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An OrSAEv learning model to improve the disaster preparedness of STEM teacher candidates

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ABSTRACT: Many science, technology, engineering and mathematics (STEM) teacher candidates lack disaster preparedness. In tertiary institutions, there is no disaster learning to improve the disaster preparedness of STEM teacher candidates. Therefore, it is necessary to develop an innovative learning model, such as the OrSAEv learning model assisted by Joko Tingkir computer applications that can improve the disaster preparedness of STEM teacher candidates. Development of the OrSAEv learning model is underpinned by theory: constructivism, learning through observation, discovery learning, cognitive processes, learning behaviour, multi-representation and scaffolding; as well as empirical outcomes. The OrSAEv learning model has four phases: 1) orientation (Or); 2) disaster preparedness (S); 3) action (A); and 4) evaluation (Ev). The results show that the OrSAEv learning model assisted by Joko Tingkir can be a solution in higher education to improve the disaster preparedness of STEM teacher candidates.

INTRODUCTION

Indonesia is located on the boundary of an active tectonic plate. Indonesia is a fertile country with abundant natural resources. The area where the plates meet is the path of earthquakes, a series of active volcanoes and a threat of tsunamis along the coastline. Higher education can play a role in disaster risk reduction (DRR) activities and can educate the nation's citizens and improve the welfare of the community [1]. The State University of Surabaya is one of the universities in Indonesia that educates prospective teachers.

The State University of Surabaya has an important role in increasing the capacity of the community to implement disaster risk reduction. This was reinforced by a circular on the Guidelines for Disaster Learning in Universities and Commemoration of Disaster Preparedness Day 2019. The circular, from the Ministry of Research, Technology and Higher Education explains and emphasises that universities play an important role in producing competent and insightful human resources for DRR. Therefore, universities need to produce graduates who behave in harmony with the principles of DRR. This move was strengthened by the Sendai Framework for DRR (SFFDRR 2015-2030), which has the goal of both building disaster preparedness for more effective responses and building back better during post-disaster recovery in the school community, and increasing school residents understanding of DRR, to become disaster-resilient schools [1-3].

The findings of preliminary studies at the State University of Surabaya are that there are still many STEM teacher candidates who lack disaster preparedness. That is because there is no disaster learning to improve the disaster preparedness of STEM teacher candidates. It is necessary to develop an innovative learning model that can improve the State University of Surabaya STEM teacher candidates' awareness of, and preparedness for disasters.

The innovative OrSAEv (see definition below) learning model is suitable for increasing the disaster preparedness of STEM teacher candidates. The OrSAEv learning model is a natural-disaster method developed specifically to improve the preparedness of STEM teacher candidates, who are supported by Joko Tingkir computer applications. Development of the OrSAEv learning model is supported by current learning theories: constructivism, learning through observation, discovery learning, cognitive processes, metacognition, multi-representation and scaffolding, as well as the empirical foundations of current research and scientific publications. The OrSAEv learning model has four phases; namely, 1) orientation (Or); 2) disaster preparedness (S); 3) action (A); and 4) evaluation (Ev).

LITERATURE REVIEW

Disaster Preparedness

Disaster preparedness is a condition whereby society, the individual and a group have the ability physically and psychologically to deal with disasters. The general disaster preparedness activities are:

- the ability to assess risk;
- effect standby planning;
- effect resource mobilisation;
- have the right education and training;
- develop a response mechanism;
- be versed in information management;
- carry out a rehearsal/simulation [1-3].

Based on the description above, it can be concluded that disaster preparedness is a series of actions undertaken to anticipate disasters through good organisation, as well as through effective and efficient steps [1-3], which have three main aspects: disaster knowledge, disaster response attitudes and post-disaster evacuation skills.

Disaster Learning in Higher Education

Universities, to implement disaster learning, should compile policies related to disaster risk reduction efforts at tertiary institutions. The disaster learning strategy is intended to increase the knowledge, capacity and skills of students to be able to undertake DRR efforts on campus and in the community [1]. The main strategy in the disaster learning process is basically *learning by doing*. Based on these considerations, the learning strategy is carried out with conceptual learning at an early stage, then continued with practical learning, and it is hoped that students will have a strong attitude in dealing with disasters. Disaster learning in higher education is shown in Figure 1.

