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Self-Discipline Practices Inventory in Learning Mathematics: Instrumentation Process

Roxanne Kaye S Bihasa[1*], Elaina Mae D Santillan [2], Lorlaine R Dacanay[2], Jerald Moneva[2]

[1]Department of Mathematics, Rosemont Hills Montessori College, Cebu Technological University, Cebu, Philippines

[2]Department of Mathematics, University of the Visayas, Cebu, Philippines

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***For Correspondence :** Roxanne Kaye S Bihasa, Department of Mathematics, Rosemont Hills Montessori College, Cebu Technological University, Cebu, Philippines;

Email: roxannekayesantillan15@gmail.com

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ABSTRACT

Self-discipline is necessary to keep everything in order and motivated while learning. This paper designs an instrument that measures student's self-discipline practices in learning mathematics. The researcher used the measure approach introduced by Michael T Kalkbrenner last 2021. Measure is an acronym comprising: a) make the purpose and rationale clear, b) establish empirical framework, c) articulate theoretical blueprint, d) synthesize content and scale development, e) use expert reviewers, f) recruit participants, and g) evaluate validity and reliability. Self-discipline practice inventory, a ten item scale has been developed and validated. The results show that the newly created instrument possesses internal consistency reliability and construct validity.

Keywords: Self-discipline; Instrument; Instrumentation; Measure approach; Scale

INTRODUCTION

The global COVID-19 pandemic has seriously affected daily life. Schools, students, and parents have all suffered greatly as a result of closing schools and keeping children at home with little to no access to learning. One of the most stressful aspects of the current scenario is its unpredictability. A common response to this uncommon circumstance is fear and worry. Researchers found that, since the onset of the pandemic, 46% of 977 parents of teenagers stated that their kid had shown symptoms of a new or worsening mental health issue [1]. In the Philippines, a study analyzing the psychological effects of COVID-19 during its early phase in 2020 with 1,879 respondents was published. According to the findings, one-fourth of students said they experienced moderate to severe anxiety, and one-sixth said they experienced moderate to severe depression.

The most widely reported information about the education crisis came from the organization for Economic Cooperation and Development's (OECD) Program for International Student Assessment (PISA) report from 2018, which revealed that Filipino students performed the worst among 79 nations in reading, mathematics, and science. Due to social isolation and missing out on regular social outlets like sports, extracurricular activities, and hanging out with friends, many teenagers may experience frustration, anxiety, and a sense of disconnection. All that is required is a resolute will and a sense of obligation to oneself and the nation as a whole [2].

To mitigate the impact of COVID-19 at this pivotal moment, it is crucial to understand how people will react to the situation study states that effective teaching techniques that might boost students academic achievement and satisfaction are both connected to their mental health. People who have self-discipline can better monitor and control their conduct. It may be easier for highly disciplined people to focus on their objectives for their happiness, health, and professions. When it comes to achievement and involvement, they are more cautious. Being able to manage one's conscious decisions to act, speak, or think at any time is known as self-discipline. This is the capacity of the mind to control the body. During the mathematical learning process, it is crucial to uphold order and discipline. It encourages us to start and finish new projects or endeavors. Breaking the established rules and becoming disorderly while learning reveals students' weak character. There will be consequences for such undisciplined behavior in the future.

The pandemic's impact on everyday activities and the difficulties of learning one of the core academic disciplines mathematics were quite overwhelming for students. In this connection, the researcher would like to learn how each student learned mathematics despite the new normal. The main aim is to develop a tool that might perhaps be used to assess the self-discipline practices of Filipino senior high school students in learning mathematics. This study will show the instrumentation process in creating a research tool that can be effectively used to collect data for the study. This would also report the validity and reliability tests of the instrument. The instrumentation procedure would stimulate additional study and the creation of fresh tools for encouraging self-discipline in crises [3].

MATERIALS AND METHODS

The measure approach was adopted as a guide in developing and validating an instrument. This was introduced by Michael T. Kalkbrenner last 2021. MEASURE is an acronym comprising: a) make the purpose and rationale clear, b) establish empirical framework, c) articulate theoretical blueprint, d) synthesize content and scale development, e) use expert reviewers, f) recruit participants, and g) evaluate validity and reliability (Figure 1) [4].

Figure 1. The measure Approach to instrument development process flow.

