Conceptualizing and Validating Information Security Culture as a Multidimensional Second-Order Formative Construct

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***Abstract*— This paper discusses a pilot study on conceptualization and validation of Information Security Culture (ISC) as a multidimensional second-order formative construct. The concept was developed in our previous works, and is based on widely accepted concepts of Organizational Culture and ISC. The model is validated using samples from employees of one Malaysia Public University. The Partial Least Squares Approach to Structural Equation Modeling (PLS-SEM) using Smart-PLS software was used to model and analyse the data. The ISC construct was treated as reflective-formative second-order construct and analysed using the latest approach in PLS-SEM. The findings empirically support the conceptualization and validation of ISC as a reflective-formative second-order construct with all seven dimensions being significant in contributing to the underlying concept of ISC. The study contributes to the ISC literature by providing new insights on the conceptualization, operationalization and validation of ISC the concept based on widely accepted concepts and approaches.**

Keywords- ISC concept; reflective-formative second-order; PLS-SEM.

I. INTRODUCTION

Due to increasing number of security breaches and attacks caused by employee's behavior, scholars and experts recommended practitioners to cultivate Information Security Culture (ISC) in guiding the security behavior in an organization. A number of studies related to ISC have been conducted to utilize this culture ranging from understanding of ISC to the development and validation of ISC frameworks and assessments [1]. However, there is still unclear what are the comprehensive guidelines to cultivate the ISC that effectively will influence employee's security behavior. Moreover, there is no common understanding of what ISC is and what factors or dimensions should be used to conceptualize ISC [2].

In terms of concept, generally, there are two ways of conceptualization found in the literature. The first approach is by using a general construct with particular number of reflective items. Although this approach is mostly used in the literature, there are some limitations pertaining to the applicability of the items to represent the elements or aspects of ISC cultivation. Since it is a reflective construct, the items or indicators used to measure the ISC construct are representing similar aspect of ISC only. This is because the items for a reflective construct are interchangeable [3]. As a result, these items could not be used to represent the particular distinctive aspects of ISC and the findings from this type of ISC conceptualization could not be utilized as aspects to be used in ISC cultivation. Furthermore, this approach is not comprehensively representing the actual meaning of the ISC itself because ISC is a culture that should be cultivated by multiple aspects. The second approach is by conceptualizing ISC as a multidimensional formative second-order construct with a particular number of first-order dimensions. In this way, the ISC construct is measured by several different aspects of ISC that form the concept [4]. This second approach of conceptualization provides more clear indications on the aspects that could be used as guidelines and strategies in ISC cultivation compared to the first approach.

This paper discusses ISC as a multidimensional second-order formative construct by proposing and validating the ISC concept that was developed in our previous works [5][6]. Section II discusses literature review and the conceptualization of ISC concept followed by the methodology used to validate it in Section III. Section IV presents results and analysis of data followed by the discussion of findings in Section V. Section VI justifies limitations of the study and finally the conclusion is presented in Section VII.

 ISBN: 978-1-61208-641-5

II. LITERATURE REVIEW AND MODEL DEVELOPMENT

There are many definitions of ISC in the literature. [7] in his systematic literature review on ISC studies has found that most of the ISC definitions were related to the model of Organizational Culture by [8] in one way or another. [9] defines ISC as the belief of individual employees on the value of complying with information security standards and policies. The latest definition by [10] refers to ISC as the collection of perceptions, attitudes, values, assumptions, and knowledge that guide the human interaction with information assets in [an] organization with the aim of influencing employees' behavior to preserve the information security.

Although there is quite a number of definitions, [1] suggested that there seems to be a common understanding that ISC "consists of a shared pattern of values, mental models and activities that are traded among an organisation's employees over time, affecting information security". In terms of ISC conceptualization, there are basically two approaches available in literature. The first one is in the form of general aspect of ISC construct measured by several reflective indicators such as in [11][12]. The second conceptualization approach treats ISC as a multidimensional second-order construct, such as in [13][14]. According to [15], "a multidimensional construct is a single theoretical concept that is measured by several related constructs". Using this second approach, ISC is conceptualizing as a Higher-Order Construct (HOC) consisting of several lower-order latent constructs. These lower-order latent constructs are the indicators of ISC construct, where constructs are described as multidimensional when their indicators are themselves latent constructs [16].