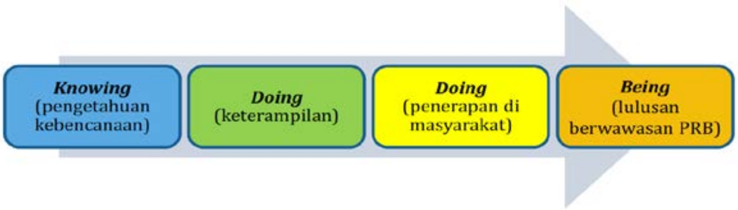

Figure 1: Disaster learning in higher education.

The outcome of disaster leerning by students are graduates with an insight into disaster risk reduction [1]. The results of the analysis by researchers show that the schemes for learning disasters in tertiary institutions - provided by a government ministry - are implemented over many years. These can be used to improve the disaster preparedness of STEM teacher candidates.

Joko Tingkir Tsunami Prediction

The Joko Tingkir tsunami prediction is a virtual laboratory computer program that enables users to source information on the latest earthquake, such as location, magnitude and depth, as well as their tsunami potential. Tsunami potential is obtained from several earthquake parameters, which are then calculated using a method developed in the Faculty of Mathematics and Natural Sciences at the State University of Surabaya by Professr Madlazim. The Joko Tingkir tsunami prediction will provide a warning through notification of a potential earthquake; the interface is shown in Figure 2.

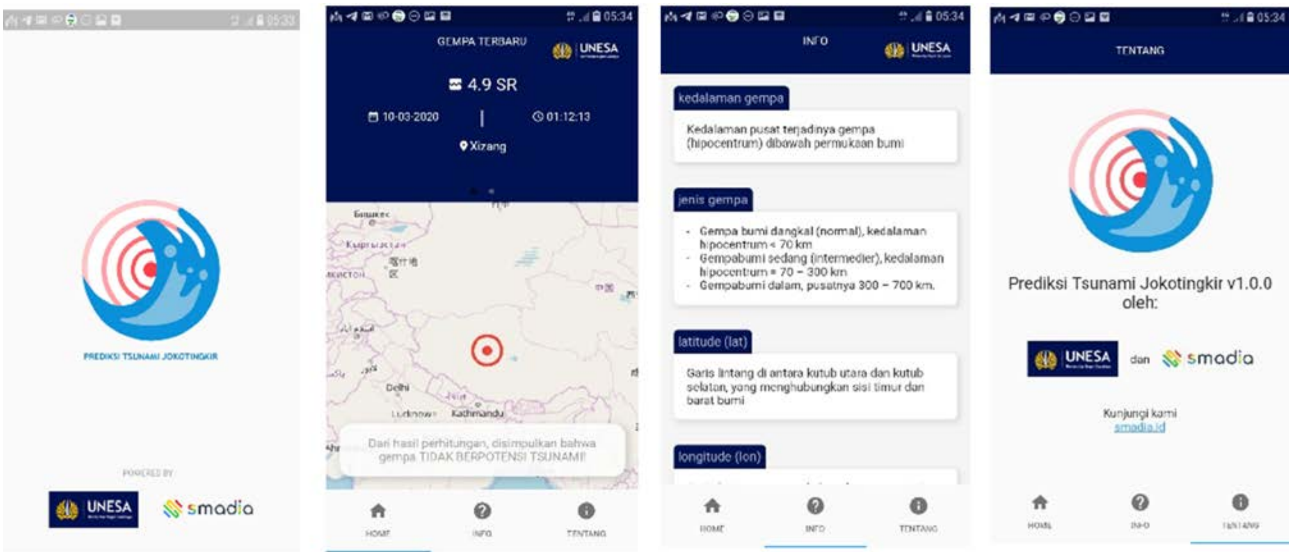

Figure 2: Screenshot of the Joko Tingkir interface (Source: Playstore/PrediksiTsunamiJokotingkir).

DISCUSSION

Learning Model Design

As stated earlier, the OrSAEv learning model is underpinned by theory viz. constructivism, learning through observation, discovery learning, cognitive processes, learning behaviour, multi-representation and scaffolding, as well as by empirical studies. The OrSAEv learning model has four phases: orientation (Or); disaster preparedness (S); action (A); and evaluation (Ev).

Table 1: Theoretical and empirical basis of the OrSAEv learning model.