Step 1: Make the purpose and rationale clear

Researchers should evaluate the available literature on the subject as part of this phase to ascertain whether they can use/adapt an existing measure or if an instrument development study is required, a proposed construct of measurement is necessary. Researchers should carefully assess the methodological rigor of an instrument development study if a measure already exists in the literature by contrasting the techniques used to create the test with accepted empirical standards (such as The measure approach). If there is not a measure in the literature to evaluate the researcher's preferred measurement construct, an instrument development study is required.

The developed instrument's main goals were to highlight the need for such a measure in the Philippines and to fill a measurement gap for evaluating integrated aspects of self-discipline with a single, relatively brief composite scale. The new tool will offer a lot of potential for measuring self-discipline practices in mathematics learning and in advancing subsequent study. Research on the development of instruments to measure attitudes towards mathematics has been done by many in the field of mathematics education but only rare for self-discipline. Most of the research was focused on self-control, self-efficacy, self-regulation, and conscientiousness where self-discipline was typically considered as a subscale in each personality trait. The measure of self-discipline is usually from the conscientiousness scale of the personality trait inventory. Conscientiousness or intellect, one of its five dimensions, is defined as the propensity to exercise self-discipline, do one's duties, and pursue goals. It is supported by Thomas, who explained that being self-disciplined is a very common trait of a conscientious person. It has to do with being goal-oriented and organized to the extent of relying on one's discipline to make anything work. In some studies, the tools for self-control were employed to gauge the degree of self-discipline whereas the researchers used the Brief Self-Control Scale by Tangney, Baumeister, and Boone. Some would utilize the 50 item international personality item pool five factor models, a self-report personality test that measures the big five personality traits as they are outlined in Costa and McCrae's updated NEO Personality Inventory (NEO-PI-R).

Upon researching articles in the search databases like PubMed, Google Scholar, and Cochrane, there has not been much work done on creating tools for self-discipline. As a result, the creation of a new instrument will serve as a beneficial tool for identifying students' self-discipline practices when learning mathematics [5].

Step 2: Establish empirical framework

To establish an empirical framework for the item development process, researchers are tasked with identifying a theory or theories and/or synthesizing findings from the existing literature. An empirical framework in this context refers to at least one theory or academic work (peer reviewed, for example) that offers a set of principles or presumptions that support the proposed measurement construct [6].

The empirical framework for the new instrument was developed based on two well-established theoretical models of the 50 items international personality item pool five factor and the HEXACO model. A proposed taxonomy for personality qualities called the Big Five has been around since the 1980's in psychological trait theory. Conscientiousness is one of the five aspects of both the Five Factor Model and the HEXACO model of personality. One of its subscales is being self-disciplined, conscientious people are typically diligent, disciplined, and trustworthy. Self-discipline is the ability to regulate oneself and alter one's ideas and behaviors for the improvement of oneself. For students, this can entail maintaining their concentration in class or on tasks, avoiding distractions during lectures or study sessions, and making sure that they meet deadlines. The researcher used the two models of personality traits to set the main theoretical framework for developing the theoretical blueprint and the initial pool of Self-Discipline Practices Inventory (SDPI) items as this were consistent with her goal to develop a measuring tool of self-discipline practices in learning mathematics [7].

Step 3: Articulate theoretical blueprint

By developing a theoretical framework, researchers can start organizing and refining their empirical framework. Researchers can improve the content validity of a measure by using a theoretical blueprint, which provides them with two main benefits: (a) defining the content and domain areas for the construct of measurement; and (b) figuring out the approximate proportion of items that should be developed across each content and domain area.

The components of self-discipline practices in learning mathematics are prudence/carefulness, organization/orderliness, and diligence/hard work according to the HEXACO model and IPIP model. Self-discipline practices inventory was created by the researcher using the three related adjectives or scales of the HEXACO model and are traits of a self-disciplined person according to the international personality item pool five factor model. Conscientiousness, which the researcher modified from the IPIP personality factor subscales and component items, is the domain area on the blueprint. The prudence, organization, and diligence content areas of the HEXACO model, for instance, are all connected to self-discipline, a subscale of conscientiousness in the five factor model, based on the SDPI blueprint. The approximate total number of items that made up the initial pool is shown for each intersecting content and domain area on the blueprint (Table 1).

Table 1. Theoretical blueprint: Self-discipline practices inventory.