Compared to the first approach, the conceptualization of multi-dimensional second-order is useful when a greater specificity of understanding is warranted in case of a theoretical construct [17]. [18] in their security behavior study has suggested that whereas two or three measurement items might suffice to define a construct of peripheral interest, a multi-dimensional construct allows researchers to develop items that describe a construct in terms of multiple sub-constructs and making the nature of the construct clearer and more visible. Moreover, ISC is a complex concept and according to [16][19], a complex concept should be modelled as a multidimensional construct so as to permit a more thorough measurement and analysis. This is consistent with [20] that suggested ISC security culture is a multidimensional concept that has often been investigated in a simplistic manner.

In our previous studies [5][6], we adopted the general concepts of Organizational Culture by [8] and ISC by [21] to formulate the dimensions used to represent the ISC concept, as illustrated in Figure 1. These works produced an ISC concept in seven dimensions, namely Procedural Countermeasures (PCM), Risk Management (RM), Security Education, Training and Awareness (SETA), Top Management Commitment (TMC), Monitoring (MON), Information Security Knowledge (ISK) and Information Security Knowledge Sharing (ISKS).

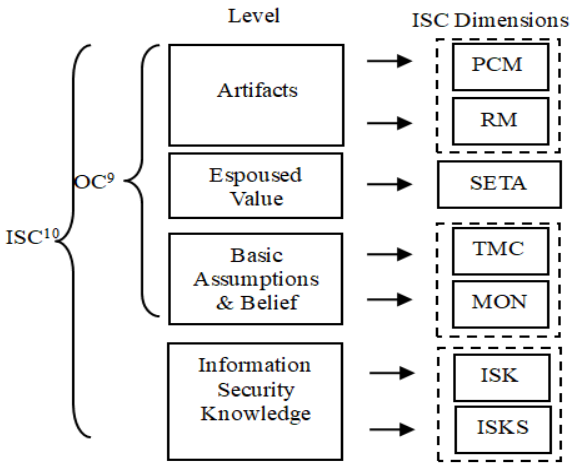

Figure 1. Formulation of ISC Dimensions [6]

Review of literature also revealed that the ISC concept is associated with these seven dimensions as discussed in [5] [6]. In order words, there are theoretical and empirical findings that suggest all the seven dimensions are influencing ISC. Although these dimensions are conceptually distinct, at a more abstract level, each can be viewed as describing a different facet of the overall construct of ISC [16][22][23]. These seven dimensions are forming the ISC construct, suggesting that the relationship between the ISC construct and its lower-order constructs is formatively similar to prior study [14]. This type of relationship is also referred to as aggregate by [16]. An aggregate construct 'combines or aggregates specific dimensions into a general concept', with the relationships flowing from the dimensions to the construct [24].

III. RESEARCH METHOD

A. *Measures*

This pilot study employed survey methodology to validate the proposed ISC model. Table I shows a summary of items used in this study to measure the respective constructs of ISC dimensions. The total measures were 30 in the questionnaire to represent the seven ISC dimensions. According to the table, most of the measurement items in this study are taken directly from prior tested and validated studies. The usage of previously validated instruments is strongly recommended in information system research [25] and it will increase and assure the content validity and reliability of the items used for the constructs in the study [26]. Only items of ISK were not directly adopted from the previous studies. The development of the items for this construct was based on literature analysis on this construct particularly in [21][27]–[30]. Additionally, the existing

scales in the literature also adapted in developing the items. All items were captured using a 7-point Likert scale ranging from (1) Strongly Disagree to (7) Strongly Agree to provide a more accurate view of their attitudes and perceptions [31]. Although most of the items in the questionnaires were adopted and adapted from the previous studies, a series of pre-tests have been conducted to ensure the validity for the context of this study. The responses from these tests were used to improve and refine the questionnaires.