Theoretical support	Empirical support
Phase 1: orientation (Or)	
1. ARCS theory [4]. 2. Attention: students must pay attention to the model in the learning process [5][6]. 3. Advanced organisers: directing students can help bring together new information [7].	1. The need for conditioning and preliminary preparation of student learning styles, self-efficacy and academic intrinsic motivation in the learning process [8-11]. 2. The government should always carry out disaster preparedness activities [12]. Disaster preparedness activities are not specifically programmed, but merely information. The areas on the banks or in the area around the river should have disaster preparedness, especially mental recovery during and after a disaster occurs [15].
Phase 2: disaster preparedness (S)	
1. The cognitive constructivist theory by Piaget (1954, 1963) [13]. 2. Vygotsky's social constructivist theory has two implications surrounding the theory of social learning and the zone of proximal development [6]. 3. Retention, so that the procedural knowledge possessed can be remembered, students must do repetition [5].	1. The government should always carry out disaster preparedness activities [11]. See Phase 1, 2 above. 2. The limitations of the application of SIGANA training in improving disaster preparedness in Pecalang in the Strait of Badung Village, arise because simulations have not yet been carried out with settings that resemble actual disasters. Therefore, for further training, simulations must include role playing [12]. 3. Many victims due to an earthquake disaster [14]. 4. Changes in attitude depend on individual acceptance of the stimulus provided. Individuals have a great tendency to accept information if the individual: likes the stimulus; the ease of understanding information; there is interest and attention; and the urgency of the stimulus [15].
Phase 3: action (A)	
1. Cognitive distribution theory: conveying ideas to others can improve their own understanding [5]. 2. Theory of cognitive apprenticeship [6]. 3. Theory of production [5-6].	1. Lack of opportunities to provide realistic feedback on the quality of ideas generated; this reduces student motivation and inhibits student confidence in solving problems [16]. 2. In line with the results of other studies, there is a need to improve disaster preparedness [17]. 3. The results of the study that experience significantly influences the readiness of students, which means that the higher the disaster experience, the better the preparedness [18]. 4. The subject does not remember disaster preparedness, because the school has never carried out preparedness education activities, and the training conducted at the time of the study was the first time for these students [19].
Phase 4: evaluation (Ev)	
1. Motivation: students need further training to obtain motivation [8][9][10]. 2. Self-evaluation: students must be able to evaluate the process and results of scientific creativity and collaboration as a reflection for further action [9]. 3. Students are motivated through experience [20].	1. Evaluation of ideas of others can improve problem-solving abilities [21]. 2. The need for teacher evaluations of the process of inquiry and problem solving; without feedback little knowledge is obtained [22]. 3. Occupational safety and health are an inseparable part of daily life; even safety signs can be found in public places, agencies and institutions [15].

OrSAEv Learning Model

The OrSAEv learning model is a natural-disaster learning model developed specifically with the aim of increasing the disaster preparedness of STEM teacher candidates, who are supported by the use of Joko Tingkir computer applications related to disaster.

Learning Environment

As in general learning models, the teaching and learning activities for the OrSAEv learning model require lecturers to plan activities in a structured and systematic manner, as stated in the learning tools based on the OrSAEv learning model. The OrSAEv learning model is supported by natural-disaster applications.

Syntax

The OrSAEv learning model has a four-phase syntax.

Table 2: The OrSAEv learning model with Joko Tingkir.

Learning activities	Learning achievement
Phase 1: orientation (Or) In this phase the Joko Tingkir application on disaster preparedness plays an important role in the success of other phases, because the ability of lecturers to use the virtual laboratory application will facilitate classroom management, so that STEM teacher candidates are more motivated in learning. In addition, students have been directed to understand the problems to improve disaster preparedness.	Disaster preparedness
Phase 2: disaster preparedness (S) Conceptual learning is done to provide basic knowledge about disasters. This basic knowledge of disasters includes knowledge of potential disaster threats, vulnerabilities, capacities and disaster risks.	Disaster preparedness: disaster knowledge
Phase 3: action (A) At this stage, STEM teacher candidates are expected to apply their disaster management capabilities, both on campus and off campus. The outcome of the disaster learning process is the profile of graduates with a vision of disaster risk reduction. It is hoped that STEM teacher candidates will have a strong attitude in dealing with disasters.	Disaster preparedness: disaster response attitudes and post-disaster evacuation skills
Phase 4: evaluation (Ev) Lecturers involve STEM teacher candidates in evaluating disaster preparedness for STEM teacher candidates. The lecturer directs the STEM teacher candidates to condition what needs to be prepared for the next meeting.	Disaster preparedness

Social System

The social system in the model includes the relationship of STEM teacher candidates with other STEM teacher candidates and the relationship of STEM teacher candidates with lecturers [23]. This social system emphasises the construction of knowledge undertaken actively by each STEM teacher candidate, but the construction will be stronger if done collaboratively.

