300 pre-service teachers. Subsequently, in the second stage, a confirmatory factor analysis (CFA) was performed using data collected from 174 pre-service teachers. The findings indicated that the psychometric properties of the Self-Confidence Scale for Interdisciplinary Teaching (SCSIT) were robust and satisfactory for measuring confidence levels in interdisciplinary teaching. Consequently, a valid and reliable assessment tool, which can be used in research on interdisciplinary teaching, was introduced to the literature.

Key words: *interdisciplinary teaching; pre-service teachers; science education; self-confidence.*

Introduction

In today's world, where technological advancements take place at a great pace, different disciplines mutually cooperate to solve the problems occurring on the way (Turna & Bolat, 2015). The concept of "interdisciplinarity" emerges at this point, referring to the integration or synthesis of the knowledge structure or the mentality of two or more disciplines with the aim to produce a broader and more powerful meaning, explanation, or product (Rhoten et al., 2009). Interdisciplinary studies require a multidimensional view of problems, integrating information from

different disciplines. Therefore, a single discipline is no more sufficient for solving complex problems. What binds together real-life problems with interdisciplinary research, on the other hand, is interdisciplinary teaching (Duerr, 2008). In interdisciplinary teaching, students are enabled to establish related connections and form meaningful associations by integrating two or more disciplines with coherent links (You, 2017). Through teaching processes where an interdisciplinary approach is followed, many gains, which become life-long learning skills needed for the student's future learning process, are acquired (Jones, 2009). The research results in the literature have shown that interdisciplinary teaching is efficient in the development of student's academic success, critical and reflective thinking skills, creativity, cooperation, and communication skills (Acarlı, 2020; Guven & Sulun, 2018; Howlett et al., 2016; Jones, 2009; Putica & Trivić, 2017; Styron, 2013; Walshe 2017; White & Carpenter, 2008). Science is a field that interacts with many disciplines in terms of structure as well as subjects and concepts (Bybee, 2010). Therefore, while the perspectives of different disciplines are required in many fields, this need is especially felt more in science education. Many subjects of science have connections with chemistry, physics, geology, and biology, and are highly interdisciplinary. When learning these subjects, students thus have to deal with problems that are not easily understood or solved within a single discipline and natural events. Therefore, the concepts of science must be taught, in unity, by establishing associations with other disciplines. Besides, science is also connected with other fields like sports and arts, being based on their common points, so courses can be made more attractive. It is known that presenting science courses as integrated with sports and arts has a positive effect on the student's cognitive structure and success. which makes learning easier (Bopegedera, 2005; Kaittani et al., 2017; Spintzyk et al., 2016). Teaching that is based on a discipline prevents students from establishing and discovering the relations between the concerned fields, which in turn, results in their poor understanding of interdisciplinarity and weak scientific literacy (You, 2017). Hence, it is important that students learn how to evaluate interdisciplinary subjects from the perspective of different courses. The ability to associate subjects with different disciplines will contribute to somewhat more creative and critical approaches to handling complicated problems and trying different solutions. At this point, the responsibility of teachers has considerably increased. Managing an interdisciplinary teaching process, simultaneously enabling students to synthesize information in other fields for solving complicated problems, also requires the teacher to have knowledge and skills in the given area. In interdisciplinary teaching, teachers should be qualified to cooperate and communicate among themselves and also able to integrate information from different disciplines (Duerr, 2008). Having these qualities, especially the one to teach in the fields of science where there are various interdisciplinary areas of study, is a must today. However, the related research shows that teachers and pre-

service teachers (PTs) do not have sufficient knowledge of interdisciplinary teaching (Cimen, 2002; Dervisoglu & Soran, 2003; Mikseret al., 2008; Ozaydinli Tanriverdi & Kilic, 2019). Cura and Ercan Yalman (2019) state that PTs in elementary science had not internalized an interdisciplinary approach in their undergraduate studies and that they had a hard time designing activities, also giving proper examples to be used in interdisciplinary teaching. The researchers have also concluded that a few of PTs were familiar with the interdisciplinary approach and used it purposefully, and while some of the participants had no knowledge of it, some could not apply the approach purposefully because they simply did not have the relevant in-depth knowledge. In their research, Sahin, Gocuk and Sevgi (2018) have explored the interdisciplinarily-related formation levels of pre-service teachers of physics, chemistry, biology, and science. The findings have revealed that the participating pre-service teachers demonstrated higher success in answering questions within their specific disciplines while displaying less success when addressing interdisciplinary questions. In other words, the PTs, who specialized in their fields, have experienced difficulties in the process of interdisciplinary knowledge transfer. In their research, Altundag, Alkan, and Acarli (2021) have investigated the extent to which interdisciplinary teaching approaches are incorporated in teacher training programs. As a result, they have determined that there is a need for improvement in the active use of interdisciplinary teaching, the direction towards interdisciplinary teaching, and the physical opportunities regarding interdisciplinary teaching. They state that including the contents for these needs in sciences in the study programs at teacher education faculties will make PSTs ready for today's conditions. The studies carried out with teachers also suggest that teachers do not have adequate knowledge and skills regarding interdisciplinary teaching. For instance, as a result of their research, Karakus, Turkkan and Karakus (2017) determine that science and mathematics teachers have misconceptions about the interdisciplinary approach, and they emphasize the importance of cooperation with other branch teachers and instructions to be included in-service training. Ozaydinli Tanriverdi and Kilic (2019) have researched the ideas and classroom applications of maths, physics, chemistry, and biology teachers related to the interdisciplinary approach. As a result , it has been revealed that the teachers had knowledge and attitude regarding interdisciplinary teaching, at a conceptual level, and yet, they were not able to plan interdisciplinary course teaching. Despite their positive thoughts towards interdisciplinary teaching, it was seen that the majority of them could not carry practice the interdisciplinary applications in the classroom because of the lack of time, tight schedules, and alike. Haatainen, Turkka and Aksela (2021) have examined the perceptions and self-efficacy beliefs of science teachers related to integrated science education, that is, a broader concept that includes interdisciplinary science teaching. In their research, they conducted an online survey with 95 Finnish

science teachers. The study indicated that teachers viewed integrated science education as a relevant teaching method but challenging to be implemented and applied seldom. It was emphasized that the teachers' self-efficacy perceptions and their limited experience affected their willingness to implement the method. The research conclusion is that teachers need support to better understand and implement integrated science education. von Knebel, Schroeder and Bögeholz (2023) have investigated the factors influencing self-efficacy in interdisciplinary science education among pre-service and in-service teachers of biology, chemistry, and physics, as well as their trainees. The study identified teaching experience, desire to teach science, number and type of studied science subjects as the factors which influence the self-efficacy beliefs of interdisciplinary science teaching. The greater the number of science subjects studied (i.e., more parts of interdisciplinary science), the higher the self-efficacy beliefs about interdisciplinary science teaching. It appears that having knowledge to establish connections related to the topic in different disciplines is important for self-efficacy in interdisciplinary science education. To design teaching for an interdisciplinary approach and to ensure the transfer between branches are hard tasks (Savard & Samson, 2014). Besides, the lack of interdisciplinary teaching goals and the complexity of interdisciplinarity makes the process of interdisciplinary teaching hard for evaluation (Madison & Augsburg, 2013; Mueller et al., 2014). To perform these tasks, teachers and PTs should have enough awareness and motivation alongside the knowledge. However, the research shows that the importance of interdisciplinary teaching has not been absorbed sufficiently (Cura & Ercan Yalman, 2019; Mikser et al., 2008). The development of knowledge, attitudes, and skills regarding interdisciplinary teaching in teacher training programs currently becomes crucial. During the education period of PTs, knowing the level of their self-confidence about this knowledge and skills, and how it changes, is important for determining and eliminating deficiencies on this matter. It is considered that the use of practical assessment tools would be beneficial for this purpose. One of the recent studies in the literature on this issue has been conducted by Handtke and Bögeholz (2019). Handtke and Bögeholz (2019), including pre-service and trainee teachers, developed the "Self-Efficacy Beliefs of Interdisciplinary Science Teaching Instrument". This is based on the pedagogical content knowledge model for teaching science. In addition to the theoretical model's nine dimensions, they introduced a new dimension "Teaching Ethically Relevant Issues," leading to a 10-dimensional scale for the literature. This study aimed to develop a scale that would allow for a comprehensive judgment of the level of self-confidence specific to interdisciplinary teaching, being based on the required teacher knowledge, skills, and competencies for interdisciplinary teaching within the relevant literature framework. For this purpose, the Self-Confidence Scale for Interdisciplinary Teaching (SCSIT) was created to contribute to the literature by assessing the self-confidence levels of pre-service science teachers (PSTs) in interdisciplinary teaching.

Methodology

Item development

In the item writing process, first of all, there was a literature review with reference to the learning-teaching process and teacher competencies in interdisciplinary teaching. Besides, the knowledge, skills, and proficiencies that a teacher should have, during a course in which an interdisciplinary approach is followed, were reviewed following the steps of a course plan. In the light of the information compiled throughout literature scanning, 41 trial items about interdisciplinary teaching were written (24 positives, 17 negative), and an item pool was created. In order to ensure the content validity, suitability, and sufficiency of items in terms of determining self-confidence about interdisciplinary teaching, two experts from the field were consulted. Moreover, in the first stage, the trial form of the scale was applied to 50 PSTs and incomprehensible or ambiguous statements were amended. Following the expert opinions and trial period, suitable items were chosen among those that had similar statements, while those items that were advised to be removed were removed from the trial form. At the end of the process, it was decided to use the draft form which consisted of 19 positives and 11 negatives, a total of 30 items (see Appendix). The given items were stated in a way that would depict the self-confidence regarding interdisciplinary teaching, and the answers were graded in a 5-point Likert type as "strongly agree=5", "agree=4", "neither agree nor disagree=3", "disagree=2" and "strongly disagree=1".

