

Designing and Developing a Creative Science Inquiry-Based (CSi) Pedagogy Model to Facilitate Primary School Science Teachers Using the Nominal Group Technique and Interpretive Structural Modelling

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ABSTRACT: This study was conducted to design, develop and evaluate a creative science inquiry-based pedagogy model (CSi) using the Design and Developmental Research (DDR) approach. The study was carried out in three phases. Phase I is a need analysis phase that was conducted through a survey method to identify the level of creativity and the level of creative practice by inquiry in teaching. The sample was 75 primary school science teachers who were selected by purposive sampling method while the study instruments were the Torrance Creative Thinking Test (TTCT) and a set of creative practice questionnaire. The data were analyzed descriptively and it was found that the level of creativity of science teachers was moderate ($m=409.77$, $sd=109.56$), while the level of creative practice in inquiry was high ($m=4.388$, $sd=0.481$). Phase II of the study is the design and development phase involving 11 experts consisting of lecturers and experienced primary school science teachers. This phase applied the Nominal Group Technique (NGT), using a list of creative science inquiry-based teaching and the Interpretive Structural Modelling (ISM) method was used to develop the model. In the final stage of phase II, a CSi model consisting of 30 elements was generated and the elements were classified into three dimensions (Independent, Linkage and Dependent) throughout four themes (Teacher Knowledge, Teacher Skills, Teacher Preparation and Teacher Commitment). The evaluation of several aspects in Phase III was carried out using the Fuzzy Delphi Method (FDM) involving 28 science teachers. Findings were found to meet 2 assessment conditions (i) triangular fuzzy numbers ; $d \leq 0.2$, expert consensus percentage $\geq 75\%$ and (ii) fuzzy score ≥ 0.5 . Consensus shown the satisfactory level of the aspects evaluated. This study had finally proposed a CSi model to facilitate primary school science teachers to become more competent in teaching and at the same time hone the creative and inquiry nature of teachers and students in science subjects.

1. INTRODUCTION

In Malaysia, teachers' overall creativity was low yet they perceived that they employed highly creative practices in the classroom (Abdullah et al., 2021). The teachers claimed that they use various teaching strategies and also the open-ended tasks during the teaching and learning process. Research suggest that fostering scientific creativity among primary students requires teachers who are adequately prepared for inquiry-based science education (Cremin et al., 2018; Paudel, 2020). When teachers employ strategies that model creative thinking, such as incorporating imaginative thinking and encouraging idea generation, this support students' creative development (Thompson, 2017). Furthermore, training initiatives should focus on scaffolding component skills and helping teachers overcome obstacles in implementation. In other Asia Pacific region countries for example Australia, the science teachers working under the Australian Curriculum mandate display partial understanding of creativity. Many can name elements of creative thinking but remain uncertain about how to operationalise them, often defaulting to project-based or inquiry activities that demand extended class time (McLure, Won, & Treagust, 2024). The study notes limited emphasis on hypothesis generation, analogical reasoning, and mental-image use, indicating gaps in fostering deeper creative cognition.

The creative capacity of primary school science teachers in Indonesia is closely tie to their professional competence and the methods they employ for instructional design. Studies indicate a significant, positive correlation between teachers' overall professional competence (including pedagogical competence) and their elementary students' creativity though this correlation is characterized as weak (Weran & Kuswandono, 2021). Teacher creativity is evident in developing modern instructional model. Elementary teachers use diverse strategies such as integrating local culture and digital tools, when designing Project-Based Learning (PBL) model to foster students' engagement and problem solving. However, challenge remain notably limited institutional support and training opportunities

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(Raza, Akhtar, & Amin, 2024). Efforts to nurture creativity in primary science instruction often involve developing specific learning materials that align with creative principles.

Over the past decade, Singapore's primary school science teachers have been positioned as the "leaders of inquiry" and by extension, the primary drivers of classroom creativity (Ministry of Education, 2014). The National Institute of Education (NIE) has continuously revised its pre-service and in-service programmes to embed the three "IN" s which are Inspire, Inquire and Innovate within the science curriculum explicitly linking these to the 21st century competencies such as creativity (Science Syllabus 2023/2024, p.1) (Curriculum Planning and Development Division, 2024). Empirical work shows a gap between policy intent and classroom practice. Observations of beginning teachers (the 2008 cohort) reveal the predominance of teacher-centred, content driven instruction, with only modest confidence (mean≈3.0 on a 5-point scale) for delivering inquiry-based lessons that would nurture creativity (Long & Bae, 2018). Formative assessment studies similarly note that teachers favour closed questioning and detailed feedback, limiting opportunities for open ended and creative exploration (Hussain & Kwek, 2024).

Across these contexts, common barriers include insufficient professional development, limited resources, and curriculum pressure that constrain time for open-ended inquiry. To raise teacher creativity, actions need to be taken to sustained collaborative communities, and policy shifts that allocate classroom time for design and inquiry-rich science lessons. Thus, this study seeks to design and develop a creative science inquiry-based (CSi) pedagogy model to facilitate the primary school science teachers.

