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STEM EDUCATION IN SCHOOLS: TEACHERS' READINESS TO CHANGE

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Abstract

Change is an important aspect for the implementation of STEM education in school. For teachers to implement STEM, they should have readiness to change and to have no resistance to change. However, teachers are still teaching for examination purposes regardless of the efforts from the Ministry urging them to change. Thus, the aim of this study was to investigate 20 science teachers and 18 pre-service teachers' readiness to change and resistance to change with regards to STEM implementation. The participants were involved in the STEMBuild Training of Trainers (TOT) Program. The program consisted of three phases, which were: conception of STEM, knowledge building, and practical implementation. The content of the program was in-line with the Malaysian primary school curriculum. This was a pre-experimental design study because it involved only one group. Change beliefs scale and resistance to change scale were administered after the program. For the change beliefs scale the teachers had the highest mean score for Personal Valence and lowest mean score for Self-efficacy. Even though these two subscales of change beliefs showed opposite direction of belief towards change, the participants mean scores of the overall change beliefs was high which indicated a positive inclination towards the change. In terms of resistance to change scale, the teachers were generally supporters of the change. The findings revealed that the participants were ready to carry out the STEM activities in school, they adhered to the belief for this change and their resistance to change was minimal.

Keywords: Readiness to change, Resistance to change, STEMBuild, STEM education, Training of trainers.

1. Introduction

STEM education is new to Malaysian education system, thus introducing the conception of STEM and its pedagogical approach to teachers are necessary so that STEM could be successfully implemented in schools. The Malaysia Ministry of Education has produced a guideline for the implementation of STEM in the teaching and learning process [1]. In the primary school context, science should be interactive and coupled with hands-on activities to develop students' motor skills [2]. Students need an environment that provides them with opportunities to engage in the practice of science, technology, engineering, and mathematics through real-world problems. Primary students have the capacity to engage in scientific and engineering practices as they develop conceptual understanding [2]. Children need opportunities to observe, engage in activities and present their thinking in order for them to deepen their understanding of the basic concepts [3]. Edy et al. [4] added that students' creativity and meaningful learning flourish when their teachers take into account all aspects of learning.

2. Problem Statement

Teaching children in today's education system is a challenge because of their diverse capacity and different rates of learning [1]. The assumption of teaching is that when children are taught in the classroom, they are able to learn science and mathematics concepts and in tandem acquire innovative and inventive skills. However, teaching methods of teachers have not changed much regardless of the present aim of education because of the emphasis on examination outcomes. Efforts from the ministry as reflected in the Education Blueprint 2013-2025 listed STEM initiatives as a way to move forward but teachers are still confused about the various aspects of STEM and how is it difference with what they are currently doing. Therefore, training teachers in the STEM pedagogical approaches, development of STEM activities and the conception of STEM education are vital

However, teachers must be willing to accept these changes in order to avoid internal conflicts that might ruin the goal of the change [5, 6]. Past literature on organizational change, have stressed the importance of managing the change and how the change is implemented. An individual's perception on what is there for them in that change, whether more work or responsibility for them should also be given the necessary consideration. These might be seen to them as an extra burden and thus might lead to the resistance to change [5, 7]. Thus, readiness for change in individuals is dependent on the particular change that the individuals have to do and what the impact is on them [5, 8, 9]. In order to lessen the resistance to change, it is imperative that teachers have a positive stance about the change, and believe that such changes would bring positive implications for themselves, the students and school [5, 10].

Readiness is a precursor of resistance [5]. Ministry of Education leaders and policy makers introduced purposeful system wide changes, in this case STEM Education, in an effort to increase students' participation in STEM fields. However, the differences and conflicts between the policy makers and teachers must be confronted as these purposeful changes are introduced. Conflicts must be resolved for change to happen, only then can it create a state of readiness. The biggest barrier in implementing change is resistance to change [7]. Jones et al. [7] added that individuals are more resistant to change when they assume that there would be new and more workload, and would be submitted to evaluation.