Participants

Purposive and convenience sampling techniques were used together in the research. In purposive sampling, to determine the most suitable group for research purpose is essential (Andrade, 2021). Convenience sampling, on the other hand, is a method which prioritizes the minimization of the loss of time, money, and workload of the researcher, along with the collection of data from the most accessible sample (Creswell, 2014). In this study, purposive sampling was used considering the fact that the participants who had taken courses of professional teaching knowledge and other essential courses from different disciplines would produce more realistic results in answering the scale. In this respect, the sample included the PSTs, who were about to finish the second, third and fourth years of Biology, Physics, Chemistry, and Elementary Science Teaching Programs at the end of the fall semester in the 2021-2022 school year. In addition, following the convenient sampling method, data was collected from five (5) large-sized universities with numerous students. More participants could, thus, be reached quickly and easily.

During the data collection process, the researchers presented a printed copy to those who could be accessed face to face, while the others unreachable in person were sent the scale online. In both cases, a voluntary participation approval was

received from the participants. The implementation of the scale was conducted in accordance with the volunteerism of the participants. The participants had 25 minutes available to respond to the scale. They had been duly informed about the study's scope and their right to withdraw their involvement at any stage. The content of the study does not have any threats to the physical or mental health of the participants. Furthermore, the participants' personality rights and private information were protected. The received scale forms were checked by the researchers; those that were randomly answered, had multi answers for the same item or left unanswered were not taken into consideration. In addition, before starting the analysis, box-plot graphics were examined, and forms displaying outliers were not taken into consideration.

During the scale development process, a suitable sample quantity was determined since the exploratory factor analysis (EFA) and the confirmatory factor analysis (CFA) were to be done. Recommendations suggesting a sample size of at least five times the number of items for EFA (Bryman & Cramer, 2001) or at least 300 participants for a more reliable analysis (Tabachnick & Fidell, 2013) were considered. In this study, the exploratory factor analysis of the draft scale including 30 items was done with data gathered from 300 participants. For CFA, on the other hand, the knowledge that it would be sufficient if the sample quantity was at least five times the item number (Muthén & Muthén, 2002; Stevens, 2009) was considered. Accordingly, the correctness of the structure, determined as a result of EFA, was tested by doing CFA on data collected from 174 participants. Thus, within the scope of studies for the scale development, a total of 474 students were reached. The demographic information is presented in Table 1.

Table 1
Distribution of the sample demographic features

Demographic features	f (%)(EFA; n=300);	f (%) (CFA; n=174)
Program		
Biology Education	38 (12.7)	35 (20.1)
Chemistry Education	52 (17.3)	35 (20.1)
Physics Education	41 (13.7)	23 (13.2)
Elementary Science Education	169 (56.3)	81 (46.6)
Gender		
Female	239 (79.7)	146 (83.9)
Male	61 (20.3)	28 (16.1)
Grade		
2nd class	82 (27.3)	45 (25.9)
3rd class	127 (42.3)	67 (38.5)
4th class	91 (30.3)	62 (35.6)

Data analysis

In order to determine the scale structural validity, the techniques of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were used. Before both analyses, reverse coding had been done for negative items. For the missing data, the average of the answers given to that item (series mean) was used, as suggested by Mertler and Vannatta (2005). Thus, the data was prepared for the analysis like this.

During the stage of EFA, in order to determine the data's suitability for factor analysis, the Kaiser Meyer Olkin Measure of Sampling Adequacy (KMO) and Bartlett's test of sphericity were done. The KMO statistics indicate whether the data set is adequate for the factor analysis, while Bartlett's test of sphericity determines the correlation matrix significance. There are various standards for the suitable KMO value in literature, .6 or over is usually regarded as a sufficient sample quantity. As for Bartlett's test of sphericity, it is expected to be significant ($p<.05$) (Tabahnick & Fidell, 2013). Whether the data met the univariate normality assumption was examined by calculating the kurtosis and skewness coefficients (Tabachnick & Fidell, 2013).

The aim of the scale development study is to explain the variance in the measured variable. The objective here is to extract the maximum variance from the dataset and consolidate a large number of variables into a fewer components. Among the factor extraction techniques in EFA, the technique that will best serve this purpose is the principal components analysis (Conway & Huffcutt, 2003; Tabahnick & Fidell, 2013). Therefore, the principal components analysis was preferred as the factor extraction technique in the research and the factors were determined by applying the varimax rotation. It is suggested that factor loadings should be ≥.30 to ensure that the characteristics to be measured are adequately differentiated (DeVellis, 2012). In this study, the lower limit of factor loading was determined as 0.40 in order to select the most contributing items to the total explained variance.

The structre accuracy, revealed in EFA, was tested with CFA. In accordance with the sample quantity and suggestions in literature, X^2/df (Chi-square Goodness of Fit/ degree of freedom), SRMR (Standardized Root Mean Square Residual), RMSEA (Root Mean Square Error of Approximation), GFI (Adjusted Global Fit Index), NFI (Normed Fit Index), NNFI (Non-Normed Fit Index), CFI (Comparative Fit Index) indexes were taken into consideration for CFA (Chiang & Liu, 2014; Hooper et al., 2008; Kline, 2015).

Within the scope of the scale reliability, in order to determine internal consistency, Cronbach's Alpha coefficient, inter-item total correlation and corrected item-total correlation were calculated. Cronbach's Alpha refers to how mutually compatible the scale items are. The recommendation that this value should be 0.7 or above (DeVellis, 2012) was taken into account. Attention was paid for ensuring that all values in the inter- item total correlation matrix were positive. Positive values indicate that items measure the same feature (Pallant, 2016). The corrected item -

total correlation value, on the other hand, determines each item's relation with the total points. For each item, this value was required to be above .3 (Pallant, 2016).

Results

This section presents the findings that are related to the SCSIT validity and reliability.

Results related to validity

The scale construct validity was first analyzed by using the exploratory factor analysis (EFA). For the scale that depicts the self-confidence of PSTs when it comes to interdisciplinary teaching, the Kaiser-Meyer-Olkin (KMO) value was .96; as a result of Bartlett's test of sphericity the chi-square value was found significant (X^2=7746.74; df=406; p<.05). These results show that the data was sufficient for the factor analysis. Therefore, it was determined that the premises of factor analysis were met. It was observed that the skewness and kurtosis values of the given items varied between +1.5 and -1.5 (Table 2). Accordingly, the data meet the assumption of univariate normality (Tabachnick & Fidell, 2013).

During the analysis, an item that is coded as P2 (*I can recommend resources conducive to interdisciplinary instruction for my students*) was removed from the scale due to a high factor value in a second dimension. After repeating the analysis, when the rotated components matrix was examined, it was seen that the scale items were gathered under two factors, the item factor loads in both dimensions were over .4 and had values ranging from .623 to .860. However, it was noticed that before the operation of varimax rotation, those items in negative dimensions had over .4 factor loads also in positive dimensions. The given finding gave the impression that the scale could only measure in a single factor, and this situation was taken into consideration for the rest of the ongoing analysis process.

The findings of the analysis regarding the total variance showed 2 components with over 1 eigenvalue. In factor analysis only the factors which have 1 or over 1 eigenvalue are accepted as stable (Pallant, 2016). In other words, two factors were advised for the scale structure. Besides, the scree plot curve also shows a rapid decline starting from the position of the second factor (Figure 1). The slope makes a plateau after the second point. In other words, after this point, the contribution of the components to the variance is so small and so close to each other. This finding supportes the opinion that the scale has a structure with two factors.

When the findings of the total explained variance, the rotated components matrix and the eigenvalue scree plot were jointly considered, it was determined that the scale items were gathered in 2 dimensions as *positive items about self-confidence* (18 items; eigenvalue: 15.16) and *negative items about self-confidence* (11 items: eigenvalue: 3.61). The total variance, declared by two factors, was calculated as 64.71%. The positive factor's contribution to this variance is 52.28%, while the negative factor's contribution is 12.43%. When each item in the communalities table

is examined in terms of their explanation rates of variance in the common factor altogether, the values were determined as ranging between .434 and .780. When these values are .3 and over, it means that the items in the factor are in good compliance with other items (Pallant, 2016). Besides, the correlation between the positive and the negative factor was analyzed. The Pearson correlation coefficient was used to calculate the correlation, considering the continuous nature and normal distribution of the data (Pallant, 2016). A significant level of correlation (r=.552) between the positive and the negative factor was determined. In fact, the high correlation between the indicators belonging to different structures is not something that was expected. A high correlation is associated with the probability that these structures might be measuring the same feature (Kline, 2015). When this finding taken into consideration with the finding before the rotation operation, the items with the negative dimension had high factor loads in the positive dimension, supported the opinion that the scale could make measurements at a single dimension.

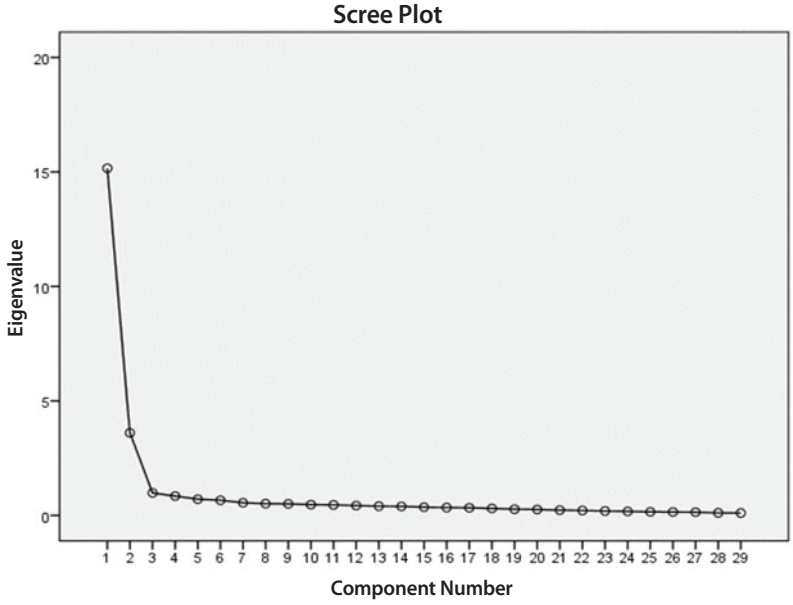

Figure 1. The eigenvalue scree plot of the SCSIT

Information about the factor loadings of the items in the rotated component matrix, together with the item means, the standard deviations (sd) and the skewness/kurtosis coefficients, is presented in Table 2.