Content area	(Domain) Conscientiousness
Prudence	3
Orderliness	3
Diligence	4
Total	10

Step 4: Synthesize content and scale development

Researchers should be clear about the specifications of their proposed measuring construct and consider how it varies from other latent variables before creating an initial pool of items to prevent repetition. Individual pools of items should be first created by researchers using the empirical framework and blueprint. During the initial stage of item development, researchers should aim to create an extensive list of items (*i.e.,* as many as feasible). The researcher might then check for duplication to amend or minimize their list. Each member of the research team can then generate a list of probable topics. After a series of meetings when they evaluate and discuss each other's lists, they can agree on the initial pool of items that will be sent to the expert reviewers [8].

By using the theoretical frameworks, which include the HEXACO and five factor personality theories as well as a blueprint to direct the item development process, the researcher started synthesizing and constructing the scale. She ensured the articles were concise and understandable. Throughout the item development process, she sought assistance from the five master teachers. Based on the empirical framework and blueprint, each master teacher created a unique list of potential items. They gather the best things along with the researcher until they agree on the ones that will make up the initial pool of self-discipline practices inventory items.

Step 5: Use expert reviewers

Experts are recruited to help in item development; however, different experts (*i.e.,* those who were not involved in creating the first pool of items) should be included in this stage to offer a new, unbiased viewpoint. The average number of expert reviewers is three to five, but the literature has documented up to 20 expert reviewers. The main goal of the expert review procedure is to increase the measure's content validity by getting input on "how relevant they think each question is to what you aim to assess" from a panel of experts.

Three qualified reviewers received the initial pool of self-discipline practices inventory items. The reviewers combined expertise in academe and teaching spanned more than 20 years. The reviewers included a statistician, a subject area expert, and an expert in validating research. They assigned the following ratings to the items: 1-very inaccurate, 2-inaccurate, 3-neutral, 4-accurate, and 5-very accurate. Items having a mean rating of 2.5 ought to be thrown out. The experts made no recommendations as to what more items should be included [9].

Step 6: Recruit participants

Researchers should review and receive the required Institutional Review Board (IRB) approval before gathering data from human beings. During pilot testing, also known as preliminary testing, the instrument is given to a small developmental sample that closely resembles the target population. Pilot testing enables researchers to evaluate their processes and look for technological or data imputation problems (for instance, a survey item that requests a written response but only allows one numeric entry). The option to get participant input on the items' content and readability is another benefit of pilot testing. Before starting data collecting, researchers should decide on the minimal sample size and sampling technique for the main study.

The researcher pilot tested or did preliminary testing on a small sample of the target respondents. Although there are several rules for what makes a small pilot sample, pilot samples typically have between 25 and 150 people. The Cronbach's alpha reliability result from the pilot testing is acceptable and excellent at 0.941. And every item's computed value is greater than Pearson's critical value of 0.396, therefore all the items are considered valid. The researcher looked at the item content's readability and clarity as well as any errors that may have occurred during the administration. After 25 respondents completed the questionnaire and made no changes to the items, the data collecting for the main study started.

According to the Subject to Variable ratio (STV ratio) rule, the study's sample size was set at 10. For each item on the instrument, there should be at least 10 respondents. Given that there were ten items, the bare minimum sample would be 100 respondents. During the data gathering process, 104 senior high school students voluntarily answered the questionnaire. The questionnaire and instructions were made available online while the researcher maintained the respondents' privacy [10].

Step 7: Evaluate validity and reliability

Testing for validity (the scale is measuring what it is supposed to measure) and reliability (consistency of results) evidence of the measure and its subscales is the last step in first validating scores on a new measure. To prove the validity of their interpretative justification for validity evidence, test developers are required to provide a variety of

sorts of evidence. A researcher should compute a test of the measure's reliability or consistency of scores once they have established validity evidence for scores on their instrument. There are many types of reliability evidence, including test-retest, alternate forms, inter rater, and internal consistency.

RESULTS

The researcher evaluated initial validity and reliability evidence for scores on Self-discipline practices inventory items by conducting construct validation. And internal consistency reliability.

Construct validation

Pearson correlation coefficients were utilized to test the convergent construct validity, and the rater's responses to the SDPI and the total scores of the standardized inventory were correlated. Likert or adjectival scale scores frequently have interval characteristics and parametric tests are sensitive to these interval assumptions. Therefore, the Pearson correlation coefficients were found to be appropriate (Table 2).

Table 2. Descriptive statistics.