Research questions to guide this study are:

- (i) What are the appropriate elements to be included for the design and development of CSi pedagogy model according to experts' views?
- (ii) What is the order (rank) of the elements of the CSi pedagogy model according to expert agreement?
- (iii) What is the form of the CSi pedagogy model according to expert agreement?
- (iv) What is the classification of elements of CSi pedagogy model according to the driving power and the dependent power according to the expert agreement?
- (v) What is the classification of the elements of CSi pedagogy model according to dimensions based on expert agreement?
- (vi) What is the classification of CSi pedagogy model according to the theme based on expert agreement?

2. METHODS

This study aimed to find out the appropriate elements to design and develop a creative science inquiry-based (CSi) pedagogy model. This method applied the Design and Developmental Research (DDR) by Richey & Klein (2013). DDR comprises of three phases and the design and development falls into the second phase. This phase is divided into two sub-phases (i) sub-phase designing and (ii) sub-phase developing. Both phases gathered data derived from the same expert group (three lecturers and eight experienced primary school science teachers). According to Siti Farhah and Saedah (2015), someone who are constantly in a field for more than five years can be called as expert. For sub-phase designing, research had implemented the modified Nominal Group Technique (NGT) to get prior information from the experts and for sub-phase developing, research had employed the Interpretive Structural Modelling (ISM). At this point, NGT and ISM were used because both techniques obtained information from the experts that have the same interest and knowledge to be shared regarding the issue studied. The instrument used for sub-phase designing was a list of 37 creative science inquiry-based teaching elements.

Modified Nominal Group Technique (NGT)

Modified NGT made consensus building more effective by adding flexibility, iterative drafting, and extended extraction (Søndergaard et al., 2018). The step-wise NGT structure will ensure equal speaking opportunities. This method is a structured, well established, multistep, facilitated, group meeting technique used to generate and prioritize responses to a specific question by a group of people who have expert insight into a particular area or interest (Søndergaard et al., 2018). This method complied with the checklist created during the first phase of this study (need analysis phase). During the session, experts were required to analyze a list of 37 creative science inquiry-based science teaching elements and determine the most appropriate elements to be the output of the pedagogy model. They were also needed to give their degree of agreement for each element based on 7-points Likert scale as follows:

- 1- Extremely disagree
- 2- Very disagree
- 3- Disagree
- 4- Moderately agree
- 5- Agree

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- 6- Very agree
- 7- Extremely agree

Final elements obtained from modified NGT session were given score, and the percentage of agreement for each element was calculated in order to rank each element based on their score. Only elements scored at least 70% of expert agreement will be selected as the final elements. The final list then carried to the next sub-phase developing (Khalil & Abdullah, 2023).

Interpretive Structural Modelling (ISM)

ISM is defined as a process that aimed at assisting researcher to better understand their belief and to recognize clearly things they unknown. This technique transforms unclear, poorly articulated mental model of system into visible and well-defined model (Attri, Dev, & Sharma, 2013). This technique also involves ISM software that has been built by Sorach Incorporation' called Concept Star. This software is used to assist in the process of discussion and selection of a list of elements among experts that is made behind closed doors to determine the relationship between each element that has been included in the software. ISM is a technique that is built to help the human brain to manage information and ideas through a clear structure for a problem (Ariffin, 2018).

3. RESULTS AND DISCUSSION

A group of 11 experts involved during this phase (see **Table 1**). These experts contributed for both sub-phase designing and sub-phase developing via different discussion sessions. From the table, we can see that all of them have more than 10 years of service experience. Three of the experts are lecturers (27%), while eight of them are primary school science teachers (73%). One of them has 10 years of teaching experience, three experts with 11 years of experience, an individual with 12 years of experience, 15 years, 18 years, 19 years, 21 years, 25 years, and 30 years of experience each.

Table 1. Frequency distribution of experts by field of expertise and years of service

Position	Expertise	Years of service	Number	Total number
Lecturer	Pedagogy	30 years	1	11
Lecturer	Pedagogy	19 years	1	
Lecturer	Science	11 years	1	
Teacher	Science	15 years	1	
Teacher	Science	18 years	1	
Teacher	Science	21 years	1	
Teacher	Science	11 years	1	
Teacher	Science	12 years	1	
Teacher	Science	11 years	1	
Teacher	Science	10 years	1	
Teacher	Science	25 years	1	

Table 2 showed the result obtained from the NGT session which answered the first research question *What are the appropriate elements to be included for the design and development of CSi pedagogy model according to experts' views?*

From 37 elements, experts agreed to withdrawn 7 elements. According to them, the elements were eliminated from the list due to having similar interpretation. The experts were then required to give their score based on 7-point Likert scale for each element and the finding were shown in the **Table 2**. From the table, all elements showed more than 70% of expert agreement. The elements were given rank based on the score starting from rank 1 (highest score and highest expert agreement) to rank 9 (lowest score and lowest expert agreement).