As a second stage in determining the validity, CFA was done by using the LISREL 8.7 program with the data of 174 participants. Thus, whether the determined factor structure with EFA for the scale was a valid model or not was tested. When the system outcome was examined, it was determined that the critical sample quantity (CN) proposed for the analysis was 100. Therefore, the data of 174 participants were sufficient and suitable for CFA.

Table 2
Item factor load, average, and standard deviation values

Item No	Factor loading		Mean	sd	Skewness	Kurtosis
	Factor 1 (Positive Items)	Factor 2 (Negative Items)				
P1	**.725**	.293	3.48	.941	-.148	-.169
P3	**.774**	.181	3.62	.980	-.395	-.234
P4	**.797**	.318	3.84	.913	-.468	-.059
P5	**.714**	.347	3.74	.945	-.447	-.241
P6	**.754**	.225	3.84	.949	-.473	-.352
P7	**.727**	.274	3.72	.969	-.392	-.410
P8	**.834**	.267	3.66	.952	-.288	-.416
P9	**.851**	.235	3.66	.924	-.247	-.305
P10	**.718**	.318	3.59	.915	-.212	-.516
P11	**.703**	.261	4.02	.934	-.840	.481
P12	**.851**	.236	3.88	.920	-.545	-.009
P13	**.836**	.208	3.80	.943	-.506	-.164
P14	**.860**	.179	3.83	.938	-.480	-.284
P15	**.830**	.196	3.69	.944	-.393	-.192
P16	**.847**	.193	3.71	.918	-.324	-.334
P17	**.795**	.251	3.73	.937	-.401	-.352
P18	**.750**	.234	3.72	.983	-.513	-.282
P19	**.792**	.241	3.82	.927	-.490	-.101
N1	.200	**.658**	4.17	.899	-.891	.112
N2	.236	**.742**	4.11	.847	-.836	.572
N3	.212	**.623**	3.95	.935	-.710	.051
N4	.199	**.754**	4.27	.867	-1.165	1.207
N5	.295	**.646**	3.65	1.085	-.517	-.476
N6	.252	**.745**	3.78	.980	-.671	.027
N7	.284	**.789**	3.92	.915	-.580	-.181
N8	.176	**.763**	3.94	.866	-.669	.248
N9	.211	**.821**	4.02	.921	-.892	.576
N10	.206	**.698**	3.86	.949	-.645	.094
N11	.194	**.767**	3.84	.946	-.708	.308

In the stage of model verification with CFA, firstly, analysis was made on the basis of a two-factor structure which appeared as a result of EFA. In the first stage, the t values of the items, regarding their condition of explaining the observed variable, were controlled. Parameter estimations are meaningful at a level of .05 if t values are over 1.96, and at a level of .01 if over 2.56 (Jöreskog, et al., 2000; Kline, 2015). As it was determined that the t values of 3 items, coded as P1, P3, and P4, were below 1.96, it was decided to remove these items from the scale. After the repeated analysis following the removal of these three items, the two items coded as P5 and P6 were removed from the scale. This decision was based on their relatively low factor loadings (.38 and .31) compared to the other items, high measurement

errors (.85 and .90), and their negative impact on the model fit indices. (Thus, 1 item was removed in EFA, 5 were removed in CFA and the scale got its final form with 24 items). The removed items did not cause any loss in the scale scope. There are various items in the scale which question the information in the removed items (The removed items are presented on the scale provided in the attachment.).

When the suggested modifications in the model analysis results were examined, it was seen that there were items under the same factor linked to each other, and confirming the relationships of these items improved the model fit values. For instance, the semantic connection between items P10 (*When necessary, I can use the terminology from other disciplines to make explanations about the subject*) and P11 (*I can contact teachers from other disciplines for interdisciplinary teaching*) was confirmed by the researchers. And as a result of this, a modification on the model was allowed. When the fit indexes calculated for the model were analyzed, the chi-square goodness of fit ($\chi 2$) statistics was seen as significant ($p<.01$). While it is an unwanted situation for this test to come out meaningful if the sample quantity is 200 and more, it is advised that it would be better to check χ^2/df value (Hoe, 2008; Jöreskog et al., 2000). In this study, χ^2/df value was calculated as 2.1 ($\chi^2=508.38$, df=242). If this value is 2.5 or lower, it is called a perfect fit (Kline, 2015). Besides, other fit indexes calculated for the model are given in Table 3.

Table 3
Model-data fit values for the two-dimensional model of the SCSIT

Sample size	χ^2/df	SRMR	RMSEA	GFI	NFI	NNFI	CFI
174	2.1	.042	.08	.80	.97	.98	.98

While .08 and lower SRMR and RMSEA values, and .90 and over NFI, NNFI, and CFI values indicate a good fit, .80 and over GFI value indicates an acceptable fit (Chiang & Liu, 2014). As a result, these values of fit indexes are convenient for the model to be confirmed. These findings supported the construct validity of the scale. The two-dimensional SCSIT model is presented in Figure 2.

There should not be a very high correlation (for example >.85) between indicators that are accepted as belonging to different structures. Such a situation means that the indicators measure the same feature with each other (Kline, 2015). Therefore, in this study, in the model obtained as a CFA result (Figure 2), the high correlation between the factors (.96), increased the probability that these two factors measured a single feature. Besides, even though the items were gathered in two factors as an EFA result, when the rotation operation was not done, it was found that items in the negative dimension had .4 and more factor loads also in the positive dimension. It was also notable that the difference between the total variances that the given factors revealed was also too high (positive factor: 52.28%; negative factor: 12.43%). Therefore, all the items in both factors were moved to a single factor, and the CFA was repeated. The repeated CFA gave a fit model, which indicated that the items

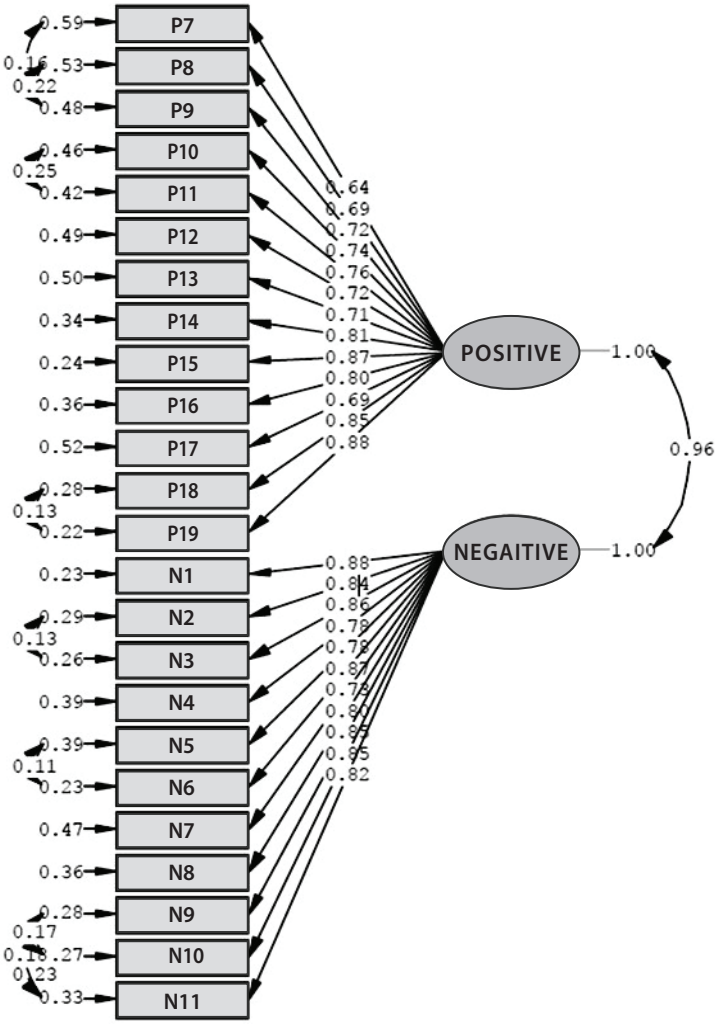

Figure 2. The two-dimensional model of the SCSIT

were suitable for measuring in a single factor (Figure 3). χ2/df value for this one-dimensional model was calculated as 2.1 (χ^2=506.23, df=241). Other fit indexes, calculated for the model, are given in Table 4.

Table 4

Model-data fit values for the one-dimensional model of the SCSIT

Sample size	χ^2/df	SRMR	RMSEA	GFI	NFI	NNFI	CFI
174	2.1	.043	.08	.80	.97	.98	.99

The values of fit indexes given in Table 4 are appropriate and acceptable for the model to be confirmed (Chiang & Liu, 2014). Hence, based on all these data, it was

determined that the scale can be used as a one-dimensional scale which includes positive and negative items (Figure 3).

