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# The confirmatory factor analysis of science creative pedagogy (SCP) model

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ABSTRACT

Creative pedagogy is an instructional strategy that emphasizes the central importance of creativity in successful learning. Even though creativity among teachers has been extensively studied, the contributing factors in creative pedagogy are still inconclusive. To bridge the gap, a cross-sectional survey has been conducted to develop the Science Creative Pedagogy (SCP) Model by focusing on the elements that potentially support the motivation for implementing SCP. Therefore, the purpose of this study is to assess the validity and reliability of the CSP measurement model developed in Malaysia. A survey was administered to 409 primary school science teachers, covering the six constructs of elements of creative practice, namely knowledge (PG), environment (SEKITAR), teaching aids (BBM), skills (KEM_GURU), science process skills (KPS), and attitudes (SIKAP). The confirmatory factor analysis was performed, and subsequently, the discriminant validity, convergent validity, and reliability of the measurement model were computed. From the findings, the initial model was then modified from five items per construct to three items per construct, resulting in a refined SCP measurement model. Maps of teachers' creative pedagogy will be made using the construct. This will help the teachers' management bodies to set up a better environment for science teacher who wants to use the SCP in their classrooms.



## 1. Introduction

Cremin and Chappell (2021) performed a systematic review on creative pedagogies in light of the growing international attention on creativity in science education. The overarching themes derived from the evidence about creative instructional techniques and their potential impact on students' creativity diverge, and appear to focus on the schooling ecosystem and particularly on the teachers' creativity in teaching. Another important signposting from the same study is that the historical trends in creative pedagogy are inclined towards the Western and Global North (Cremin and Chappell, 2021; Glăveanu et al., 2015), indicating a gap in the research data on creative pedagogy in other regions, including South East Asia. On the other hand, the existing empirical data on creative pedagogy from Western and Global North must be reviewed carefully before it is taken into consideration in the formulation of the policy, curriculum, and national practices in Asia (Cheung, 2016), with the concern that creativity is culturally and environmentally contextualized (Cheng, 2011). Cremin and Chappell (2021) also reported that the information on creative pedagogy is predominantly acquired through qualitative approaches compared to quantitative, grasping the methodological gap of the creative pedagogies studies (Davies et al., 2013).

Given the huge gap in the extensively explored creative pedagogy, a large-scale study is required to develop Science Creative Pedagogy (SCP) Model in the national context. The hindsight prior to the survey is the need to develop and confirm the construct to establish a reliable measurement model. In a previous study, Jeffrey (2006) proposed factors that affect creative pedagogy which serves as an important reference for this study. The purpose of this study is to confirm the measurement model of the creative pedagogy in science education. This perspective idea from this study provides a reliable

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and valid model for extensive data collection. Later, the verified questionnaire data will form some baseline evidence to the policy maker to review the creative pedagogy and devise the best-fit strategy in the national education system.

## 2. Creative pedagogy

The concept of creative pedagogy has increasingly been employed by the Malaysian Ministry of Education indirectly in curriculum development, policy and plans. In Malaysia, the demand for a more creative curriculum began as an afterthought in the 1980s. It has since become an integral part of the national curriculum in 1994 known as the Critical and Creative Thinking Skills (CCTS), (BPK, 2014). In conjunction with the Malaysian Education Development Plan 2013-2025 and 21st Century Education, critical and creative elements have been continually emphasized in the revised national science curriculum several times. Even though the term 'creative' is always deemed as contradictory to 'critical,' nevertheless in Malaysian education, both terms are co-existing. That is, creative and critical thinking are complementary components and have been considered as such in Malaysian instructional designs, teaching and learning activities, and integrated curricular programs. Therefore, it is quite prevalent that the studies on teachers' creativity and students in Malaysia are inclined toward discussing both terms, critical and creative, as a wholesome concept (Nadara and Peng, 2018). In 2014, the Higher Order Thinking Skills (HOTs) were introduced to refine the aspect of creativity by the Ministry of Education through several national-level strategic plans which have driven the educators and researchers to focus on the creative pedagogy ecosystem and its dynamic nature of being adapted into different psychometric and demographic context (Nachiappan et al., 2019).