From the findings shown in **Table 2**, twelve (12) elements (element 1,4,5,7,9,10,11,12,17,19,23 and 25) scored full score (77points) with 100 percent of agreement. Three elements (element 6, 20 and 25) recorded 76 points with 98 percent of agreement. Other three elements (element 2, 16 and 18) recorded 75 points with 97 percent of agreement. Element number 3,14 and 30 recorded 73 points with 95 percent of agreement. Next, element 8 recorded 72 points with 95 percent of agreement and element 29 recorded 71 points with 92 percent of agreement. Element number 13 and 15 recorded 69 points with 90 percent of agreement. Elements 22, 27 and

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28 recorded 67 points with 87 percent of agreement. Lastly, elements 21 and 24 recorded 65 points with 84 percent of agreement. All these elements were arranged into the ranks (from 1; highest points and percent of agreement to 9; lowest score and percent of agreement). The scores and percent of expert agreements determined the arrangement of all the elements into ranks as shown in **Table 3** and this answered second research question *What is the order (rank) of the elements of the CSi pedagogy model according to expert agreement?*

The arrangement based on rank as shown in **Table 3** was made to enable the elements to be analyzed using Interpretive Structural Model tool. From the table, the elements were classified into nine ranks (1 to 9) with twelve elements fell into the first rank, three elements in the second rank, followed by another three in third and fourth rank. One element fell into the fifth and sixth rank. Two elements in seventh rank, followed by three elements in the eighth rank and lastly two elements in the ninth rank. After obtaining the rank for each element, this study then furthered to sub-phase developing where ISM was applied. ISM involved a few steps of voting between pairs of elements according to **Table 3**. Relation phrase and conceptual phrase were built to connect the items. **Figure 1** showed the model obtained at the end of ISM session.

Table 2. Score, percentage, status of acceptance and rank of each element

Bil .	Elemen Pengajaran Kreatif	P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P1 0	P1 1	Jumla h Skor	Peratu s	Status penilaian	Keduduka n (Ranking)
1	Guru hendaklah berpengetahuan tentang kandungan mata pelajaran sains yang diajar.	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1
2	Guru hendaklah berpengetahuan tentang kaedah mengajar sains.	7	6	7	7	7	6	7	7	7	7	7	75	97	Diterima	3
3	Guru hendaklah berpengetahuan tentang tahap kebolehan murid.	6	6	7	7	7	6	7	7	7	6	7	73	95	Diterima	4
4	Guru hendaklah berpengetahuan dalam memilih sumber pengajaran.	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1
5	Guru hendaklah berpengetahuan dalam menentukan objektif pengajaran.	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1

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Bil .	Elemen Pengajaran Kreatif	P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P1 0	P1 1	Jumla h Skor	Peratu s	Status penilaia n	Keduduka n (Ranking)
6	Guru hendaklah menggunakan bahan sebenar yang didapati dari alam sekeliling untuk pengajaran (contoh: daun, batu, buah-buahan, serangga, bahan kitar semula dan lain-lain).	7	7	7	6	7	7	7	7	7	7	7	76	98	Diterima	2
7	Guru hendaklah menjalankan aktiviti pengajaran di luar kelas untuk menarik minat murid terhadap mata pelajaran sains.	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1
8	Guru hendaklah menjalankan aktiviti luar kelas yang sesuai bagi membantu murid-murid agar mereka berupaya mengaitkan pembelajaran sains dengan kehidupan seharian.	6	7	6	6	7	6	7	7	7	6	7	72	94	Diterima	5
9	Guru hendaklah menggalakkan penggunaan deria yang	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1

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Bil	Elemen Pengajaran Kreatif	P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P10	P11	Jumlah Skor	Peratus	Status penilaian	Kedudukan (Ranking)
10	sesuai dan ini membantu murid dalam mempelajari sains dengan lebih baik (bau, sentuh, dengar, lihat atau rasa). Guru hendaklah mengubah suai bahan sebenar sebagai bahan bantu mengajar untuk pengajaran sains.	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1
11	Guru hendaklah menggunakan bahan bantu mengajar dalam pengajaran dapat mempelbagaikan strategi pengajaran mereka.	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1
12	Guru hendaklah menggunakan bahan bantu mengajar dapat membantu pengajaran Sains menjadi lebih menarik.	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1
13	Penggunaan bahan bantu mengajar telah menyedarkan murid tentang kegunaan Sains dalam	6	6	7	6	6	6	6	7	7	6	6	69	90	Diterima	7

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Bil	Elemen Pengajaran Kreatif	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Jumlah Skor	Peratus	Status penilaian	Kedudukan (Ranking)
14	kehidupan seharian. Guru hendaklah menggunakan bahan bantu mengajar untuk merangsang pemikiran murid.	7	7	7	7	6	6	7	6	7	7	6	73	95	Diterima	4
15	Guru hendaklah menggunakan bahan bantu mengajar membantu dalam mencapai objektif pengajaran Sains.	6	6	6	5	7	7	6	7	7	5	7	69	90	Diterima	7
16	Guru hendaklah mempunyai kemahiran merancang persediaan pengajaran.	7	6	7	6	7	7	7	7	7	7	7	75	97	Diterima	3
17	Guru hendaklah mempunyai kemahiran mengurus bilik darjah dalam menggalakkan penglibatan murid.	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1
18	Guru hendaklah mempunyai kemahiran mempelbagaikan strategi pengajaran.	7	7	7	7	7	6	7	7	6	7	7	75	97	Diterima	3
19	Guru hendaklah	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1