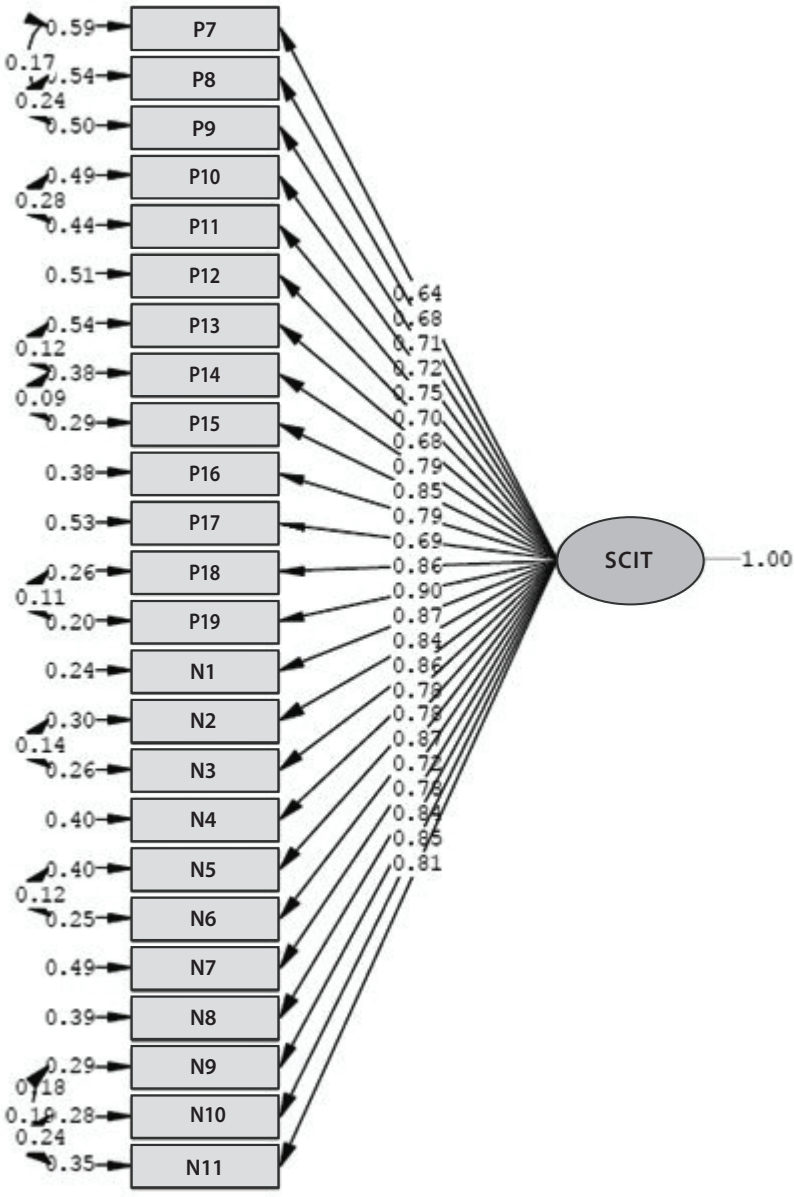

Figure 3. The single dimensional model of the SCSIT

Results related to reliability

Cronbach's Alpha internal consistency coefficient was calculated to determine the scale measurement reliability. Cronbach's Alpha reliability coefficient, which was calculated for the final scale with 24 items (with the EFA data), was found as .96. When the inter-item correlation matrix, calculated for 24 items, was examined, it was determined that all the values were positive. This situation is another indicator that the items measured the same feature. Besides, it was seen that all the values of corrected item-total correlation were over .3, and between .529 and .786 (Table 5). These values indicate each item's high relation with the total points. The given findings show that the scale is a suitable assessment tool for making reliable measurements for determining self-confidence for interdisciplinary teaching.

Table 5
Item-total statistics

Item No	Item -Total Correlation	Cronbach's α if item deleted
P7	.698	.96
P8	.782	.95
P9	.778	.95
P10	.725	.96
P11	.678	.96
P12	.786	.95
P13	.748	.96
P14	.753	.96
P15	.742	.96
P16	.759	.96
P17	.746	.96
P18	.702	.96
P19	.744	.96
N1	.547	.96
N2	.623	.96
N3	.529	.96
N4	.607	.96
N5	.601	.96
N6	.639	.96
N7	.700	.96
N8	.592	.96
N9	.658	.96
N10	.571	.96
N11	.605	.96

Discussion and conclusion

Jones (2009), in his study examining the interdisciplinary approach sophisticatedly, emphasizes that the interdisciplinary approach has outcomes that turn into lifelong learning skills for students, providing progress in critical thinking, communication, creativity skills and the academic process. From this aspect, he states, the interdisciplinary approach became an important and challenging technique in modern curriculum, while at the same time interdisciplinary teaching is a time-consuming process with difficulties. The most important and difficult task in the interdisciplinary teaching process falls on teachers. Teachers should have sufficient knowledge and skills to manage the interdisciplinary teaching process. At this point, it is important to know and follow the development process of PTs in interdisciplinary teaching during their education to train qualified teachers on this subject. Therefore, it has become important to be able to measure the self-confidence levels of PTs, who are the teachers of the future, about interdisciplinary teaching, practically and accurately. With this research, the "Self-Confidence Scale for Interdisciplinary Teaching", which can be used in determining the self-confidence levels of PSTs about interdisciplinary teaching, was brought into literature. The scale items are graded in a 5-point Likert scale, and the minimum point that can be received from the scale is 24, while the maximum point is 120. High total points are evaluated as the PSTs have high self-confidence about interdisciplinary teaching.

According to the EFA results, the SCSIT includes two factors which have positive and negative items. However, it was noticed that before the operation of varimax rotation, those items in the negative dimension had over .4 factor loads also in the positive dimensions; in addition, the difference between the total variances explained by the factors (positive factor=52.28%; negative factor=12.43%) and the difference between their eigenvalues (positive factor= 15.16; negative factor= 3.61) was very high. Besides, as a result of the calculation done in the EFA, based on the average points of positive-negative items, it was determined that there was a significant relation between the two dimensions ($r=.552$, $p<.01$) and as a result of the CFA, calculated for a two-factor structure, it was determined that there was a positive and high-level relation ($r=.96$) between the dimensions. On the other hand, there should not be a high correlation between indicators, which are accepted as belonging to different structures (Kline, 2015). These findings indicate that two dimensions including positive-negative items, in fact, measure the same feature with each other. Therefore, it was concluded that the scale showed a single-dimensional structure, which included positive-negative items. As a result of the CFA done for the scale single-dimensional structure, the chi-square goodness of fit/ degree of freedom rate was 2.1, and if this value is below 2.5 it means that the structure shows a perfect fit (Kline, 2015). The RMSEA value is .08, and according to this value, the compliance of the scale structure to the model is at a good level (Chiang & Liu 2014). When all the other fit indexes (GFI, NFI, NNFI, CFI) are

analyzed together, the scale was confirmed to have a 24-items single structure. Cronbach's Alpha reliability coefficient of the scale was calculated as .9. If this value is over .7 (DeVellis, 2012), it shows that the items in the scale are coherent with each other. Besides, the facts that all the values in the inter-item correlation matrix were positive, and that all the item-total correlation values were over .3, indicate that the interior consistency of the scale is high.

In summary, the sufficiency of the psychometric features of the developed scale was exhibited. According to the findings of validity and reliability studies, it was concluded that the SCSIT is suitable for use in scientific research. The data to be obtained via the scale will help to practically determine the self-confidence levels of PSTs about interdisciplinary teaching. The lacking points of PSTs' self-confidence can be determined with the application of the scale, precautions can be taken, and improvements can be made in teacher training programs to make up for these lacks. Based on the findings, new course contents can be developed for teacher training programs regarding interdisciplinary teaching. By periodically applying the developed scale, it will be possible to practically survey the levels of PSTs about interdisciplinary teaching. Thus, researchers will be able to easily determine the effect of courses and various applications in teacher training programs on self-confidence about interdisciplinary teaching. The given scale can also be used as a pre/after test in experimental studies to determine the effectiveness of applications for developing interdisciplinary teaching skills of PTs. Besides, it would also be useful if the scale is adapted for PTs or teachers studying in disciplines other than science.

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Appendix

Self-Confidence Scale for Interdisciplinary Teaching

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
	1	2	3	4	5
**P1. I can design educational processes conducive to interdisciplinary instruction. I can plan education and training processes in accordance with interdisciplinary teaching….*	☐	☐	☐	☐	☐
N1. I have difficulties in cooperating with teachers from other branches.	☐	☐	☐	☐	☐
**P2. I can recommend resources conducive to interdisciplinary instruction for my students.*	☐	☐	☐	☐	☐
**P3. I can develop teaching materials conducive to interdisciplinary instruction.*	☐	☐	☐	☐	☐
N2. I have difficulties in establishing bonds with other disciplines while conveying knowledge about my field.	☐	☐	☐	☐	☐
N3. My level of knowledge in my field is not sufficient for interdisciplinary teaching.	☐	☐	☐	☐	☐
**P4. I can support students' meaningful learning by interrelating subjects in my classes with other disciplines.*	☐	☐	☐	☐	☐
**P5. I can integrate knowledge from different disciplines in solving problems.*	☐	☐	☐	☐	☐
N4. I have difficulties in associating the knowledge about my field with daily life.	☐	☐	☐	☐	☐
**P6. I can enhance students' motivation by highlighting the interdisciplinary aspects of subjects.*	☐	☐	☐	☐	☐
N5. I do not have sufficient knowledge about interdisciplinary teaching.	☐	☐	☐	☐	☐
N6. I have difficulties in choosing equipment and material suitable for interdisciplinary teaching.	☐	☐	☐	☐	☐
P7. I can follow the current studies about interdisciplinary teaching and adapt them to my courses.	☐	☐	☐	☐	☐
P8. I can perform different interdisciplinary applications inside and outside the classroom.	☐	☐	☐	☐	☐
N7. I have difficulties in adding interdisciplinary activities to my course plans.	☐	☐	☐	☐	☐
P9. I can manage the process of learning and teaching in accordance with interdisciplinary teaching.	☐	☐	☐	☐	☐
P10. When necessary, I can use the terminology from other disciplines to make explanations about the subject.	☐	☐	☐	☐	☐

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
	1	2	3	4	5
N8. I have difficulties in deciding which subjects in my field are suitable for interdisciplinary teaching.	☐	☐	☐	☐	☐
P11. I can contact teachers from other disciplines for interdisciplinary teaching.	☐	☐	☐	☐	☐
N9. I have difficulties in associating the subjects in my field with other disciplines.	☐	☐	☐	☐	☐
P12. I can attract the attention of students to the course by presenting an interdisciplinary point of view.	☐	☐	☐	☐	☐
P13. I can use different methods and techniques of teaching effectively and correctly in an interdisciplinary process.	☐	☐	☐	☐	☐
P14. I can make the students think through other disciplines' points of view.	☐	☐	☐	☐	☐
P15. I can evaluate the curriculum in terms of interdisciplinary teaching.	☐	☐	☐	☐	☐
P16. At the end of the assessment and evaluation process, I can give feedback suitable for interdisciplinary teaching.	☐	☐	☐	☐	☐
N10. I have difficulties in reaching sources, which can be used in interdisciplinary teaching.	☐	☐	☐	☐	☐
P17. While teaching a subject from my field, I can use knowledge and methods from other disciplines.	☐	☐	☐	☐	☐
N11. I have difficulties in teaching knowledge from different disciplines with an integrated approach.	☐	☐	☐	☐	☐
P18. I know the points in my field, which have relations with other disciplines.	☐	☐	☐	☐	☐
P19. In my course, I can relate knowledge from other disciplines to my field when appropriate.	☐	☐	☐	☐	☐
Thank you for your participation!					