The teachers' creativity in the teaching and learning process is highly valued in providing quality education. Sidek et al. (2021) concluded that the studies on CCTS in science subjects in Malaysia have revealed a degree of moderate and low mastery of students' scientific creativity. It was further discovered that teachers' role in supporting students' scientific and creative enterprise had a favorable influence. However, the finding demonstrates that the student's mastery of creative thinking skills in science disciplines is still lacking, posing a significant barrier to the country's prospective ability to generate highly skilled individuals (Abdullah et al., 2021). Narayanan (2017) discovered that creative and innovative teaching strategies help students to understand a concept better and develop the interest in learning more about the concept. She further reckons that the application of many creative teaching techniques fostered the long-term memory of the lesson, which has yielded a positive relationship between creativity and student academic attainment. In the context of science teachers, Al-Abdali and Al-Balushi (2016) discovered that science teachers had a moderate level of creativity but practised high levels of creativity. Even though the science teachers considered themselves as understanding the meaning of creativity, they also admitted that their creativity skills and implementation in the classroom were moderate (Daud et al., 2012). Studies of student creativity also gained the interest among researchers. Ling et al. (2015) utilized different tests to gauge creativity, however, both reported that the polytechnic students had high creativity. In such situations, a student's ability to demonstrate creativity may also be a good indicator of a teacher's creativity (Abdullah et al., 2015).

Unfortunately, the study on teacher creative pedagogy does not provide a solid idea of the important factors for teachers to practice creativity in the classroom. Even though Chan and Yuen (2014) found that teachers believe that personal factors and environmental factors could facilitate or hinder creativity, Davies et al. (2013) were more concerned about the availability of material to use as a teaching aid and how it shaped one's creativity in pedagogy. Despite the availability of teaching aids, it was pointed out that the ability of the teacher to infuse their science process skill in pedagogical planning contributed to the creativity in pedagogy (Rauf et al., 2013; Teck., 2019) and eventually the students also had better understanding in same skill as well (Abell et al., 2013). Another important idea is that teachers could adopt the frugal or thrifty approach (Barajas et al., 2018) by using readily available material creatively to teach. As the studies in creative pedagogy reveal several fragmented ideas of the contributing factors in creative pedagogy, Hashim (2002) and Rahaimah and Lin (2018) asserted that the most serious issue is the teachers' hesitation to employ creative teaching and learning strategies owing to a lack of knowledge and skills.

This research is not the first attempt to identify factors in creative pedagogy in Malaysia. Jeffrey (2006) explored the factor contributing to creative pedagogy employed by science teachers using the positivist approach as well as updated the empirical study related to creative pedagogy and three important theories in creativity: Sternberg Creativity Theory, Torrance Creativity Theory, and Amabile Creativity Theory. Regarding the mentioned six constructs, this study further looked into the relevant factors of teachers' creative pedagogy to establish a valid and reliable measurement model. The precisely recognized measurement would later be visualized and acted upon by science teachers and policymakers.

## 3. Methodology

This study was conducted to assess the validity and reliability of the SCP model measurement for primary school science teachers using the positivist approach. The validity of the SCP measurement model in this study was computed from the response of the 409 teachers whom selected through purposive sampling. The analysis was conducted as suggested by Kline (2015), and the steps in Awang (2012) were repeated; 1) performing the Confirmatory Factor Analysis (CFA) and modification if required and 2) analyzing the measurement model indexes. This study used a questionnaire as a research instrument, which consisted of five parts, namely A, B, C, D, and E (Table 1). Part A contains respondents' profile information, while Parts B, C, D, and E cover the constructs of elements of creative practice, namely knowledge, environment, teaching aids, skills, science process skills, and attitudes. To determine if this model matched the observed data, a CFA was conducted to determine if the criteria of unidimensionality, validity, and reliability of the study model were met.