TABLE I. SUMMARY OF ITEMS USED

Construct	Sources
PCM	[32]; [33]
RM	[30], [34]
SETA	[30], [34]
TMC	[35], [36]
MON	[32], [33], [14]
ISK	Adapted from [30], Self-definition by referring to [21], [27], [28]
ISKS	[37]

B. Sample Design and Data Collection

The data for this pilot study are collected using an online survey conducted for the duration of two weeks at one selected public university in Malaysia. The questionnaires' survey is designed using Google form and all responses are stored in the Google drive. In this cross-sectional survey, the invitations to participate were sent to respondents via e-mail with the survey's questionnaires attachment.

Since this is a pilot study conducted as a preliminary test before the actual study, the survey was targeted to get a minimum sample size that was appropriate to validate the model. The survey managed to get 92 respondents. Five invalid responses were removed from 92 due to having the same responses to all the questions (straight lining) and outliers. The final accepted samples were 87.

Specifically, the sample size calculation for this study has employed statistical power and effect size as suggested by [3] and recommended by [38]. This rule takes the number of maximum arrows pointed to a construct in the model, significance level and R^2 into consideration in calculating the minimum sample size. In our research model, since the maximum arrow pointed to ISC is the maximum, which is 7, according to [38], the minimum sample size of 80 is required to achieve a statistical power of 80% for detecting R^2 values of at least 0.25 (with a 5% probability of error). Therefore, 87 samples are appropriate for this study.

The ISC concept in this study is operationalized as a formative second-order construct formed by seven dimensions of first-order constructs. Each dimension is representing a strategy or principle element of ISC in an organization. This is consistent with [39] that used lower-order constructs to represent dimensions of strategic key components of instrumental and symbolic constructs. By using this approach, we could analyze the weights of the lower-order constructs to examine their relationship with ISC so that we could know which dimensions have relevance and significance in contributing to the ISC concept.

IV. RESULT AND ANALYSIS

A. Common Method Bias

Since data for the dependent and independent variables are provided by the same respondent, there is possible bias called Common Method Bias (CMB) or Common Method Variance (CMV) in the data collected. To test this bias, Harman's Single Factor Test [40] has been conducted. An unrotated factor analysis of all items yielded seven factors, the largest of which accounted for 47.55 percent of the variance. As an additional test, the correlation matrix [41] was examined to identify any highly correlated constructs ($r > 0.90$). The results have shown that all constructs had correlations below the threshold, which is less than 0.90. From these two tests, we conclude that the CMV bias is not a serious threat in this study.

B. Respondents' Profiles

Table II shows the profiles of respondents involved in this study. The respondents have a fair distribution of gender, with the majority of them being Malay. Most of them work in academics, followed by administration and management employees. In terms of highest academic qualification, the majority of the respondents had a Bachelor Degree or higher. The majority of the respondents had more than 5 years' experience working at this university.

TABLE II. RESPONDENTS' PROFILES

Demographic profile		N=87	Valid percentage (%)
Gender:	Male	39	44.8
	Female	48	55.2
Age:	18 - 24	2	2.3
	25 - 34	37	42.5
	35 - 44	38	43.7
	45 - 54	9	10.3
	55 and above	1	1.1
Race:	Malay	80	92
	Chinese	4	4.6
	Indian	1	1.1
	Others	2	2.3
Highest Education:	PhD	23	26.4
	Masters	18	20.7
	Bachelor Degree	27	31
	Diploma	10	11.5
	College	5	5.7
	Secondary School	4	4.6
Work experience:	Less than 2 Years	13	14.9
	2 to 5 Years	20	23
	5 to 10 Years	22	25.3
	10 to 20 Years	31	35.6
	20 Years and over	1	1.1
Service Type:	Academic	36	41.4
	Management	24	27.6
	Administration/Support	27	31

 ISBN: 978-1-61208-641-5

In summary, these demographic profiles show that the sample consists of appropriate sampling across the organization.