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Bil	Elemen Pengajaran Kreatif	P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P1 0	P1 1	Jumlah Skor	Peratus	Status penilaian	Kedudukan (Ranking)
20	mempunyai kemahiran komunikasi dengan murid. Guru hendaklah berupaya menilai kualiti hasil kerja murid.	7	7	7	7	7	7	7	7	6	7	7	76	98	Diterima	2
21	Guru hendaklah tahu setiap elemen dalam KPS.	6	6	7	5	7	6	5	5	6	6	6	65	84	Diterima	9
22	Guru hendaklah mempelbagaikan kaedah pengajaran untuk mencapai Kemahiran Proses Sains murid.	6	6	7	6	5	7	6	5	7	6	6	67	87	Diterima	8
23	Guru hendaklah menjalankan aktiviti amali untuk mencapai KPS murid.	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1
24	Guru hendaklah menggunakan alatan tambahan untuk mencapai KPS murid.	6	6	5	6	6	6	5	7	6	6	6	65	84	Diterima	9
25	Guru hendaklah menjalankan pengajaran aktif dalam kelas Sains.	7	7	7	7	7	6	7	7	7	7	7	76	98	Diterima	2
26	Guru hendaklah memberi peluang kepada	7	7	7	7	7	7	7	7	7	7	7	77	100	Diterima	1

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Bil	Elemen Pengajaran Kreatif	P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P1 0	P1 1	Jumlah Skor	Peratus	Status penilaian	Kedudukan (Ranking)
27	murid untuk bertanya dan mengeluarkan idea sendiri. Guru hendaklah menggalakkan pembelajaran secara berkumpulan untuk percambahan idea.	7	7	5	6	7	7	6	5	5	6	6	67	87	Diterima	8
28	Guru hendaklah menerapkan elemen kemahiran berfikir aras tinggi dalam pengajaran sains.	6	6	6	6	7	7	6	6	5	6	6	67	87	Diterima	8
29	Guru hendaklah mendedahkan murid menjawab soalan pada aras tinggi.	6	6	7	6	7	7	6	7	6	6	7	71	92	Diterima	6
30	Guru hendaklah sentiasa mendorong murid untuk belajar dan meminati sains.	7	7	7	7	7	6	7	6	6	6	7	73	95	Diterima	4

P; Pakar (Expert)

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Table 3. Rank of each element

No elemen	Kedudukan mengikut <i>rank</i>	Elemen Pengajaran Kreatif Sains secara Inkuiri	<i>Rank</i>
1	1	Guru hendaklah berpengetahuan tentang kandungan mata pelajaran sains yang diajar.	1
4	2	Guru hendaklah berpengetahuan dalam memilih sumber pengajaran.	1
5	3	Guru hendaklah berpengetahuan dalam menentukan objektif pengajaran.	1
7	4	Guru hendaklah menjalankan aktiviti pengajaran di luar kelas untuk menarik minat murid terhadap mata pelajaran sains.	1
9	5	Guru hendaklah menggalakkan penggunaan deria yang sesuai dan ini membantu murid dalam mempelajari sains dengan lebih baik (bau, sentuh, dengar, lihat atau rasa).	1
10	6	Guru hendaklah mengubah suai bahan sebenar sebagai bahan bantu mengajar untuk pengajaran sains.	1
11	7	Guru hendaklah menggunakan bahan bantu mengajar dalam pengajaran supaya dapat mempelbagaikan strategi pengajaran mereka.	1
12	8	Guru hendaklah menggunakan bahan bantu mengajar supaya dapat membantu pengajaran sains menjadi lebih menarik.	1
17	9	Guru hendaklah mempunyai kemahiran mengurus bilik darjah dalam menggalakkan penglibatan murid.	1
19	10	Guru hendaklah mempunyai kemahiran komunikasi dengan murid.	1
23	11	Guru hendaklah menjalankan aktiviti amali untuk mencapai KPS murid	1
26	12	Guru hendaklah memberi peluang kepada murid untuk bertanya dan mengeluarkan idea sendiri.	1
6	13	Guru hendaklah menggunakan bahan sebenar yang didapati dari alam sekeliling untuk pengajaran (contoh: daun, batu, buah-buahan, serangga, bahan kitar semula dan lain-lain).	2
20	14	Guru hendaklah berupaya menilai kualiti hasil kerja murid.	2
25	15	Guru hendaklah menjalankan pengajaran aktif dalam kelas sains.	2
2	16	Guru hendaklah berpengetahuan tentang kaedah mengajar sains.	3
16	17	Guru hendaklah mempunyai kemahiran merancang persediaan pengajaran.	3
18	18	Guru hendaklah mempunyai kemahiran mempelbagaikan strategi pengajaran.	3
3	19	Guru hendaklah berpengetahuan tentang tahap kebolehan murid.	4
14	20	Guru hendaklah menggunakan bahan bantu mengajar untuk merangsang pemikiran murid.	4
30	21	Guru hendaklah sentiasa mendorong murid untuk belajar dan meminati sains.	4
8	22	Guru hendaklah menjalankan aktiviti luar kelas yang sesuai bagi membantu murid-murid agar mereka berupaya mengaitkan pembelajaran Sains dengan kehidupan seharian.	5
29	23	Guru hendaklah mendedahkan murid menjawab soalan pada aras tinggi.	6
13	24	Penggunaan bahan bantu mengajar telah menyedarkan murid tentang kegunaan sains dalam kehidupan seharian.	7
15	25	Guru hendaklah menggunakan bahan bantu mengajar membantu dalam mencapai objektif pengajaran sains.	7
22	26	Guru hendaklah mempelbagaikan kaedah pengajaran untuk mencapai Kemahiran Proses Sains murid.	8
27	27	Guru hendaklah menggalakkan pembelajaran secara berkumpulan untuk percambahan idea.	8