## 4. Findings and discussion

### 4.1. Confirmatory factor analysis (CFA)

The purpose of Confirmatory Factor Analysis (CFA) is to evaluate measurement models. Any item which doesn't match the measurement model because of low factor loading should be eliminated from the model in CFA. Certain fitness indexes are used to determine the fitness of a measurement model. If the number of items deleted in a model exceeds 20% of the total number of items in the model, the construct is considered inaccurate or known as failed confirmatory. CFA may be calculated separately for each measurement model or simultaneously for the pooled measurement model. After determining the model fit for the individual constructs, the validity of the entire measurement model for this study must be assessed before building and evaluating the structural model. This is to prove that the entire structures are valid and in harmony. The convergent validity, discriminant validity, and multicollinearity of the model constructs were used to assess the validity of the entire measurement model (Hair et al., 2016).

CFA commenced with a specification of the model, followed by model identification, parameter estimation, goodness-of-fit assessment, and subsequently model re-specification. These steps were repeated in the assessment of each 1) individual measurement model, 2) the entire measurement model, and 3) the structural model until the model validity was achieved. The models' validity was assessed using the established criteria for CB-SEM evaluation listed in Table 1. In CFA, the model should fulfill at least one of the index categories of absolute fit, incremental fit, and parsimonious fit indices. The analysis was carried out using AMOS graphic software to evaluate the measurement of the SCP Model in compliance with the suggested values of the acceptance value as shown in Table 1. If the models did not reach the minimum acceptance value, then they would be re-specified until they fit the criteria, as given in Table 1.

**Table 1:** Acceptance level of index category

| Category | Index | Acceptance level |
|---|---|---|
| Absolute fit | Chisq (discrepancy chi Square) | p > 0.05 |
| | RMSEA (Root Mean Square of Error Approximation) | RMSEA < 0.08 |
| Incremental fit | CFE (Comparative Fit Index) | CFI > 0.90 |
| | NFI (Normed Fit Index) | NFI > 0.90 |
| Parsimonious fit | Chisq/df (Chi-Square/Degrees of Freedom) | Chi/df < 5.0 |

Based on Fig. 1, the six constructs, and 30 items were assessed. However, the factor loading of RMSEA (0.90), CFI (0.871), and NFI (0.839) did not reach the minimum values as suggested in Table 1.

Therefore, modifications to this model should be made by eliminating items with a modification index (MI) value greater than 10, ensuring that each construct represented at least three elements (Hair et al., 2016). After re-analysis of the refined model, the factor loading showed that it had reached the values suggested in Table 1. Fig. 2 depicts the change in the correspondence index following the alteration, which shows that some items had been removed.

Table 2 shows the comparison of the index value of the earlier model and the modified model.

### 4.2. Discriminant validity

There are two methods of measuring discriminant validity used in determining highly correlated constructs: The Fornell and Larcker (1981) criterion and the HeteroTrait-MonoTraite (HTMT) of Henseler et al. (2015). The Fornell-Larcker method is conducted by comparing the correlation values between sub-constructs which are lower than the square root value of the Average Variance Extracted (AVE) value for each sub-construct. Based on Table 3, it was found that all sub-construct correlations were lower than the square root value of AVE. The HTMT method refers to the correlation between the sub-constructs studied. Based on the criteria of Henseler et al. (2015), any correlation between sub-constructs which was less than a value of 0.90 indicated a satisfactory degree of discriminant validity. Based on Table 3, it was found that all HTMT correlation values were below 0.90.

**Table 2:** The index value of the earlier model and the modified model

| Index | Initial model (6 constructs, 30 items) | Modified model (6 constructs, 18 items) |
|---|---|---|
| Chisq (discrepancy chi Square) (p > 0.05) | 0.000 | 0.000 |
| RMSEA (Root Mean Square of Error Approximation) (RMSEA < 0.08) | 0.090 | 0.079 |
| CFI (Comparative Fit Index) (CFI > 0.90) | 0.871 | 0.937 |
| NFI (Normed Fit Index) (NFI > 0.90) | 0.839 | 0.914 |
| Chisq/df (Chi-Square/Degrees of Freedom) (Chi/df < 5.0) | 4.298 | 3.520 |