3. Change beliefs

Readiness for change is the beliefs and attitudes of individuals that are influenced simultaneously by these factors: what is being changed, how the change is being implemented, under what circumstances the change is occurring, and the individuals whom are being asked to change. Based on Hendrickson and Gray [11] the revised model of Readiness for Change (Fig. 1) shows readiness for change is created when appropriateness, management support, self-efficacy and personal valence are present to support the change. Appropriateness refers to the content and context of the program being given to the teachers which could be very different from what they are currently doing. Thus, the aim of the program is to address discrepancy between the present and desired future. Management support means support from state and district education officers as well as the school management team to help teachers undergo the necessary changes. Finally, self-efficacy and personal valence are individual attributes. Self-efficacy is related to an individual's confidence to change. It acts as a motivation for change if the individual's self-efficacy is high. Personal valence depends on the teacher perception if believe the change is beneficial or important to them. Holt et al. [12] models suggest that all four dimensions constitute readiness for change.

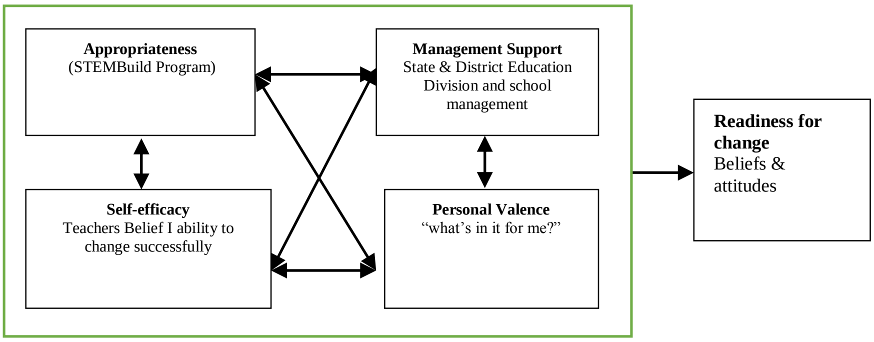

Fig. 1. Revised model of Readiness for change model [12].

Teachers will be the implementers of STEM education in schools. Teachers are the one that have to make the big leap of change, therefore they must agree and want to make the changes. This leap of change is huge because teachers would need to change the way they teach science in schools, to prepare for more hands-on activities and they must find meaning for the question -'why must I do this?' For teachers to be open to the change, they will need to go through various experiences [12-14]. When expose to various experiences, the teachers would have greater interest and this would lead to greater need for variety. Thus, these teachers would be able to create more tolerance for uncertainty and would be more adamant to pursue unfamiliarity [14]. Teachers have different beliefs regarding the change that is expected from them and this can lead to stress, uncertainty and anxiety. The findings from the assessment of the change beliefs can help to give insights on how much the teachers are willing to buy-in toor oppose the change. Armenakis et al. [15] state that individual beliefs for change are drivers of motivations either to support or to resists. They also stress that by assessing these change beliefs, leaders are in a better position to plan and implement initiatives for change [15].

4. Resistance to Change

Resistance to change usually depicted as the negative aspect of readiness, hence, it is seen as an obstacle to change. Usually, employees resist to change if they believe that the change would affect their work situation. Garrison et al. [16] in their 12 items resistance to change scale addressed how individuals respond to change. They categorized these behaviours into two factors. The first factor is the pro-change behaviours which reflect their agreement toward change and the second factor is the anti-change behaviours which shows their disagreement toward the change.. Based on these factors, they were then able to develop four behavioral prototypes (Fig. 2). Behavioral prototypes that are present in any change implementation are called resistors and supporters [16].