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No elemen	Kedudukan mengikut <i>rank</i>	Elemen Pengajaran Kreatif Sains secara Inkuiri	<i>Rank</i>
28	28	Guru hendaklah menerapkan elemen kemahiran berfikir aras tinggi dalam pengajaran sains.	8
24	29	Guru hendaklah menggunakan alatan tambahan untuk mencapai KPS murid.	9
21	30	Guru hendaklah tahu setiap elemen KPS	9

Figure 1 showed the finding from ISM session. All of the elements were displayed in the creative science inquiry-based pedagogy model. This answered the third research question *What is the form of the CSi pedagogy model according to expert agreement?* From **Figure 1**, elements with same value of driving power and dependent power were clustered together. Each elements have their driving power (DP) and dependent power (DEP). Driving power is the power that drives the other element/ activity to achieve goals and objectives on its own (Abdullah et al., 2014). Whilst depending power is the power that depends on other elements to achieve its goal. The stronger the driving power, the weaker the dependent power.

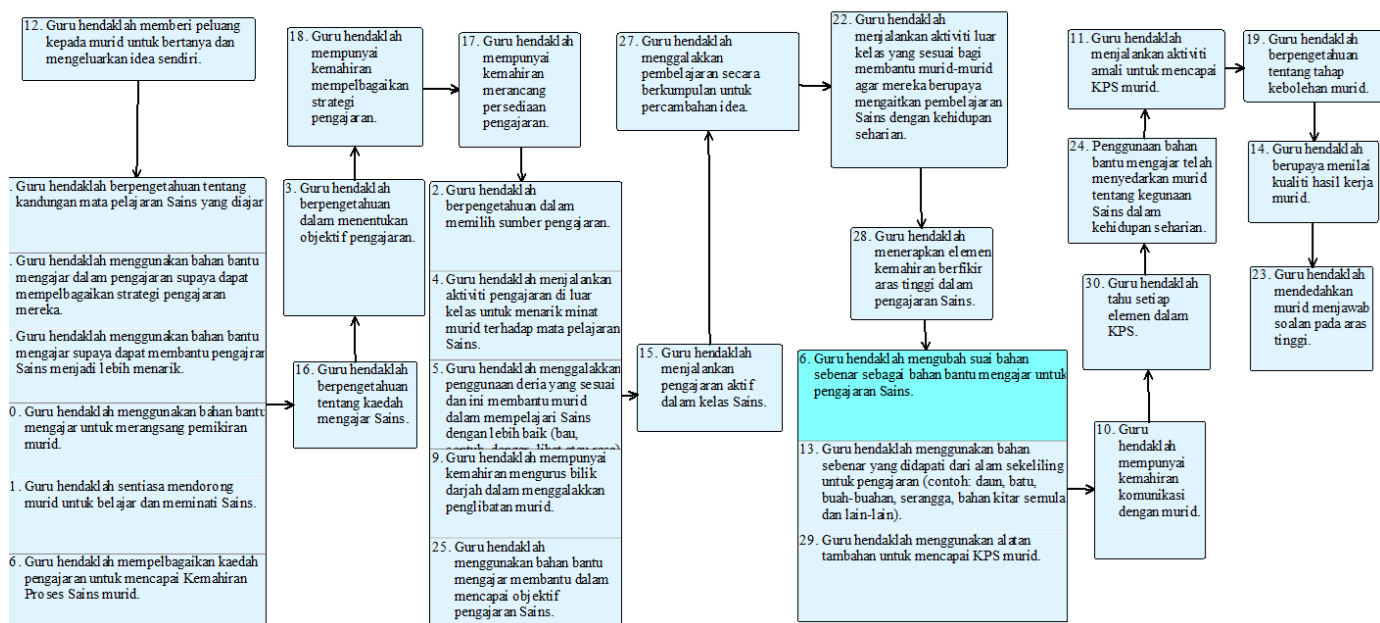
To identify the DP and DEP of each element, research has proposed the reachability matrix as shown in **Table 4**. The number shown at the end of the horizontal axis was the driving power while the number at the end of vertical axis was the DEP. This finding will help to answer the fourth research question *What is the classification of elements of CSi pedagogy model according to the driving power and the dependent power according to the expert agreement?*

From **Figure 1** and **Table 4**, element number 12 has the highest driving power (DP=30) and lowest dependent power (DEP=1). The element was located at the most top of the model. This informed that, teacher needs to give the opportunity to the students to voice out their opinion/ ideas in a creative science inquiry-based classroom. To implement creative pedagogy in an inclusive manner, teacher should also give students the opportunity to ask questions and express their own ideas. This is in line with the conceptual framework by NRC (2013). According to this framework, the first characteristic for student centered learning is to involve in scientifically oriented questions. Engaging students with scientific questions is also one of the key features of inquiry-based learning (NRC, 2013).

This finding is supported by Ayua and Eriba (2015). According to them, for a creative teaching of science, teachers need to accept and celebrate extraordinary ideas and questions asked by students by responding to these ideas and questions by giving good grades and providing learning materials that can encourage their creativity (Ayua & Eriba, 2015).