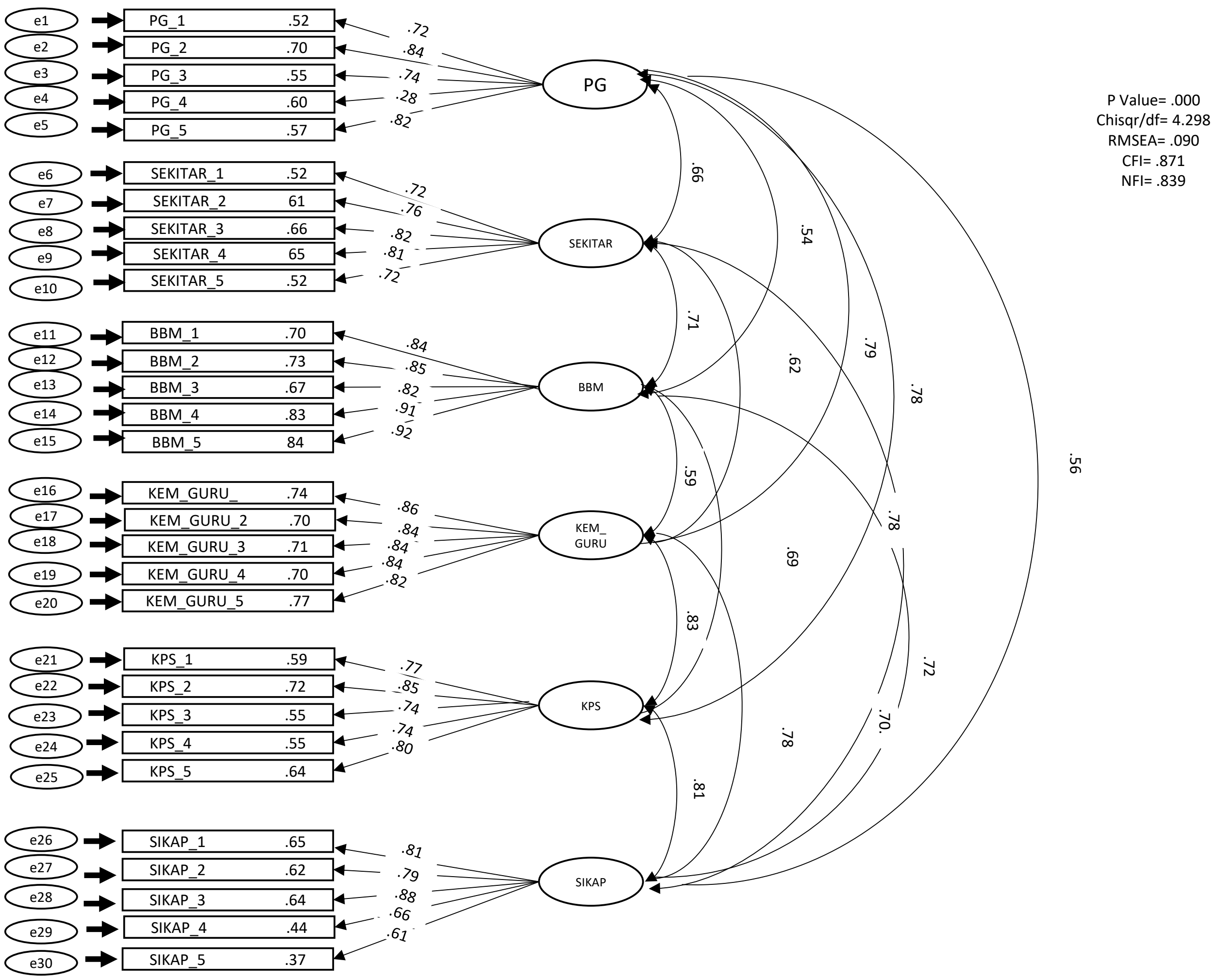


**Fig. 1**: The index value of the measurement model

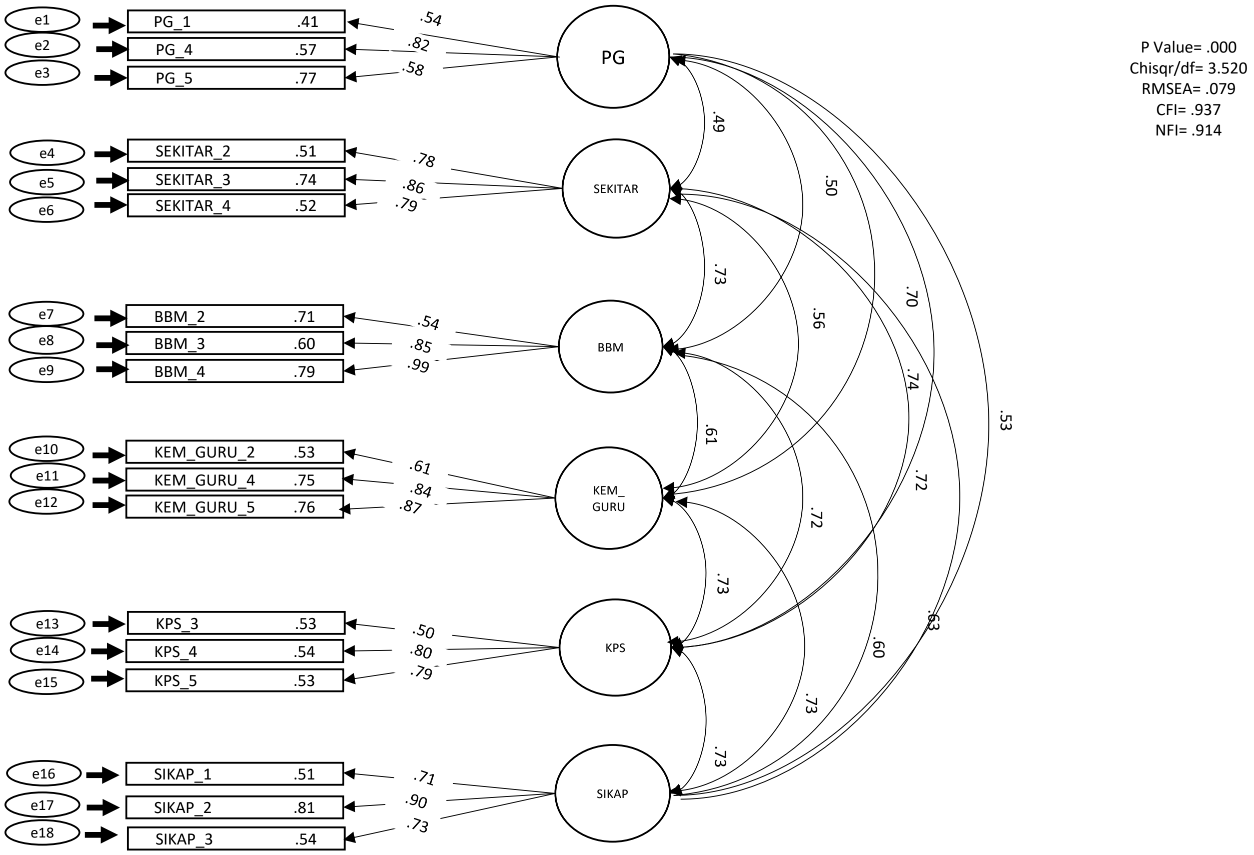


**Fig. 2:** The index value of the modified measurement model

**Table 3:** HTMT correlation value of six constructs

| | PG | SEKITAR | BBM | KEM_GURU | KPS | SIKAP |
|---|---|---|---|---|---|---|
| PG | | | | | | |
| SEKITAR | 0.534 | | | | | |
| BBM | 0.534 | 0.728 | | | | |
| KEM_GURU | 0.759 | 0.580 | 0.612 | | | |
| KPS | 0.742 | 0.732 | 0.729 | 0.733 | | |
| SIKAP | 0.554 | 0.673 | 0.626 | 0.774 | 0.756 | |

### 4.3. Convergent validity and reliability

Convergent validity refers to the degree to which one item in a similar construct is related to other variables and measures of the same construct. The correlation value of a similar construct or variation discovered in each item measuring its construct is used to compute convergent validity. Meanwhile, reliability is the consistency of an instrument even if the test has been repeated several times. The construct reliability coefficients refer to internal consistency indicating the construct uniformity of latent variables (Hair et al., 2010). According to Hair et al. (2010), if the construct of the measurement model and the Average Variance Extracted (AVE) value is greater than 0.5 and the composite reliability (CR) is greater than 0.70, the model's validity is confirmed (Hair et al., 2010). AVE values in this study were calculated using the following formula (Hair et al., 2010):

$$Average\ Variance\ Extracted\ (AVE) = \sum K^2/_n$$

From the analysis, the CR value range was between 0.825 to 0.890, and the AVE value was above 0.5 for all the constructs in the measurement model (Table 4).