C. Data Analysis

The study employed the PLS-SEM to validate the model. The main reason is the model constitutes both reflective and formative constructs and also violates the assumption of multivariate normality [42][43]. PLS-SEM also has been commonly used by different scholars and provides a robust way to analyse the survey data [44][45]. Furthermore, PLS-SEM requires small sample sizes to conduct a valid analysis [46] compared to other techniques and all these criteria made PLS-SEM the most appropriate technique to be used in this pilot study. The Smart PLS (version 3.2.4; [47]) software was used to run the analysis by applying the technique of bootstrapping in order to evaluate the factor loadings' significance and path coefficients. Following the widely adopted two-step approach to SEM [48], the quality of the measurement model for all first-order constructs and second-order constructs were assessed first to ensure the validity and reliability of the measurements. Then, the structural model was analyzed by estimating the paths between the model's constructs determining the significance of path relationships.

1) Estimation of HOC in PLS-SEM through Repeated Indicator Approach

In repeated indicator, a higher-order latent variable can be constructed by specifying a latent variable that represents all the manifest variables of the underlying lower-order latent variables [49]–[51]. In this study, the higher-order factor, which is the ISC construct, is created using the indicators of its lower-order factors, which are PCM, RM, SETA, TMC, MON, ISM and ISKS. Table III shows ISC as a second-order construct constitutes seven dimensions of PCM, RM, SETA, TMC, MON, ISK and ISKS as underlying first-order constructs, each with their specific manifest variables.

By using this approach, the estimation of all the latent variables could be done simultaneously rather than estimating the higher-order and lower-order constructs separately [52]. Therefore, this estimation will avoid the interpretational confounding by taking the whole nomological network into consideration [39]. This approach is suitable since the primary objective of this study is to investigate the relationships of seven dimensions towards the ISC concept, which determines the appropriateness of these dimensions in representing the ISC concept.

TABLE III. SUMMARY OF ITEMS

Cultural Dimensions (First- Order Constructs)	Manifest Variables of First-Order Constructs	Number of Manifest Variables
PCM	PCM1, PCM2, PCM3, PCM4	4
RM	RM1, RM2, RM3, RM4	4
SETA	SETA1, SETA2, SETA3, SETA4	4
TMC	TMC1,TMC2, TMC3, TMC4	4
MON	MON1, MON2, MON3, MON4	4
ISK	ISK1, ISK2, ISK3, ISK4, ISK5	5
ISKS	ISKS1,ISKS2,ISKS3,ISKS4,ISKS5	5
Total items:		30

Specifically, this study employed repeated indicator approach with Mode A and path weighting scheme to model the second-order factors in the PLS analysis. According to [53], Mode A corresponds to correlation weights derived from bivariate correlations between each indicator and the construct. Mode B corresponds to regression weights, the standard in ordinary least squares regression analysis. Formative type models are commonly estimated by using Mode A for the repeated indicators, in the case the first-order constructs are reflective [53]–[55]. Furthermore, Mode A is more suitable since the aim for this particular assessment is to validate the relationship between each dimension with ISC concept rather than the regression of dimensions towards the ISC concept. In this study, since the seven ISC dimensions have been taken as the reflective first-order construct but as formative indicators for the second-order construct, therefore, Mode A was used for the higher-order repeated indicators.

2) Assessment of Measurement Model

Figure 2 shows the factors' loadings and path coefficient obtained from the PLS-Algorithm. Table IV shows the results of Cronbach's Alpha, Composite Reliability (CR) and Average Variance Extracted (AVE) that measures all items for first-order constructs. It shows that Cronbach's Alpha for each construct exceeds the threshold of 0.70 [56], AVE is greater than 0.50 [26] and CR is greater than 0.80 [55]. This means that the measurements are acceptable. In terms of loadings, all items are loaded highly on their own latent variable, and thus all measurements have satisfactory levels of reliability.