Items	N	Min	Max	Mean	Std. Dev	Item total correlation
I do my classwork right away.	104	1	5	3.48	1.08	0.716
I am always prepared to learn.	104	1	5	4.01	1.11	0.757
I make sure to carry out my plans.	104	1	5	3.76	1.1	0.753
I do not need a push to start doing my tasks in learning Mathematics.	104	1	5	3.42	1.06	0.759
I set up a good study area at home.	104	1	5	3.54	1.16	0.778
I surround myself with good people who inspire me.	104	1	5	3.97	1.14	0.779
I forego some of my current stressful activities.	104	1	5	3.38	1.04	0.748
I meet deadlines and follow schedules.	104	1	5	3.64	1.12	0.812
I take good notes.	104	1	5	3.61	1.16	0.82
I like to make study plans in advance.	104	1	5	3.39	1.15	0.788

According to Table 2, respondents gave ratings ranging from 1 (the lowest scale) to 5 (the highest scale). The responses' variability is only about one scale away from the mean, or 3.0. All the items are retained with a stable mean. The items appear to have item-correlation values between 0.7 to 0.8. All of the items were strongly correlated, this means that the SDPI and the standardized test correspond with one another. Thus, convergent validity was observed.

Exploratory factor analysis

Exploratory factor analysis is a statistical method used to illustrate how a large number of variables are organized. Finding the underlying correlations between measured variables is the major objective of EFA. The 104 respondents' sample was utilized to investigate the instrument's structure using EFA with an oblique rotation (direct oblimin), which could result in item reduction. To account for the anticipated relationship between the different domains, oblique rotation was adopted. Principal component analysis was utilized because it is a strong and adaptable method capable of providing an overview of complex multivariate data. PCA can be used for a variety of purposes, including discovering relationships between variables and relationships between samples (such as clustering), identifying outliers, identifying and quantifying patterns, and developing new hypotheses (Table 3).

Table 3. KMO and Bartlett's test.

Kaiser-Meyer-Olkin measure of sampling adequacy.		0.93
Bartlett's test of sphericity	Approx. *Chi-Square*	716.722
	df	45
	Sig.	0

To assess whether the sample is large enough and whether at least two of the items are correlated strongly enough for the researcher to do a factor analysis, the Kaiser-Meyer-Olkin Measure (KMO) of Sampling Adequacy and Bartlett's

test of sphericity was computed first. These two measures will also aid in determining whether or not the researcher ought to do a principal component analysis. Table 3, shows that conducting an exploratory analysis is appropriate based on Kaiser-Meyer-Olkin Measure equaled to 0.93 which is very acceptable and Bartlett's test of sphericity is significant. Based on the scatter plot and the eigenvalues, the number of factors was established. The analysis produced a one component solution considering the eigenvalues of each factor were greater than 1.

Only one component was extracted, making it impossible to rotate the solution. The single component, accounting for 67.76% of the variation, has ten items. This demonstrates how these questions only evaluate one component. The self-discipline factor will be used to describe the component. The factors and item loading are listed in Table 4. A new item's factor loading should be more than 0.6 for each new item. Items with a factor loading of 0.6 or less should be removed from the measurement model. No items will be deleted since their values during loading are more than 0.6.

Table 4. Component matrix.

Items	Component
I do my classwork right away	0.811
I am always prepared to learn	0.827
I make sure to carry out my plans	0.825
I do not need a push to start doing my tasks in learning Mathematics	0.775
I set up a good study area at home	0.766
I surround myself with good people who inspire me	0.804
I forego some of my current stressful activities	0.712
I meet deadlines and follow schedules	0.847
I take good notes	0.826
I like to make study plans in advance	0.801
Extraction method: Principal component analysis	
a. 1 component extracted	

Test of difference

Test differences were computed to determine whether the means of the two constructs differ. Table 5 shows that the grand mean of the SDPI (researcher made) is 3.620, SD of 0.89, and SEM of 0.087. It shows that the mean, standard deviation, and standard error mean of the newly developed tool are slightly greater than the standardized test. This would imply that the results of the two questionnaires were closely similar to one another.

Table 5. Group statistics.

	Type of questionnaire	N	Mean	Std. deviation	Std. error mean
Means	Researcher-Made	104	3.62	0.89	0.087
	Standardized	104	3.61	0.772	0.076

When two independent samples are assumed to be drawn from a similar or identical population, t-test statistics assume equal variances. The independent t-test requires the homogeneity of variance assumption, which states that both groups have the same variance. This implies that the homogeneity of variances assumption is violated if the researcher rejects the null hypothesis of Levene's Test. The researcher will rely on the equal variances assumption if Levene's test shows that the variances are equal between the two groups, such as when the p-value is high. The researcher will rely on the second row of output, Equal variances not assumed, if the results of Levene's test show that the variances are not equal between the two groups (p-value is small).