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Figure 1. The model of creative science inquiry-based (CSi) from ISM



ISM with Secondary Links - Model Completed

Table 4 Reachability Matrix

El	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	D P	
1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	
2	0	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	0	0	1	0	0	1	1	1	1	0	1	1	1	1	19	
3	0	1	1	1	1	1	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	1	1	1	1	0	1	1	1	1	22	
4	0	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	0	0	1	0	0	1	1	1	1	0	1	1	1	1	19	
5	0	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	0	0	1	0	0	1	1	1	1	0	1	1	1	1	19	
6	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	1	10	
7	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	
8	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	
9	0	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	0	0	1	0	0	1	1	1	1	0	1	1	1	1	19	
10	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	7
11	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	4
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	30	
13	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	1	10	

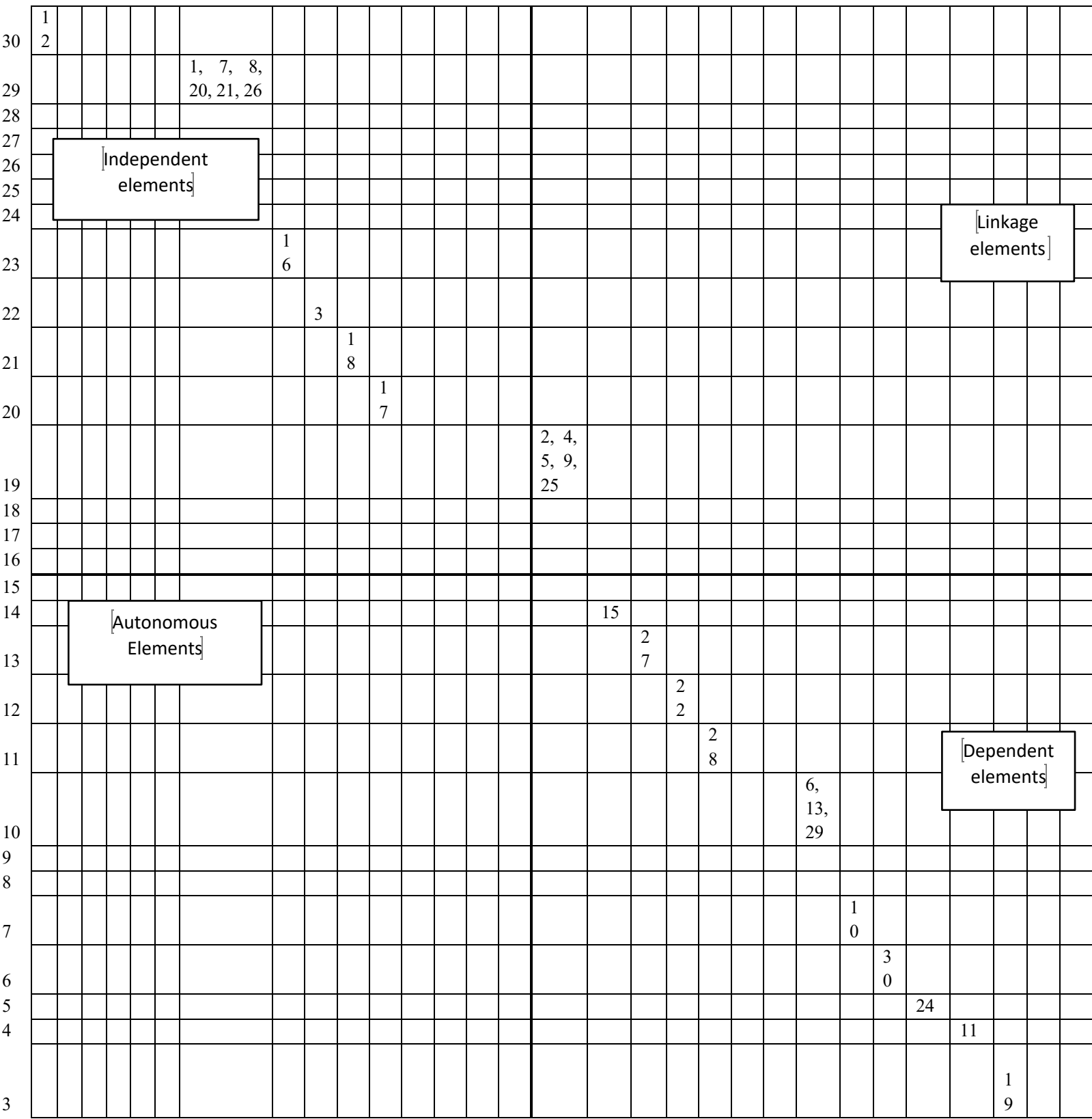
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14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2			
15	0	0	0	0	0	1	0	0	0	1	1	0	1	1	1	0	0	0	1	0	0	1	1	1	0	0	1	1	1	1	1	4	
16	0	1	1	1	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1	1	1	1	2	3	
17	0	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	1	0	1	0	0	1	1	1	1	0	1	1	1	1	2	0	
18	0	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0	1	1	1	1	0	1	1	1	1	2	1	
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	3	
20	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	9	
21	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	9	
22	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0	1	1	1	0	0	0	1	1	1	1	1	2
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
24	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	5	
25	0	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	0	0	1	0	0	1	1	1	1	0	1	1	1	1	1	1	9
26	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	9	
27	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0	1	1	1	0	0	1	1	1	1	1	1	3
28	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	1	1	1	1
29	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	1	1	0
30	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	6	
D E P	7	1 6	9	1 6	1 6	2 3	7	7	1 6	2 4	2 7	1	2 3	2 9	1 7	8	1 1	1 0	2 8	9	7	1 9	3 0	2 6	1 8	7	1 8	2 0	2 3	2 5			