**Items deleted from the scale as a result of analyzes during the scale development process*

P-N: Positive items are numbered using the letter P and negative items are numbered using the letter N.

Ljestvica samopouzdanja za interdisciplinarno poučavanje

Sažetak

Važnost interdisciplinarnoga obrazovanja dobro je poznata činjenica u današnjem svijetu. Međutim, osjećaju li se edukatori dovoljno pripremljenima za takav pristup u praksi? Prepoznavanje ovoga aspekta među budućim učiteljima prirodnih znanosti, koji su odgajatelji budućnosti, bit će važan korak u smislu poduzimanja napora za poboljšanjem. Polazeći od ove pretpostavke, cilj je istraživanja razviti valjan i pouzdan mjerni alat za procjenu samopouzdanja budućih učitelja u obrazovnim programima za osnove znanosti, biologiju, fiziku i kemiju. Kako bi se odredila konstruktivna valjanost ljestvice proveden je proces u dvjema fazama. U prvoj fazi izvršena je eksploratorna faktorska analiza (exploratory factor analysis; EFA) na uzorku od 300 budućih učitelja, a u drugoj konfirmatorna faktorska analiza (confirmatory factor analysis; CFA) zasnovana na podatcima prikupljenim od 174 buduća učitelja. Rezultati su pokazali da su psihometrijske karakteristike korištene ljestvice (Self-Confidence Scale for Interdisciplinary Teaching; SCSIT) dostatne i zadovoljavajuće za mjerenje razina samopouzdanja budućih učitelja u interdisciplinarnoj nastavi. U literaturu je stoga uveden valjan i pouzdan alat za vrednovanje, koji se može koristiti u istraživanjima o interdisciplinarnoj nastavi.

Ključne riječi: *budući učitelji; interdisciplinarna nastava; nastava prirodnih znanosti; samopouzdanje.*

Uvod

U današnjem svijetu u kojem je tehnološki napredak brz, ostvaruje se interdisciplinarna suradnja s ciljem rješavanja problema koji ga prate (Turna i Bolat, 2015), stoga se pojavljuje pojam „interdisciplinarnosti". Interdisciplinarni koncept podrazumijeva integraciju ili sintezu strukture znanja ili mentalnoga sklopa dviju ili više disciplina kako bi se došlo do šireg i jačega značenja, objašnjenja ili proizvoda (Rhoten i sur., 2009). Interdisciplinarna istraživanja zahtijevaju višedimenzionalan pogled na probleme, pri čemu se povezuju informacije iz različitih disciplina. Naime, jedna disciplina nije više dovoljna za rješavanje složenih problema. Ono što povezuje stvarne probleme s interdisciplinarnim istraživanjima, međutim, interdisciplinarno je poučavanje (Duerr, 2008). U interdisciplinarnom poučavanju studentima/učenicima se omogućuje da uspostave odgovarajuće i koherentno oblikovane veze, zahvaljujući upravo integraciji dviju ili više disciplina (You, 2017). Kroz nastavne

procese u kojima se slijedi interdisciplinarni pristup ostvaruju se mnoge prednosti, koje postaju vještine cjeloživotnoga učenja potrebne za budući proces učenja (Jones, 2009). Rezultati istraživanja prikazanih u relevantnoj literature pokazuju da je interdisciplinarno poučavanje učinkovito za bolji akademski uspjeh, razvijanje vještina kritičkoga i reflektivnoag razmišljanja, kreativnosti, suradnje i komunikacije (Acarlı, 2020; Guven i Sulun, 2018; Howlett i sur., 2016; Jones, 2009; Putica i Trivić, 2017; Styron, 2013; Walshe 2017; White i Carpenter, 2008). Znanost je područje u kojem se povezuju brojne discipline kako u smislu strukture tako u smislu predmeta i pojmova (Bybee, 2010). Stoga, dok su perspektive iz različitih disciplina potrebne u mnogim područjima, ova je potreba još više izražena u poučavanju znanosti. Mnoge su prirodnoznanstvene teme povezane s kemijom, fizikom, geologijom i biologijom te su izrazito interdisciplinarne. Dakle, kada uče ove predmete, studenti/učenici se moraju suočiti s problemima koji se ne mogu lako razumjeti ili riješiti unutar jedne discipline i u okvirima prirodnih događaja. Znanstveni se koncepti zato moraju skupa poučavati povezivanjem s drugim disciplinama. Osim toga, znanost je povezana s drugim područjima poput sporta i umjetnosti zbog njihovih u osnovi zajedničkih dodirnih točaka, pa kolegiji/predmeti mogu postati privlačniji. Poznato je da povezivanje znanstvenih kolegija/predmeta sa sportom i umjetnosti ima pozitivan učinak na kognitivnu strukturu i uspjeh studenta/učenika, čime im se olakšava učenje (Bopegedera, 2005; Kaittani i sur., 2017; Spintzyk i sur., 2016). Poučavanje koje se temelji na jednoj disciplini sprječava studente da uspostavljaju i otkrivaju poveznice između relevantnih područja, što pak rezultira njihovim slabim razumijevanjem interdisciplinarnosti i slabom znanstvenom pismenošću (You, 2017). Važno je pritom da studenti nauče vrednovati interdisciplinarne predmete iz perspektive različitih kolegija. Sposobnost povezivanja predmeta s različitim disciplinama donekle će pridonijeti kreativnijim i kritičnijim načinima rješavanja složenih problema te ostvarivanju pokušaja različitih rješenja. U ovom je trenutku odgovornost nastavnika značajno veća. Upravljanje interdisciplinarnim nastavnim procesom, koji istovremeno omogućuje studentima sintetizirati informacije iz drugih područja radi rješavanja složenih problema, također zahtijeva od nastavnika znanje i vještine u određenom području. U interdisciplinarnom poučavanju nastavnici bi trebali biti osposobljeni za suradnju i međusobnu komunikaciju, kao i za povezivanje informacija iz različitih disciplina (Duerr, 2008). Posjedovanje ovih kvaliteta, posebno one za poučavanje u područjima znanosti s različitom interdisciplinarnom problematikom, danas je nužnost. Međutim, relevantna istraživanja pokazuju da učitelji i budući učitelji nemaju dovoljno znanja o interdisciplinarnoj nastavi (Cimen, 2002; Dervisoglu i Soran, 2003; Mikser i sur., 2008; Ozaydinli Tanriverdi i Kilic, 2019). Cura i Ercan Yalman (2019) istaknuli su da budući učitelji prirodoslovlja/prirodnih znanosti u osnovnoj školi nisu prihvatili interdisciplinarni pristup za vrijeme svojih preddiplomskih studija te da su imali poteškoća u osmišljavanju aktivnosti i davanju odgovarajućih primjera za primjenu

u interdisciplinarnoj nastavi. Istraživači su također zaključili da samo nekolicina budućih učitelja prirodnih znanosti poznaje interdisciplinarni pristup i ciljno ga koristi, dok neki sudionici ništa ne znaju o tome, a neki ga pak ne mogu primijeniti svjesno jer nemaju relevantno znanje o tome. U svojem su istraživanju Sahin, Gocuk i Sevgi (2018) istraživali razine uspostave interdisciplinarnosti među budućim učiteljima fizike, kemije, biologije i prirodnih znanosti. Prema dobivenim rezultatima budući su učitelji postigli bolji uspjeh odgovarajući na pitanja iz njihove specifične discipline, a slabiji odgovarajući na pitanja interdisciplinarne prirode. Drugim riječima, budući učitelji koji su se specijalizirali za svoja područja imali su poteškoće pri interdisciplinarnom prijenosu znanja. U svojem su istraživanju Altundag, Alkan i Acarli (2021) proučavali koliko su interdisciplinarni nastavni pristupi uključeni u programe stručnoga usavršavanja za učitelje. Utvrdili su pritom potrebu za boljim izvođenjem aktivne interdisciplinarne nastave, potom boljim usmjeravanjem na interdisciplinarnu nastavu te konačno boljim fizičkim mogućnostima vezanim uz interdisciplinarnu nastavu. Istaknuli su kako će se uključivanjem sadržaja usklađenih s navedenim potrebama u studijske programe na fakultetima za obrazovanje učitelja prirodnih znanosti buduće učitelje pripremiti za današnje nastavne uvjete. Istraživanja provedena s učiteljima također ukazuju na to da oni ne raspolažu dovoljnim znanjem i vještinama nužnim za interdisciplinarnu nastavu. U svojem su istraživanju Karakuş, Türkkan i Karakuş (2017) utvrdili da učitelji prirodoslovlja i matematike pogrešno shvaćaju interdisciplinarni pristup pa su naglasili važnost suradnje s učiteljima iz drugih područja, kao i uključivanje određenih uputa u njihovo stručno usavršavanje. Ozaydinli Tanriverdi i Kilic (2019) istraživali su što učitelji matematike, fizike, kemije i biologije misle o interdisciplinarnom pristupu i njegovoj primjeni u učionici. Tom su prigodom otkrili da oni znaju za interdisciplinarnu nastavu i imaju svoj stav o njoj na konceptualnoj razini, ali ju ne mogu planirati. Unatoč pozitivnim mišljenjima o interdisciplinarnoj nastavi bilo je vidljivo da većina učitelja ne može izvoditi interdisciplinarnu nastavu u učionici zbog nedostatka vremena, gustih rasporeda i sl. Haatainen, Turkka i Aksela (2021) ispitali su percepciju i uvjerenost u samoučinkovitost učitelja prirodnih znanosti u vezi s njihovim integriranim obrazovanjem, odnosno širim konceptom koji obuhvaća interdisciplinarnu nastavu prirodnih znanosti. U svojem su istraživanju proveli *online* anketu s 95 finskih učitelja prirodnih znanosti. Studija je pokazala da učitelji smatraju takvo integrirano obrazovanje iz područja prirodnih znanosti relevantnom metodom poučavanja, ali izazovnom za provedbu, pa se rijetko primjenjuje. Naglašeno je da im percepcije o samopouzdanju učitelja i njihovo ograničeno iskustvo utječu na želju za provedbom te metode. Istraživanjem je zaključeno kako je učiteljima potrebna podrška da bi bolje razumjeli i primjenjivali integrirano obrazovanje iz područja prirodnih znanosti. Von Knebel, Schroeder i Bögeholz (2023) istraživali su čimbenike koji utječu na samopouzdanje kada je riječ o interdisciplinarnom obrazovanju iz područja prirodnih znanosti među budućim