Table 6 shows that the p-value is 0.178 greater than α 0.05, then the null hypothesis, which states that there is no significant difference between the variances of the two constructs, was not rejected. This demonstrates that the two constructs do not significantly differ from one another. This indicates that there is no significant difference between the test created by the researcher and the standardized test. Hence, construct validity was established.

Table 6. Independent samples test.

Levene's test for equality of variances			t-test for equality of Means						
Means	F	Sig.	t	df	Sig. (2-tailed)	Mean diff	Std. error diff	95% confidence interval of the difference	
								Lower	Upper
Equal variances assumed	1.828	0.178	0.092	206	0.927	0.0106	0.1155	-0.2172	0.2383
Equal variances not assumed			0.092	201.95	0.927	0.0106	0.1155	-0.2172	0.2384

Internal consistency reliability

Reliability is a measure of how consistently test results are reported. It ensures the accuracy of the scores derived from the multiple items used to gauge the various constructs. Clark and Watson recommended a mean inter-item correlation between 0.15 and 0.20 for scales that evaluate broad attributes, and between 0.40 and 0.50 for scales that evaluate more specific aspects (Table 7). To avoid multicollinearity, the inter-item correlation coefficient should not be too high (over 0.8).

As shown in Table 7 the mean inter item correlation is 0.599, this means that the results per item are consistent. This also demonstrates that the items correspond to the relevant construct and provide accurate measurements of the construct under investigation which is the self-discipline practices in learning mathematics.

Table 7. Summary item statistics.

	Mean	Minimum	Maximum	Range	Max/Min	Variance	N of Items
Item Means	3.62	3.375	4.01	0.635	1.188	0.052	10
Inter-item correlations	0.599	0.45	0.723	0.273	1.607	0.005	10

Table 8 shows the scale's reliability results, the corrected item-total correlation ranges from 0.7 to 0.8 which indicates that items are strongly correlated with the scale and there are no items to be deleted. Cronbach's alpha if an item is deleted displays the overall alpha if a specific item is excluded from the computation. The scale's overall alpha is 0.937, hence it is necessary for the values in the column to be closer to this value. Since the values are closer to the overall alpha there is no need to delete any item (Table 9).

Table 8. Scale's reliability results.

Items	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Squared multiple correlation	Cronbach's alpha if item deleted
Item 1	32.721	64.844	0.76	0.665	0.93
Item 2	32.192	64.157	0.777	0.639	0.929
Item 3	32.442	64.307	0.775	0.652	0.93
Item 4	32.779	65.766	0.718	0.586	0.932
Item 5	32.664	64.653	0.711	0.543	0.933
Item 6	32.231	64.14	0.751	0.633	0.931
Item 7	32.827	67.077	0.652	0.505	0.935
Item 8	32.558	63.628	0.8	0.715	0.928
Item 9	32.596	63.466	0.778	0.666	0.929

Item 10	32.808	64.04	0.75	0.634	0.931

Table 9. Reliability statistics.

Cronbach's alpha	Cronbach's alpha based on standardized items	N of Items
0.937	0.937	10

The reliability of an instrument is gauged by Cronbach's alpha. According to the literature, a Cronbach's alpha of 0.70 and above is considered good, 0.80 and above is better, and 0.90 and above is best. Table 8 demonstrates that the construct (SDPI) established high internal consistency reliability with a Cronbach's Alpha of 0.937.

DISCUSSION

Self-discipline is necessary to maintain order and motivation while learning. However, the creation of instruments to promote self-discipline in learning mathematics has not received much attention. Developing a tool for self-discipline practices of senior high school students is required to grasp and advance their current level of mathematical learning. The produced tool can aid in curriculum planning and effectively satisfy students demands.

CONCLUSION

The results show that the newly created instrument possesses internal consistency reliability and construct validity. According to this, the self-discipline practices inventory may be able to evaluate students' use of self-discipline while learning mathematics. The two personality traits models, the HEXACO model, and the IPIP model were combined to create a scale with three different subject areas. The content areas were prudence, orderliness, and diligence. Prudence is the ability to thoroughly consider decisions and restrain one's impulses. One's level of orderliness serves as a gauge for one's predisposition for order, particularly in their physical environment. Diligence is examining one's propensity for hard work. High scorers are interpreted with a strong work attitude and are prepared to put in the effort necessary to succeed, in contrast to low scorers who lack self-discipline and are not particularly keen to succeed. The self-discipline practices inventory can be replicated and improved upon by future studies.

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