 ISBN: 978-1-61208-641-5

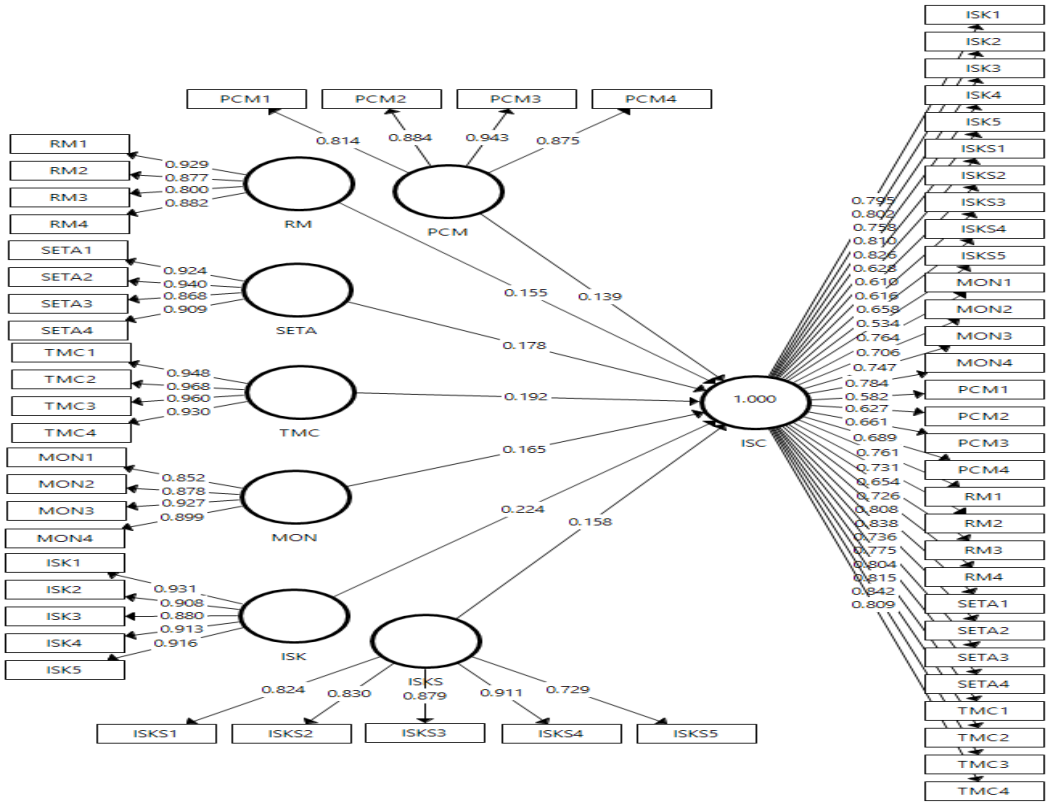

Figure 2. Factor Loadings and Weight

TABLE IV. COMPOSITE RELIABILITY AND VALIDITY

Construct	Cronbach's Alpha	CR	AVE
PCM	0.902	0.932	0.775
RM	0.895	0.927	0.762
SETA	0.931	0.951	0.830
TMC	0.965	0.975	0.906
MON	0.912	0.938	0.792
ISK	0.948	0.960	0.827
ISKS	0.891	0.921	0.700

The analysis of discriminant validity using Heterotrait-Monotrait ratio of correlations (HTMT) revealed that all values are below 0.90 [57], which indicates that discriminant validity has been established for all first-order constructs in the model.

3) Second-Order Construct Assessment

In assessing ISC as a second-order formative construct, this study used the recommendation in [58], by incorporating 3 evaluations, which are convergent validity; collinearity issues; as well as significance and relevance of formative indicators.

In measuring convergent validity, a global item of ISC that has been collected together in data collection was used to evaluate the path coefficient of the ISC construct, as illustrated in Figure 3. The result shows that the path coefficient is more than 0.70 and this suggests that the convergent validity was established.