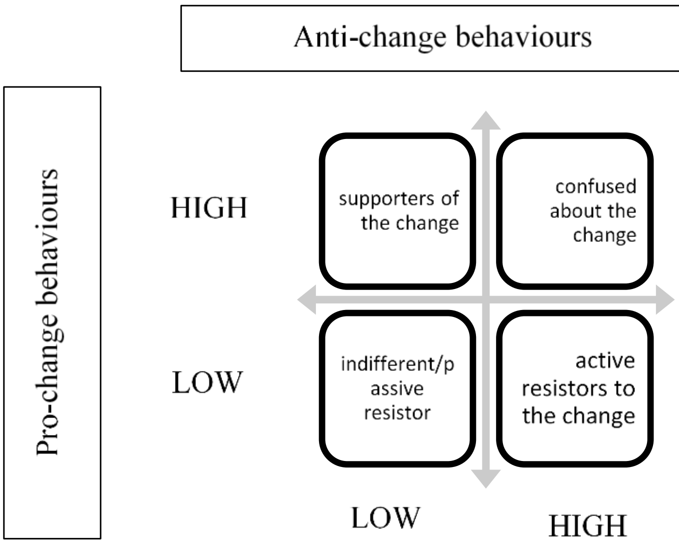

Fig. 2. Pro-change and anti-change behaviours matrix [16].

5. STEMBuild Training of Trainers Program

This program was developed based on three STEM principles: a) integration of STEM with the School Science Curriculum; b) project based activities; and c) connection with secondary science education. In every module, there were four constructs: a) theory and concept; b) activity; c) project design and develop (engineering design process); and d) showcase and challenge.

The instructional design employed in this program was the engineering design process which constitute 5 steps - ***Ask*** (analysing the problem, identifying the problem, seeking information), ***Imagine*** (brainstorming ideas for the solution, coming up with their own ideas, discussing, defending, make decision), ***Plan*** (after deciding on the solution, they draw the design, plan on how to build and test, delegate task), ***Create*** (building/making the prototype based on the design and testing), and lastly ***Improve*** (they come together to discuss what to improve to make their prototype work better). All the activities were done in teams of four members. The most important characteristic of a STEM activity is working as a team. The activities were all hands-on based on three themes in the primary science curriculum which were Life Science (5 activities), Physical Science (5 activities) and Technology and Sustainability (6 activities). The modules were developed based on topics in the curriculum and were pilot tested. The instructional design of the module starts with activities for knowledge building, which comprises of introduction to the concept, followed by hands on activities where the students have to design, build, plan on the testing method and lastly improve on their design. After each activity, a challenge was given where they have to use the concept learnt earlier in the module.

6. Methodology

This is a pre-experimental study. This study does not intend to generalize its findings or to confirm if the program has the ability to provide positive changes to the participants. This research is carried out as a simple cost-effective way to discern whether the contents of the module is worthy of further investigation and to see if any further improvement can be made to the content of the STEMBuild program. The participants for the program were 20 science primary teachers from 20 different schools in the district of Keramat and 18 pre-service teachers. The teachers teaching experience ranging from below 5 years (20%), between 6-10 years (25%), between 11-15 years (25%) and more than 15 years (30%). The pre-service students were in their fourth year of their Bachelor of Science with Education Degree from Faculty of Science. The participants went through the STEMBuild TOT Program consisting of three modules, which were Life Science, Physical Science and Technology and Sustainability. The program was carried out in 3 phases as described in Table 1.

Table 1. Description of the program.

Phase	Description of activity
1	Awareness to the concept of STEM
	Knowledge building - Training of Modules 1,2 - Hands-on activity - STEM pedagogical approach
2	On-site practical Monitoring and coaching
3	Knowledge building - training of Module 3 - hands-on activity STEM CAMP

After the training, the participants were given two questionnaires to answer. The first questionnaire was called the *Organizational Change Recipients' Beliefs Scale* (OCRBS) by Holt et al. [11]. This questionnaire consisted on 20 items, which were subdivided into four subscales - Appropriateness (5), Self-efficacy (5), Social support (6) and Personal valence (4). The scales measure teachers' perceptions on a 5-point Likert scale (1=strongly disagree and 5=strongly agree). The second questionnaire, *Resistance To Change Scale* measured extent of participants' resistance to change was developed by Giangreco [16]. *Resistance To Change Scale* consisted of 12 items with a yes - no response. The Croanbach alpha for the OCTBS was 0.94 and 0.91 for *Resistance to Change Scale*. Data analysis was carried out using SPSS (version 19).Data was presented using frequencies, percentages and mean scores.