The classification of elements into dimensions is shown in **Figure 2**. This helped to answer the fifth research question *What is the classification of the elements of CSi pedagogy model according to dimensions based on expert agreement?*

According to **Figure 2**, the elements were classified into three different dimensions which were dimension Independent, Linkage, and Dependent. Elements with DP value that was more than 15 and DEP less than 15 were clustered as Independent elements. The elements are element number 12 (DP=30, DEP=1), elements 1, 7, 8, 20, 21, 26 (DP= 29, DEP=7), element 16 (DP=23, DEP= 8), element 3 (DP= 22, DEP= 9), element 18 (DP=21, DEP=10) and element 17 (DP=20, DEP= 11). Second dimension is Linkage. Elements clustered into this dimension have the value of driving power and dependent power that higher than 15. Elements in this dimension linking the elements dimension Dependent and Independent. The elements are element number 2,4,5,9, and 25. These five elements have DP =19 and DEP= 16. The third dimension is Dependent. Elements clustered into this dimension were 6,13 and 29 (DP=10, DEP=23), element 10 (DP=7, DEP= 24), element 30 (DP=6, DEP=25), element 24 (DP=5, DEP=26), element 11 (DP=4, DEP=27), element 19 (DP=3, DEP=28), element 14 (DP=2, DEP 29) and lastly, element 23 (DP=1, DEP=30).

Figure 2. Classification of elements based on Driving Power (DP) Dependent Power (DEP)



[illegible]

DEP

The classification into dimension helped the experts to give theme to the dimension accordingly. The experts had agreed to give theme for dimension Independent as Teacher's Knowledge. Dimension Linkage was named as Teacher's Skill. While for dimension Dependent, the elements were clustered into two themes based on their DP and DEP. The themes are Teacher's Preparedness and Teacher's Commitment. The classification had answered the sixth research question ***What is the classification of CSi pedagogy model according to the theme based on expert agreement?***

Table 5 showed the classification of elements into themes based on experts' agreement. Dimension Independent was named as Teacher's Knowledge by referring to the elements contained. To realize the process of teaching creative science through inquiry, teachers must first have knowledge of the characteristics of inquiry-based learning and teaching. Among these characteristics is student-centered learning. According to Ibrahim (2003) in Abdullah et al (2021), inquiry is guided by the curiosity of students which will lead to their involvement in the learning process. Here, the role of the pupil has changed from receiving knowledge to seeking knowledge. Students who engage in inquiry learning are active because they are involved in making observations, asking questions, making hypotheses, collecting data and also solving problems.

This finding is supported by Jacob et al. (2020), where according to them teaching is a complex cognitive activity and requires teachers to apply knowledge from several domains. Teachers who have varying knowledge and integrated knowledge will have more ability than teachers who have limited knowledge.

The elements present in the Linkage dimension have a driving power greater than 15 and the dependent power is also more than 15. This means that this element has strong driving power and dependent power. Thus, the Linkage dimension is also a dimension that connects the Independent dimension (Teacher Knowledge) and the Dependent dimension (Teacher Preparation and Teacher Commitment). The elements classified into this dimension are called the Teacher Skills dimension because skills are a requirement that allows knowledgeable teachers to always be prepared and committed to carry out their duties as professional educator.

According to Tan and Caleon (2023), science teachers need to have a diverse set of skills to effectively engage students in the learning process in addition to pedagogical skills as well as hands-on experiments, demonstrations and interactive activities to facilitate students' understanding and active involvement (Alalwan et al., 2020).

Referred to **Figure 2**, there were 13 elements that fall in the Dependent dimension namely elements 15, 27, 22, 28, 6, 13, 29, 10, 30, 24, 11, 14 and element 23. The experts during the discussion session agreed with two themes for the elements clustered in the Dependent dimension, namely as Teacher Preparation and Teacher Commitment. According to the experts, the preparation and commitment of teacher for the teaching and learning process requires a teacher to have knowledge of teaching and pedagogy as well as the right skills to enable a creative teaching of science through inquiry to be implemented.

This element is in line with the findings of a study by Jamian et al. (2013) where good preparation by teachers in a single teaching and learning session can produce effective and effective teaching. In the context of this study, the application of teacher preparation elements for creative teaching is combined with in-depth learning during the teaching and learning sessions.

In this study, commitment in science teaching refers to the self-efficacy of teachers where competence is an important characteristic that guarantees the success of science teachers (Grindrod et al., 1991 in Liu et al., 2024) where the self-efficacy of teachers in the context of teaching plays an important role that can influence the development of teachers and students. Scientific inquiry as mentioned earlier is a predominant trend in science education around the world today. Its main objective is to foster inquiry science learning while instilling scientific literacy among students (NRC, 2000; Gericke et al., 2022). Teachers' self-efficacy is related to the individual's assessment of the ability to organize and implement inquiry-based science teaching as well as to engage in each final outcome that will be produced through this approach.