učiteljima biologije, kemije i fizike za vrijeme studija i u nastavne službe. Studijom je utvrđeno da su iskustvo poučavanja, želja za poučavanjem znanstvenih sadržaja, te broj i vrsta analiziranih znanstvenih predmeta čimbenici koji utječu na vjerovanja o samopouzdanju za interdisciplinarno poučavanje prirodnih znanosti. Što je veći broj proučavanih znanstvenih predmeta (tj. više interdisciplinarnih dijelova), to je veće vjerovanje u samopouzdanje za interdisciplinarno poučavanje prirodnih znanosti. Čini se da je znati kako povezivati različite discipline u neku određenu temu važno za samopouzdanje u interdisciplinarnom obrazovanju iz područja prirodnih znanosti. Planirati interdisciplinarnu nastavu i osigurati prijenos između različitih grana znanja teške su zadaće(Savard i Samson, 2014). Osim toga, nedostatak ciljeva interdisciplinarne nastave i složenost interdisciplinarnosti otežavaju vrednovanje procesa interdisciplinarnog poučavanja (Madison i Augsburg, 2013.; Mueller i sur., 2014). Za obavljanje tih zadataka, osim posjedovanja znanja, učitelji i budući učitelji trebaju biti dovoljno svjesni i motivirani. Međutim, istraživanje pokazuje da značaj interdisciplinarnoga poučavanja nije dovoljno prihvaćen (Cura i Ercan Yalman, 2019.; Mikser i sur., 2008). U tom smislu razvijanje znanja, stavova i vještina povezanih s interdisciplinarnim poučavanjem postaje ključno u programima namijenjenim stručnom usavršavanju učitelja. Tijekom obrazovanja budućih učitelja važno je znati na kojoj je razini njihovo samopouzdanje kada je riječ o ovom znanju i vještini te kako se ona mijenja, a sve to da bi se utvrdili i otklonili nedostatci u vezi s tim. Smatra se da bi korištenje praktičnih alata za vrednovanje bilo korisno u tu svrhu. Jedno od nedavnih istraživanja o tome proveli su Handtke i Bögeholz (2019). Handtke i Bögeholz (2019), u istraživanju s budućim učiteljima i učiteljima uključenima u stručno usavršavanje, razvili su „Instrument samopouzdanja za interdisciplinarno poučavanje prirodnih znanosti" koji se temelji na pedagoškom modelu znanja potrebnoga za poučavanje znanstenog sadržaja. U svoj su teorijski model uveli novu dimenziju „Poučavanje etički relevantnih pitanja", pa se tako u literaturi pojavila 10-dimenzionalna ljestvica. Cilj ovoga istraživanja bio je razviti ljestvicu koja bi omogućila sveobuhvatnu procjenu razine samopouzdanja specifičnoga za interdisciplinarno poučavanje, temeljenu na potrebnom znanju, vještinama i kompetencijama učitelja za interdisciplinarno poučavanje unutar relevantnoga teorijskog okvira. U tu svrhu predložena je Ljestvica samopouzdanja za interdisciplinarno poučavanje (Self-Confidence Scale for Interdisciplinary Teaching; SCSIT) kao prilog literaturi, a zahvaljujući vrednovanju razine samopouzdanja budućih učitelja prirodnih znanosti za interdisciplinarno poučavanje.

Metodologija

Razvoj stavki

U procesu utvrđivanja stavki prvo je pregledana literatura o procesu učenja-poučavanja i kompetencijama učitelja u interdisciplinarnoj nastavi. Osim toga,

analizirane su vrste znanja, vještine i stručnost koju bi učitelj trebao imati tijekom tečaja zasnovanoga na interdisciplinarnom pristupu, a slijedom planiranih faza rada. Na temelju informacija prikupljenih pregledom literature pripremljeno je 41 probno pitanje o interdisciplinarnoj nastavi (24 pozitivna, 17 negativnih stavki) i stvorena je baza stavki. Da bi ciljne stavke bile sadržajno valjane, prikladne i u dovoljnom broju konzultirana su dva stručnjaka u tom području. Nadalje, u prvoj fazi korištena je probna ljestvica na uzorku od 50 budućih učitelja prirodnih znanosti, a nerazumljive ili nejasne formulacije su izmijenjene. Nakon što su osigurana stručna mišljenja i provedeno probno razdoblje odabrane su prikladne među slično formuliranim stavkama, a stavke koje su bile preporučene za uklanjanje uklonjene su iz probnoga obrasca. Na kraju procesa odlučeno je koristiti se nacrtom koji se sastojao od 19 pozitivnih i 11 negativnih stavki, ukupno 30 stavki (vidi Dodatak). Stavke su tako formulirane da ukazuju na samopouzdanje u vezi s interdisciplinarnom nastavom, a odgovori su ocijenjeni primjenom Likertove ljestvice s 5 stupnjeva: „Potpuno se slažem=5", „Uglavnom se slažem=4", „Skoro se slažem=3", „Malo se slažem=2" i „Uopće se ne slažem=1".

Sudionici

Pri određivanju uzorka korištene su tehnike namjernoga i prikladnoga uzorkovanja. Kod namjernoga uzorkovanja ključno je odrediti skupinu koja je najprikladnija za cilj istraživanja (Andrade, 2021). S druge strane, prikladno uzorkovanje je metoda koja daje prioritet minimiziranju gubitka vremena, novca i radnoga opterećenja istraživača te prikupljanju podataka iz najpristupačnijega uzorka (Creswell, 2014). U ovom istraživanju korišteno je namjerno uzorkovanje uzimajući u obzir činjenicu da bi sudionici ranije uključeni u stručno usavršavanje o poučavanju ili druge bitne tečajeve iz različitih disciplina dali realnije rezultate odgovarajući na pitanja. U tom su smislu budući učitelji prirodnih znanosti pri kraju 2., 3. i 4. godine studijskoga programa biologije, fizike, kemije i metodike nastave prirodnih znanosti, na kraju jesenskoga semestra školske godine 2021./2022., uključeni u uzorak. Osim toga, podatci su prikupljeni metodom prikladnoga uzorkovanja na pet velikih sveučilišta s velikim brojem studenata. Na taj se način moglo brzo i jednostavno doći do većega broja sudionika.

Tijekom procesa prikupljanja podataka istraživači su sudionicima s kojima su imali pristup uživo dali ispis upitnika, dok su oni koji nisu mogli osobno doći upitnik dobili elektroničkim putem. U oba su slučaja sudionici dobrovoljno dali suglasnost za sudjelovanje, na temelju čega je provedeno anketiranje. Sudionici su dobili 25 minuta da odgovore na pitanja, a pravodobno su informirani o opsegu istraživanja i njihovom pravu da odustanu od sudjelovanja u bilo kojem trenutku. Istraživanje sadržajno ne predstavlja nikakvu prijetnju njihovom fizičkom ili mentalnom zdravlju, a osobne i privatne informacije su im zaštićene. Istraživači su pregledali primljene obrasce, situacije sa slučajnim odgovorima, višestrukim

odgovorima za istu stavku ili bez odgovora nisu uzete u obzir. Osim toga, prije početka analize, pregledani su grafički prikazi *box-plota*, a obrasci koji su prikazivali iznimke nisu uzeti u obzir.

Dok se ljestvica razvijala određen je odgovarajući broj uzoraka s obzirom na primjenu eksploratorne faktorske analize (EFA) i konfirmatorne faktorske analize (CFA). Uzete su u obzir preporuke o uzorku barem pet puta većem od broja stavki za EFA (Bryman i Cramer, 2001) ili najmanje 300 sudionika za pouzdaniju analizu (Tabachnick i Fidell, 2013). U ovom je istraživanju provedena eksploratorna faktorska analiza za nacrt ljestvice od 30 stavki, s podatcima prikupljenim od 300 sudionika. Za CFA, s druge strane, uzeta je u obzir spoznaja kako bi bilo dovoljno da uzorak bude barem pet puta veći od broja stavki (Muthén i Muthén, 2002; Stevens, 2009). Prema tome, strukturna valjanost, utvrđena rezultatom EFAe, testirana je provođenjem CFA na podatcima prikupljenim od 174 sudionika. Na taj su način obuhvaćena ukupno 474 studenta. Demografski podatci za uzorak prikazani su u Tablici 1.

Tablica 1.

Analiza podataka

Da bi se odredila strukturna valjanost ljestvice, korištene su tehnike eksploratorne faktorske analize (*exploratory factor analysis*; EFA) i konfirmatorne faktorske analize (*confirmatory factor analysis*; CFA). Prije njih je provedeno obrnuto kodiranje za negativne stavke. Za nedostajuće podatke korištena je srednja vrijednost odgovora na tu stavku (prosjek niza) (Mertler i Vannatta, 2005). Na taj su način podatci pripremljeni za analizu.