7. Results and Discussions

The total score of the respondents' overall readiness for change is 82.48 (82.48% of the maximum score 100). The high value indicated that the participants had high beliefs for change. The mean scores for all change beliefs subscales showed scores above average. The scores showed Personal Valence having the highest score between the four beliefs (90.7% of the maximum score); while Self-efficacy showed the lowest score (68.1% of the maximum score). According to Weiner [17], the value of Personal valence shows the change commitment of the participants. Even though the participants' belief that the change might be beneficial for them, but they were quite sceptical on whether the change can be implemented.

Personal valence is the driver of change because it is a result of a commonly shared reasons to change among members in an organization but it does not necessarily mean that the organisation is ready to change even though personal valence value is high [17]. Self-efficacy might have an influence on the overall ability to change. This subscale was rated the lowest may be due to the current scenario in schools which still put emphasis on obtaining the highest scores for academic performance even though the Ministry of Education had already clearly stated that teachers must strive to encourage higher order thinking among their students. The present assessment system has not been changed to cater for higher order thinking; where teachers are still required to complete the wide curriculum to prepare the students for high stake examinations. With this in their mind, teachers might wonder when they are to execute these STEM activities, as these activities require time and resources.

Apart from that, the new approach, which employs the *engineering design process*, require teachers to have confidence to implement the process as well as having a good knowledge of the process. Teachers also need to be familiar with the design and work of an engineer to be able to have high self-efficacy to implement STEM education in school as suggest by [3]. Gist and Mitchel [3] sees efficacy as individual judgement of the capability to perform a task. They claim that individuals assess the match between task demands and available resources for the change that is required from them in terms of financial, material and support. Thus, there is a need to expose teachers to STEM activities and find ways to help the teachers to implement the activities.

Teachers should also be aware about how engineers work, for example, how engineers develop their designs and what they do with their designs. Lastly, teachers need to be exposed to these various designs so that teachers are able to be creative and innovative in order to increase their self-efficacy.

Table 2 shows the distribution of the participants' resistance to the change. The data in the table indicated that the participants are supporters of the change (87%); they are frequently engaging in pro-change behaviours but never shown any anti-change behaviours. The category of indifferent/passive resistors to change showed the second highest percentages (13%) which means that the teachers did not facilitate the change and also did not behave in a way that reveal disagreement with the change. Not even one of the teachers was an active resistor or was confused about the change. In this situation, the move towards change seemed positive.

Managerial support is needed in terms of time, motivation and financial for teachers to execute STEM education in school. This support is important to facilitate and embrace the change. Even though the participants showed high mean scores for the overall beliefs and most of the participants are supporters of the change, these can deteriorate if not enough support are given to the teachers by their superiors [4].

Table 2. Respondents' distribution of resistance to change.

Response Category	Frequency	%
Supporters of the change	33	87
Indifferent/passive resistors	5	13
Active resistors	0	0
Confused about the change	0	0

8. Conclusion

The scores for the *Organizational Change Recipients' Beliefs Scale* were high across all four domains for the change beliefs. Teachers believed that the STEM pedagogical approach, which they were trained in this program as a change from the common way of teaching in school as necessary, can be implemented, should be supported by superiors or administrators and have personal benefit for them.

With regards to the *Resistance To Change Scale*, most of the teachers support the change. And only a few of the participants were passive resistor to change but none were active resistor or confused about the change. This might be due to the first phase in the training where awareness and concept building of STEM Education was discussed before embarking on the content of the module.