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According to Shkabarina et al. (2020), the characteristics of a creative pedagogy are the qualities of the individual who have developed (communication, intellectual, emotional, moral and so on), the ability to see and solve problems related to pedagogy (communicative, organizational, methodical), the orientation of pedagogical thinking, the willingness to show one's own personality, the ability to overcome stereotypes, the rejection of "pattern of thinking", the willingness to create new ideas and translate those ideas into life, and the ability to implement technological innovations in learning.

At the end of the NGT and ISM workshop sessions, this study concluded that there were four themes proposed and agreed by the expert panel to be the themes of the creative science inquiry-based pedagogy model to facilitate primary school science teachers as follows:

- i. Teacher's Knowledge
- ii. Teacher's Skills
- iii. Teacher's Preparation
- iv. Teacher's Commitment

Table 5. Classification of elements into themes

Dimensi	Tema	No elemen	Elemen
Independent	Teacher's Knowledge	12	Guru hendaklah memberi peluang kepada murid untuk bertanya dan mengeluarkan idea sendiri.
		1	Guru hendaklah berpengetahuan tentang kandungan mata pelajaran sains yang diajar
		7	Guru hendaklah menggunakan bahan bant mengajar dalam pengajaran supaya dapat mempelbagaikan strategi pengajaran mereka.
		8	Guru hendaklah menggunakan bahan bantu mengajar supaya dapat membantu pengajaran sains menjadi lebih menarik.
		20	Guru hendaklah menggunakan bahan bantu mengajar untuk merangsang pemikiran murid.
		21	Guru hendaklah sentiasa mendorong murid untuk belajar dan meminati Sains.
		26	Guru hendaklah mempelbagaikan kaedah pengajaran untuk mencapai Kemahiran Proses Sains murid.
		16	Guru hendaklah berpengetahuan tentang kaedah mengajar Sains.
		3	Guru hendaklah berpengetahuan dalam menentukan objektif pengajaran.
		18	Guru hendaklah mempunyai kemahiran mempelbagaikan strategi pengajaran.
		17	Guru hendaklah mempunyai kemahiran merancang persediaan pengajaran.
Linkage	Teacher's Skill	2	Guru hendaklah berpengetahuan dalam memilih sumber pengajaran.
		4	Guru hendaklah menjalankan aktiviti pengajaran di luar kelas untuk menarik minat murid terhadap mata pelajaran Sains.
		5	Guru hendaklah menggalakkan penggunaan deria yang sesuai dan ini membantu murid dalam mempelajari Sains dengan lebih baik (bau, sentuh, dengar, lihat atau rasa).
		9	Guru hendaklah mempunyai kemahiran mengurus bilik darjah dalam menggalakkan penglibatan murid.
		25	Guru hendaklah menggunakan bahan bantu mengajar membantu dalam mencapai objektif pengajaran Sains.

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Dimensi	Tema	No elemen	Elemen
Dependent	Teacher's Preparedness	15	Guru hendaklah menjalankan pengajaran aktif dalam kelas Sains.
		27	Guru hendaklah menggalakkan pembelajaran secara berkumpulan untuk percambahan idea.
		22	Guru hendaklah menjalankan aktiviti luar kelas yang sesuai bagi membantu murid-murid agar mereka berupaya mengaitkan pembelajaran Sains dengan kehidupan seharian.
		28	Guru hendaklah menerapkan elemen kemahiran berfikir aras tinggi dalam pengajaran Sains.
		6	Guru hendaklah mengubah suai bahan sebenar sebagai bahan bantu mengajar untuk pengajaran Sains.
		13	Guru hendaklah menggunakan bahan sebenar yang didapati dari alam sekeliling untuk pengajaran (contoh: daun, batu, buah-buahan, serangga, bahan kitar semula dan lain-lain).
		29	Guru hendaklah menggunakan alatan tambahan untuk mencapai KPS murid.
	Teacher's Commitment	10	Guru hendaklah mempunyai kemahiran komunikasi dengan murid.
		30	Guru hendaklah tahu setiap elemen dalam KPS
		24	Penggunaan bahan bantu mengajar telah menyedarkan murid tentang kegunaan Sains dalam kehidupan seharian.
		19	Guru hendaklah berpengetahuan tentang tahap kebolehan murid.
		11	Guru hendaklah menjalankan aktiviti amali untuk mencapai KPS murid.
		14	Guru hendaklah berupaya menilai kualiti hasil kerja murid
		23	Guru hendaklah mendedahkan murid menjawab soalan pada aras tinggi.

4. CONCLUSION

Professional development is key to the process of transforming teachers' beliefs to support inquiry practices. However, to ensure that such professional development is effective, it requires a long period of time, sustainable effort, as well as building existing trust. Furthermore, to convince teachers to practice constructivist beliefs in science teaching, teacher development programs need to provide teachers with opportunities to reflect on their own beliefs. According to Farrel et al. (2018), by doing so, teachers become more aware of the impact of these beliefs on their classroom practices. Responsible parties such as the professional development unit of the Ministry of Education are responsible for supporting and assisting practicing teachers, professional development with input from university teacher educators.

This model contains clear development objectives that can be used as a guide by science teachers while applying the elements of the model. The application of this model has several important implications that can improve the quality of education and student learning. In parallel with the application of the creative elements of science to inquiry found in this model, this approach will help to make the lessons more interesting. For example, the use of technology in teaching and learning as well as the use of teaching aids obtained from surrounding sources can increase students' inquiry, motivation and interest to continue learning science.

5. AUTHORS' NOTE

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