U EFA fazi, kako bi se odredila prikladnost podataka za faktorsku analizu, primjenjene su Kaiser Meyer Olkinove mjere adekvatnosti uzorkovanja (KMO) i Bartlettov test sferičnosti. KMO statistika pokazuje odgovara li skup podataka faktorskoj analizi, dok Bartlettov test sferičnosti određuje značajnost korelacijske matrice. Unatoč različitim standardima za odgovarajuću vrijednost KMO u literaturi, .6 ili više obično se smatra dovoljnim uzorkom. U slučaju Bartlettova testa sferičnosti očekuje se da bude značajan ($p < .05$) (Tabahnick i Fidell, 2013). Je li zadovoljena pretpostavka o jednostranoj normalnosti, provjerena je tako što su izračunati koeficijenti spljoštenosti i (a)simetričnosti (Tabachnick i Fidell, 2013).

Cilj istraživanja usmjerenoga na izradu ljestvice jest objasniti varijancu u mjerenoj varijabli. Ovdje je cilj izvući maksimalnu varijancu iz skupa podataka i konsolidirati veliki broj varijabli u manje komponente. Među tehnikama ekstrakcije faktora u EFA tom će cilju najbolje poslužiti analiza glavnih komponenata (Conway i Huffcutt, 2003; Tabahnick i Fidell, 2013). Stoga je analiza glavnih komponenata odabrana kao tehnika ekstrakcije faktora u istraživanju, a faktori su određeni primjenom varimax rotacije. Predlaže se da faktorska opterećenja budu ≥ .30 kako bi se osiguralo da su karakteristike koje treba mjeriti adekvatno diferencirane (DeVellis, 2012). U ovom je istraživanju donja granica faktorskoga opterećenja određena kao 0,40 da bi se odabrali najznačajniji elementi za sveukupno objašnjenu varijancu.

Strukturna valjanost, otkrivena u EFA, testirana je korištenjem CFA. U skladu s uzorkom i savjetima iz literature, za CFA su uzeti u obzir indeksi χ^2/df (*Chi-square Goodness of Fit/ degree of freedom*), SRMR (*Standardized Root Mean Square Residual*), RMSEA (*Root Mean Square Error of Approximation*), GFI (*Adjusted Global Fit Index*), NFI (*Normed Fit Index*), NNFI (*Non-Normed Fit Index*) i CFI (*Comparative Fit Index*) (Chiang i Liu, 2014; Hooper i sur., 2008; Kline, 2015).

U sklopu utvrđivanja pouzdanosti ljestvice, radi određivanja unutarnje konzistencije, izračunat je koeficijent alfa Cronbach, ukupna korelacija između stavaka i ispravljena korelacija između pojedinoga stavka i svih ukupno. Alfa Cronbach povezan je s kompatibilnošću stavki koje čine ljestvicu. Uzeta je u obzir preporuka da bi ova vrijednost trebala iznositi .7 i više (DeVellis, 2012). Pazilo se da su sve vrijednosti u matrici međusobne i ukupne korelacije pozitivne. Pozitivne vrijednosti ukazuju na to da stavke mjere istu karakteristiku (Pallant, 2016). Vrijednost ispravljene korelacije između pojedinačne stavke i svih ukupno, s druge strane, određuje odnos svake stavke s ukupnim brojem bodova. Za svaku stavku ova bi vrijednost trebala biti iznad .3 (Pallant, 2016).

Rezultati

U ovom dijelu su rezultati koji se odnose na valjanost i pouzdanost SCSIT-a.

Rezultati za valjanost

Konstruktivna valjanost ljestvice prvo je analizirana eksploratornom faktorskom analizom (*exploratory factor analysis*; EFA). Za ljestvicu koja prikazuje samopouzdanje budućih nastavnika u vezi s interdisciplinarnom nastavom vrijednost Kaiser-Meyer-Olkin (KMO) iznosila je .96; a rezultat Bartlettova testa sferičnosti pokazao je značajnu vrijednost (χ^2 = 7746,74; df = 406; p < ,05). Rezultati su pokazali kako su podatci dovoljni za faktorsku analizu. Stoga je utvrđeno da su pretpostavke za faktorsku analizu ispunjene. Primijećeno je da su vrijednosti asimetrije i spljoštenosti stavki varirale između +1,5 i -1,5 (Tablica 2). Prema tome, podatci zadovoljavaju pretpostavku o univarijatnoj normalnosti (Tabachnick i Fidell, 2013).

Tijekom analize stavka kodirana kao P2 (Svojim studentima *mogu preporučiti resurse koji potiču interdisciplinarnu nastavu*) uklonjena je iz ljestvice zbog visoke faktorske vrijednosti u drugoj dimenziji. Nakon ponovljene analize, pregledom rotirane matrice komponenata, primijećeno je da su stavke grupirane u odnosu na dva faktora, faktorsko opterećenje stavke u obje dimenzije bilo je iznad .4 i imalo je vrijednosti u rasponu od .623 do .860. Međutim, primijećeno je da su prije varimax rotacije te stavke u negativnoj dimenziji također imale faktorska opterećenja iznad .4 i u pozitivnim dimenzijama. Dojam je stoga da ljestvica može mjeriti samo u jednom faktoru, što je uzeto u obzir u nastavku analize.

Rezultati analize za ukupnu varijancu pokazali su 2 komponente s više od 1 svojstvene vrijednosti. U faktorskoj analizi samo su faktori koji imaju 1 ili više od

1 svojstvene vrijednosti prihvaćeni kao stabilni (Pallant, 2016). Drugim riječima, za strukturu ljestvice preporučuju se dva faktora. Osim toga, krivulja *scree plot* također pokazuje brzi pad, počevši od pozicije drugog faktora (Slika 1). Nakon drugog mjesta, nagib pravi plato. Drugim riječima, nakon toga, doprinos komponenata varijanci tako je mali i tako blizak jedan drugom. Ovaj rezultat ide u prilog mišljenju da ljestvica ima dvofaktorsku strukturu.

Slika 1

Kada su zajedno analizirani rezultati za ukupnu objašnjenu varijancu, rotiranu matricu komponenata i *scree plot* svojstvenih vrijednosti utvrđeno je da su stavke grupirane u 2 dimenzije kao pozitivne stavke o samopouzdanju (18 stavki; svojstvena vrijednost: 15,16) i negativne stavke o samopouzdanju (11 stavki: svojstvena vrijednost: 3,61). Ukupna varijanca koju su najavila dva faktora izračunata je kao 64,71 %. Doprinos pozitivnoga faktora ovoj varijanci iznosi 52,28 %, dok doprinos negativnoga faktora iznosi 12,43 %. Kada se razmotri svaka stavka u tablici komunalnih vrijednosti, vrijednosti su određene u rasponu između .434 i .780. Kada su ove vrijednosti .3 i više znači da su stavke u faktoru dobro usklađene s drugim stavkama (Pallant, 2016). Osim toga, analizirana je korelacija između pozitivnog i negativnog faktora. Koeficijent Pearsonove korelacije korišten je za izračun korelacije, uzimajući u obzir kontinuiranu prirodu i normalnu distribuciju podataka (Pallant, 2016). Utvrđeno je značajna razina korelacije (r = ,552) između pozitivnoga i negativnoga faktora. Zapravo, visoka korelacija između pokazatelja koji pripadaju različitim strukturama nije nešto što se očekuje. Visoka korelacija povezana je s vjerojatnošću da ove strukture mogu mjeriti istu značajku (Kline, 2015). Stoga, ovaj rezultat, kada se razmotri s rezultatom prema kojem su prije rotacijske operacije stavke s negativnom dimenzijom imale visoka faktorska opterećenja u pozitivnoj dimenziji, ide u prilog mišljenju da ljestvica može mjeriti u jednoj dimenziji.

Podatci o faktorskim opterećenjima stavki u rotiranoj matrici komponenata, zajedno s prosječnim vrijednostima stavki, standardnim devijacijama (sd) i koeficijentima asimetrije/spljoštenosti, prikazani su u Tablici 2.

Tablica 2

U drugoj fazi određivanja valjanosti provedena je CFA korištenjem programa LISREL 8.7 s podatcima dobivenim od 174 sudionika. Na taj je način testirano je li određena faktorska struktura s EFA za ljestvicu bila valjan model ili ne. Kada je ispitivan ishod sustava, utvrđeno je da je kritična količina uzorka (CN) predložena za analizu 100. Stoga su podatci od 174 sudionika bili dovoljni i prikladni za CFA.

U fazi provjere modela pomoću CFA prvo je provedena analiza na temelju dvofaktorske strukture koja se pojavila kao rezultat EFA. U prvom su stupnju kontrolirane t-vrijednosti stavki, uzimajući u obzir stanje u kojem su objašnjavane promatrane varijable. Procjene parametara su značajne na razini od .05 ako su t-vrijednosti veće od 1,96, i na razini od .01 ako su veće od 2.56 (Jöreskog i sur., 2000;

Kline, 2015). Kako je utvrđeno da su t-vrijednosti triju stavki kodiranih kao P1, P3 i P4 bile ispod 1,96, odlučeno je ukloniti ih iz ljestvice. Nakon ponovljene analize, bez ovih triju stavki, uklonjene su dvije stavke kodirane kao P5 i P6. Ova odluka temeljila se na njihovim relativno niskim faktorskim opterećenjima (.38 i .31) u usporedbi s drugim stavkama, visokim pogreškama mjerenja (.85 i .90) i njihovim negativnim utjecajem na pokazatelje prilagođenosti modela. (Tako je 1 stavka uklonjena u EFA, 5 su uklonjene u CFA i ljestvica je dobila svoj konačni oblik s 24 stavke). Uklonjene stavke nisu narušile opseg ljestvice. Na ljestvici su različite stavke kojima se propituju informacije iz uklonjenih stavaka (Uklonjene stavke prikazane su na ljestvici u prilogu).