Teachers needed to have a clear understanding of STEM education and the objectives of the STEM pedagogical approach that they have to adopt. Support given by the education district officers and teacher training departments would have an impact on how teachers embrace STEM pedagogical approach. The results of this study found that change beliefs were influenced by employees' readiness factors.

Teachers develop change beliefs from what they perceived about the change and by reasoning with its appropriateness, their confidence to implement it, believing that they will get the support that they need and lastly a collective agreement to change among teachers. If all of these are met, they might comply with their behaviour towards the change either by supporting, or by resisting the change.

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References

1. Madsen, S.; Miller, D.; and John, C. (2005). Readiness for organizational change: do organizational commitment and social relationships in the workplace make a difference? *Human Resource Development Quarterly, 16*(2), 213-233.
2. McRae, R.R.; and Costa, P.T. (1980). Openness to experience and ego level in loevinger's sentence completion test: Dispositional contributions to developmental models of personality. *Journal of Personality and Social Psychology*, *39*(6), 1179-1190.
3. Gist M.E; and Mitchell T.R. (1992). Self-Efficacy A Theoretical Analysis of Its Determinants and Malleability. *Academy of Management Review*, *17*,183–211.
4. Edy, L.T.; Adam, D.M.; Russell, J.E.A.; and Gaby. S.H. (2000). Perceptions of organizational readiness for change: Factors related to employees' reactions to the implementation of team based selling. *Human Relations, 46*(8), 905-918.
5. Armenakis,A.H.S.; and Mossholder, K. (1993). Creating readiness for organizational change. *Human Relations, 46*(3), 681-703
6. DeVries, R.;and Zan. B. (2012). *Moral classrooms, moral children: Creating a constructivist atmosphere in early education*. New York, NY: Teachers College Press
7. Jones, R. A.; Jimmieson, N. L.; and Griffiths, A. (2005). The impact of organizational culture and reshaping capabilities on change implementation success: The mediating role of readiness for change. *Journal of Management Studies*, *42*, 361-386.
8. Curriculum Development Division (2017). Panduan Pelaksanaan Sains, Teknologi, Kejuruteraan dan Matematik dalam Pengajaran dan Pembelajaran, Ministry of Education.
9. Katz, L. G. (2010). STEM in the early years. Collected Papers from the SEED Conference, Fall 2010
10. Giangreco, A. (2002) 'Conceptualization and operationalization of resistance to change'. Retrieved from: http://www.biblio.liuc.it/liucpap/pdf/103.pdf
11. Hendrickson, S.; and Gray, E. (2012). Legitimizing resistance to organizational change: a social work social justice perspective. *International Journal of Humanities and Social Science. 2*(5), 50-59.
12. Holt, D.T.; Armenakis, A.A.; and Harris, S.G. (2007). Readiness for organizational change: The systematic development of a scale. *The Journal of Applied Behavioral Science, 43*(2), 232-255.
13. Baer, M.; and Oldham, G.R. (2006). The curvilinear relation between experienced creative time pressure and creativity: Moderating effects of openness to experience and support for creativity. *Journal of Applied Psychology, 91*(4), 963-970.
14. Lee-Bagley, D.; Preece, M.; and DeLongis, A. (2005). Coping with Interpersonal stress: Role of big five traits. *Journal of Personality, 73*(5), 1141-1180.
15. Armenakis, A.A.; Bernerth, J.B.; Pitt, J.P.; and Walker, H.J. (2007). Organizational Change Recipients' Beliefs Scale: Development of an

Assessment Instrument. *The Journal of Applied Behavioral Science*, 3(4), 481-505.

16. Garrison, R.H.; Noreen, E.W.; and Brewer, P.C. (2007). *Managerial* accounting (ed), New York: McGraw-Hill/Irwin.
17. Weiner, B.J. (2009). A theory of organizational readiness for change. *Implementation Science*, 4(67). 1-9.