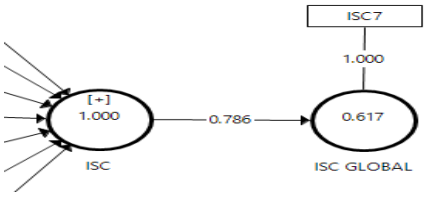

Figure 3. Convergent Validity Assessment

In terms of collinearity, Table V shows that the variance inflation factors (VIF) values for all ISC dimensions range from 1.95 to 3.75, which are below 5, thus indicating satisfactory reliability [59]. The results therefore, did not indicate a multicollinearity problem and support the formative nature of ISC.

TABLE V. WEIGHTS, T-VALUES AND VIF

ISC	Weight	t-value	VIF
PCM	0.139	11.925	2.018
RM	0.155	12.880	2.702
SETA	0.178	18.193	3.156
TMC	0.192	17.034	2.843
MON	0.165	15.543	2.965
ISK	0.224	16.851	3.754
ISKS	0.158	8.599	1.949

Note: Critical t values ***2.57 (significance level= 1%)

Table V also shows that the weight of each ISC dimension is above the recommended value of 0.10 [49]. All these weights of formative indicators also have significant t-values and have provided an empirical support to retain all the indicators [60].

Finally, in order to show the model's predictive relevance, a blindfold procedure has been done. The Q^2 values estimated by the blindfold procedure represent a measure of how well the path model can predict the originally observed values. The results of this procedure revealed that Q^2 value of ISC construct is more than 0.35 [3] and this implies that the exogenous constructs have large predictive relevance for ISC construct.

V. DISCUSSION

This pilot study has provided several important findings to be highlighted. First, since the measurement model assessments indicate that all items have passed all the criteria such as reliability and validity, this means all the items used in this study are capable to measure the particular constructs used in this pilot study and could be used in our next larger scale study. Second, by using the latest approaches and techniques especially by [58], this study empirically proved that the ISC concept is a formative second-order construct that is formed by seven first-order constructs of Procedural Countermeasures (PCM), Risk Management (RM), Security Education, Training and Awareness (SETA), Top Management Commitment (TMC), Monitoring (MON), Information Security Knowledge (ISK) and Information Security Knowledge Sharing (ISKS). This also empirically proved that seven dimensions formulated based on Organizational Culture by [8] and ISC conceptual framework by [21] are relevant and significant in contributing the underlying concept of ISC.

Although the sample population is limited to only one Malaysia public university settings, however, this findings shed some lights on the ISC concept for this particular organization as ISC is depending on organizational type and size [60][61], as well as the national culture [62][63]. Finally, since there is no common agreement on ISC definition and concept especially with regard to factors or dimensions [2], this study provides a new insight in the literature by providing a new holistic concept of ISC based on comprehensive dimensions to fill these gaps. Furthermore, since each dimension is representing an aspect of ISC, the findings from the studies that conceptualize ISC as multidimensional formative second-order construct provide clearer guidelines on aspects of ISC cultivation compared to another type of construct.

VI. LIMITATIONS AND FUTURE WORKS

Although this study provided promising findings on conceptualization and operationalization of the ISC construct, however, this is only a pilot study conducted on a small scale using minimum sample size in order to assess the adequacy of research instruments and selected research methodology before the larger scale of actual study could be conducted. Moreover, although the sample size used in this study met the requirement for data analysis in PLS-SEM as suggested by [38], a bigger sample size is required to convincingly generalize the findings to the population under study. In the next study, we are planning to collect more data from all public universities in Malaysia so that the findings could be convincingly generalized to this population.

VII. CONCLUSION

Experts and scholars recommended cultivating ISC in guiding employee's security behavior in the organizations. However, the conceptualization and operationalization of ISC is still unclear and need to be addressed properly. This study conceptualizes and operationalizes ISC construct that has been developed in our previous works. The findings confirmed that ISC is a multidimensional second-order construct that significantly formed by seven dimensions formulated based on widely accepted concepts of Organizational Culture and ISC.

ACKNOWLEDGEMENT

This research is supported by UMP Post Graduate Research Grant Scheme, RDU160359. The authors fully acknowledged Universiti Malaysia Pahang (UMP) for the approved fund which makes this important research viable and effective.

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 ISBN: 978-1-61208-641-5