Kada su predložene promjene u rezultatima analize modela pregledane, primijećeno je da su stavke pod istim faktorom povezane jedna s drugom, a potvrđivanje veza između ovih stavki poboljšalo je vrijednosti prilagodbe modela. Na primjer, semantička veza između stavki P10 (*Kada je potrebno, mogu koristiti terminologiju iz drugih disciplina kako bih objasnio temu*) i P11 (*Mogu kontaktirati nastavnike iz drugih disciplina za interdisciplinarnu nastavu*) potvrdili su istraživači. Promjena modela stoga je bila dopuštena. Kada su indeksi prilagodbe izračunati za model analizirani, statistika dobre prilagodbe chi-kvadrat testa (χ^2) pokazala se značajnom ($p < .01$). Premda nije poželjno da ovaj test bude značajan ako je količina uzorka 200 i više, preporučuje se provjera vrijednosti χ^2/df (Hoe, 2008; Jöreskog i sur., 2000). U ovom istraživanju, χ^2/df vrijednost izračunata je kao 2,1 ($\chi^2 = 508{,}38$, $df = 242$). Kada je ova vrijednost 2,5 ili niža, naziva se savršenom prilagodbom (Kline, 2015). Drugi indeksi prilagodbe izračunati za model prikazani su u Tablici 3.

Tablica 3

Vrijednosti SRMR i RMSEA od .08 ili manje te vrijednosti NFI, NNFI i CFI od .90 ili više ukazuju na dobru prilagodbu, dok vrijednost GFI od .80 ili više ukazuje na prihvatljivu prilagodbu (Chiang i Liu, 2014). Stoga su ove vrijednosti indeksa prilagodbe prikladne za potvrdu modela. Ti nalazi podupiru konstruktnu valjanost ljestvice. Dvosmjerni model SCSIT-a prikazan je na Slici 2.

Slika 2

Ne bi trebala postojati vrlo visoka korelacija (na primjer > .85) između pokazatelja koji su prihvaćeni kao pripadajući različitim strukturama. Takva situacija znači da pokazatelji mjere istu značajku jedan s drugim (Kline, 2015). Stoga, u ovom istraživanju, u modelu dobivenom kao rezultat CFA (Slika 2), visoka korelacija između faktora (.96) povećala je vjerojatnost da ova dva faktora mjere jednu značajku. Osim toga, iako su se stavke grupirale u dva faktora kao rezultat EFA, kada rotacijska operacija nije izvršena, utvrđeno je da su stavke u negativnoj dimenziji imale faktorska opterećenja od .4 i više i u pozitivnoj dimenziji. Također je primijećeno da je razlika između ukupnih varijanci koje su ovi faktori otkrili također bila prevelika (pozitivni faktor: 52,28 %; negativni faktor: 12,43 %). Stoga su sve stavke u oba

faktora premještene u jedan faktor i CFA je ponovljena. Ponovljena CFA dovela je do modela prilagodbe, što ukazuje da su stavke prikladne za mjerenje u jednom faktoru (Slika 3). χ^2/df vrijednost za ovaj jednodimenzionalni model izračunata je kao 2,1 (χ^2 = 506,23, df = 241). Ostali indeksi prilagodbe izračunati za model prikazani su u Tablici 4.

Tablica 4

Vrijednosti indeksa prilagodbe, prikazane u Tablici 4, prikladne su i prihvatljive za potvrdu modela (Chiang i Liu, 2014). Stoga, na temelju svih ovih podataka, utvrđeno je da se ljestvica može koristiti kao jednodimenzionalna ljestvica koja uključuje pozitivne i negativne stavke (Slika 3).

Slika 3

Rezultati za pouzdanost

Cronbachov alpha koeficijent unutarnje konzistentnosti izračunat je kako bi se utvrdila pouzdanost mjerenja ljestvicom. Pouzdanost Cronbachova alpha koeficijenta, izračunata za konačnu ljestvicu s ukupno 24 stavke (podaci iz EFA), iznosila je ,96. Kada je pregledana matrica korelacija između stavki, izračunata za 24 stavke, utvrđeno je da su sve vrijednosti pozitivne. Ova situacija dodatno pokazuje da se stavkama mjerila ista karakteristika. Osim toga, primijećeno je da su sve vrijednosti ispravljene korelacije stavkeukupno bile veće od .3, i između .529 i .786 (Tablica 5). Ove vrijednosti pokazuju visoku povezanost svake stavke s ukupnim bodovima. Rezultati pritom pokazuju da je ljestvica prikladan alat za pouzdana mjerenja pri određivanju samopouzdanja za interdisciplinarnu nastavu.

Tablica 5

Rasprava i zaključak

Jones (2009), u svojem istraživanju kojim detaljno proučava interdisciplinarni pristup,ističekakointerdisciplinarnipristuprezultiravještinamacjeloživotnogaučenja za studente, unapređujući kritičko mišljenje, komunikaciju, kreativnost i akademski napredak. Tvrdi da interdisciplinarni pristup tako postaje važna i izazovna tehnika u modernim kurikulima. Međutim, priznaje da je interdisciplinarno poučavanje dugotrajan proces prepun poteškoća. Na nastavnicima je glavna i teška odgovornost u procesu interdisciplinarne nastave. Nastavnici moraju posjedovati dovoljno znanja i vještina kako bi uspješno upravljali interdisciplinarnim poučavanjem. Važno je pratiti i podržavati proces razvoja nastavnika za interdisciplinarno poučavanje tijekom njihova obrazovanja kako bismo stvorili nastavnike kvalificirane za to. Stoga je postalo važno znati kako praktično i precizno mjeriti razinu samopouzdanja budućih nastavnika kada je riječ o interdisciplinarnom poučavanju. U literaturu je upravo s tim ciljem uvedena „Ljestvica samopouzdanja za interdisciplinarno poučavanje". Ova skala koristi petostupanjsku Likertovu ljestvicu za procjenu stavki,

s minimalnim rezultatom od 24 i maksimalnim rezultatom od 120. Viši ukupni rezultati ukazuju na povećano samopouzdanje budućih nastavnika prirodnih znanosti u vezi s interdisciplinarnim poučavanjem.

Prema rezultatima EFA-e, SCSIT uključuje dva faktora s pozitivnim i negativnim stavkama. Međutim, primijećeno je da su prije operacije varimax rotacije te stavke u negativnoj dimenziji imale faktorska opterećenja veća od .4 i u pozitivnim dimenzijama, i razlika između ukupnih varijanci objašnjenih faktorima (pozitivni faktor = 52,28 %; negativni faktor = 12,43 %) i razlika između njihovih svojstvenih vrijednosti (pozitivni faktor = 15,16; negativni faktor = 3,61) bila je vrlo visoka. Osim toga, kao rezultat izračuna u EFA, na temelju prosječnih bodova pozitivnih i negativnih stavki, utvrđena je značajna veza između dviju dimenzija ($r = .552$, $p < .01$), a kao rezultat CFA-e, izračunatoga za dvofaktorsku strukturu, utvrđena je pozitivna i visoka razina veze ($r = .96$) između dimenzija. S druge strane, ne bi trebala postojati visoka korelacija između pokazatelja koji se smatraju pripadajućima različitim strukturama (Kline, 2015). Ti rezultati ukazuju na to da dvije dimenzije koje uključuju pozitivne i negativne stavke zapravo mjere istu značajku jedna s drugom. Stoga je zaključeno da ljestvica pokazuje jednodimenzionalnu strukturu, koja uključuje pozitivne i negativne stavke. Kao rezultat CFA-e provedene za jednodimenzionalnu strukturu ljestvice, omjer dobroga slaganja χ^2/d.f. iznosio je 2.1, a ako je ta vrijednost ispod 2.5, to znači da struktura pokazuje savršeno slaganje (Kline, 2015). Vrijednost RMSEA iznosi .08, a prema toj vrijednosti, usklađenost strukture s modelom je na dobroj razini (Chiang i Liu 2014). Pri zajedničkoj analizi svih ostalih indeksa slaganja (GFI, NFI, NNFI, CFI) potvrđeno je da ljestvica ima jednodimenzionalnu strukturu s 24 stavke. Pouzdanost Cronbachov alpha koeficijenta ljestvice izračunata je kao .9. Ako je ta vrijednost iznad .7 (DeVellis, 2012), to pokazuje da su uključene stavke koherentne jedna s drugom. Osim toga, činjenica da su sve vrijednosti u matrici korelacija između stavki bile pozitivne i da su sve vrijednosti korelacija između stavke i svih stavki bile iznad .3, to ukazuje na visoku unutarnju konzistentnost ljestvice.

Ukratko, ovdje je pokazano kako su psihometrijske karakteristike predložene ljestvice dostatne. Prema rezultatima istraživanja valjanosti i pouzdanosti zaključeno je kako je SCSIT prikladan za upotrebu u znanstvenim istraživanjima. Podatci koji će biti dobiveni korištenjem ljestvice pomoći će da se praktično odrede razine samopouzdanja budućih učitelja prirodnih znanosti za interdisciplinarno poučavanje. Njome se mogu utvrditi nedostatci samopouzdanja budućih učitelja prirodnih znanosti te poduzeti mjere opreza i poboljšati programi usavršavanja učitelja kako bi se ti nedostatci ispravili. Polazeći od rezultata, mogu se sadržajno razviti novi programi za interdisciplinarno poučavanje učitelja. Povremenom primjenom tako razvijene ljestvice bit će moguće praktično istražiti razine samopouzdanja budućih učitelja prirodnih znanosti za interdisciplinarno poučavanje. Tako će istraživači lako odrediti kako tečajevi i različite primjene u programima usavršavanja utječu na

samopouzdanje učitelja u vezi s interdisciplinarnim poučavanjem. Ljestvica također može poslužiti kao predtest ili posttest u eksperimentalnim istraživanjima kako bi se utvrdila učinkovitost primjene na razvoj interdisciplinarnih pedagoških vještina budućih učitelja prirodnih znanosti. Osim toga, bilo bi korisno ljestvicu prilagoditi budućim učiteljima ili učiteljima koji proučavaju discipline izvan prirodnih znanosti.

Napomena

Sve procedure za društvena istraživanja koje uključuju ljudske sudionike usklađene su s etičkim standardima. Povjerenstvo za etička pitanja Sveučilišta Hacettepe razmotrilo je nacrt istraživanja, protokol broj 1948706.