**Table 4:** The CR and AVE value of six constructs

| | CR | AVE | PG | SEKITAR | BBM | KEM_GURU | KPS | SIKAP |
|---|---|---|---|---|---|---|---|---|
| PG | 0.825 | 0.615 | 0.784 | | | | | |
| SEKITAR | 0.849 | 0.653 | 0.484 | 0.808 | | | | |
| BBM | 0.890 | 0.730 | 0.499 | 0.725 | 0.854 | | | |
| KEM_GURU | 0.873 | 0.697 | 0.736 | 0.565 | 0.612 | 0.835 | | |
| KPS | 0.838 | 0.632 | 0.701 | 0.720 | 0.724 | 0.728 | 0.795 | |
| SIKAP | 0.828 | 0.619 | 0.525 | 0.626 | 0.597 | 0.727 | 0.732 | 0.787 |

From Table 4, the model possessed satisfactory convergent validity and high reliability of the all-measured constructs.

The analysis of 30 items for a total of six constructs found that the original model needed to be modified. After the process of review and analysis had been performed repeatedly, the final model was established. The refined SCP measurement now consisted of three items per construct and yielded a total of 18 items for six constructs. The six constructs are knowledge (PG), environment (SEKITAR), teaching aids (BBM), skills (KEM_GURU), science process skills (KPS), and attitudes (SIKAP). The final version is now well-fitting, with all non-standardized estimates statistically significant, all standard errors acceptable, and all standard estimates above moderate strength, indicating that the instrument is reliable and valid. The questionnaire is now appropriate to gauge school teachers' perspectives on creative pedagogy in Malaysian schools. From herein, this measurement model could be further developed into a structural model better to gauge the variables in teachers' creative pedagogy.

## 5. Discussion

Confirmatory factor analysis is an important analysis tool for this study for investigating causal relationships between latent and observable variables in a priori specified, theory-derived models (Mueller and Hancock, 2001). The fundamental advantage of CFA is that it can help researchers to bridge the frequently noticed gap between theory and observation. In this study, readily available instrument's psychometric properties were evaluated to confirm that the chosen instrument is appropriate for the study aims and setting. Removing the items that do not load on the appropriate factor yielded 18 items as compared to 30 items. Therefore, the CFA in the context of this study was the pre-analysis decision (Alhija, 2010) on the unidimensionality, reliability, and validity of the instruments prior to the final analysis.

In terms of unidimensionality, the screening of the quality of each construct would contain items only related to the respective concept of interest (Atkinson et al., 2011), allowing the quality of measuring a single construct to be measured. At the same time, the reliability of the instrument is also confirmed by measuring the precision and accuracy of the instrument by verifying the measurement structure of the instruments (Ghazali et al., 2020). On the other hand, by reducing the item with low factor loadings, the overall number of observed variables refers to the latent factors based on commonalities within the data (Suhr and Shay, 2009).

The SCP Model was deployed in this study by creating multiple items for each of several specific theoretical constructs based on literature reviews. Then, the findings from CFA indicated the potential changes in the SCP Model by providing useful information about the data's fit to a theory-derived measurement model and flag out prospective item weaknesses for the subsequent analyses. Therefore, in this study, CFA evaluates the fit of observed data to a priori-conceptualized, theoretically grounded model. Using CFA, the specific hypothesized causal relationships between latent factors and their observed indicator variables are measured and thus acted upon by removing them if they are not fit. The final SCP model can now be applied in the field.

## 6. Conclusion

Following the confirmatory factor analysis, the discriminant validity, convergent validity, and reliability of the measurement model were calculated. Based on the findings, the initial model was refined by reducing the number of items per construct from five to three, resulting in a refined SCP measurement model. The construct will be used to create maps of teachers' creative pedagogy. This will assist teachers' management bodies in creating a more conducive environment for science teachers who wish to use the SCP in their classrooms.

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## Compliance with ethical standards

## Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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