Reaction Principles

This relates to how students pay attention and treat STEM teacher candidates. Lecturers should:

- motivate and remind STEM teacher candidates to always emphasise disaster preparedness.
- provide feedback, praise, create opportunities for STEM teacher candidates to ask questions, think and to criticise the lecture process, so that there is an increase in disaster preparedness of STEM teacher candidates.
- respond to STEM teacher candidates' behaviour during the learning process by modelling, as they develop and solidify disaster knowledge.

Support Systems

An environment that provides a conducive atmosphere for activities is a positive one. The support system for a learning model is all the means, materials and tools to implement the OrSAEv learning model using natural-disaster applications. Below are the support systems in the OrSAEv learning model:

- Learning tools refer to the OrSAEv learning model; namely, lesson plan, worksheet, handout, student teaching materials, disaster-preparedness evaluation instruments.
- Professionalism of lecturers in teaching.
- Availability of disaster preparedness learning needs in the form of laboratory equipment and ICT media and their supporting systems (such as laptops). The use of ICT [24-31], e-learning [32-36] and mobile learning [37-38] can improve students' learning outcomes and STEM teacher candidates' knowledge [39-42].

Novelty of the OrSAEv Learning Model

- The innovative OrSAEv learning model assisted by the Joko Tingkir virtual laboratory application can be implemented in three or four meetings, to improve the disaster preparedness of STEM teacher candidates.
- Implementation of the OrSAEv learning model assisted by Joko Tingkir tsunami prediction means it is possible to source information about the latest earthquake, such as location, magnitude and depth along with the tsunami potential.

CONCLUSIONS

The OrSAEv learning model is a natural-disaster learning method developed specifically with the aim of increasing the disaster preparedness of STEM teacher candidates and is supported by the Joko Tingkir virtual laboratory applications. Development of the OrSAEv learning model is underpinned by theories, such as constructivism, learning through observation, discovery learning, cognitive processes, learning behaviour, multi-representation and scaffolding, as well as by empirical studies.

The OrSAEv learning model has four phases, which are orientation (Or); disaster preparedness (S); action (A); and evaluation (Ev). The OrSAEv learning model should be tested to demonstrate the feasibility to improve the disaster preparedness of STEM teacher candidates.

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REFERENCES

1. Paripurno, Munadi, Koesuma, Ismail and Mardiatmo, *Panduan Pembelajaran Kebencananaan*. Jakarta: Kemenristekdikti (2019) (in Indonesian).
2. Masitoh, Y., Pengurangan risiko bencana gempabumi pada komunitas sekolah dasar di kecamatan lembang kabupaten bandung barat. *J. Dialog Penanggulangan Bencana*, 9, **1**, 18-29 (2018) (in Indonesian).
3. Supriyono, P., *Seri Pendidikan Pengurangan Risiko Bencana Gempabumi*. Yogyakarta: C.V ANDI Offset (2014) (in Indonesian).
4. Bandura, A., Self-efficacy: toward unifying theory of behavioral change. *Psychological Review*, 84, **2**, 191-215 (1977).
5. Moreno, R., *Educational Psychology*. New York: John Wiley and Sons (2010).
6. Slavin, E.R., *Educational Psychology*: *Theory and practice*. Boston: Pearson (2011).
7. Jones, B.D., Epler, C.M., Mokri, P., Bryant, L.H. and Paretti, M.C., The effects of a collaborative problem-based learning experience on students' motivation in engineering capstone courses. *Interdisciplinary J. of Problem-Based Learning*, 7, **2** (2013).
8. Jones, H.M.B. and Vall, O.C., Preparing special educators for collaboration in the classroom: pre service teachers' beliefs and perspectives. *Inter. J. of Special Education*, 29, **1**, 1-12 (2014).
9. Bembenutty, H., Cleary, T. and Kitsantas, A., *Applications of Self-regulated Learning Applied across Diverse Disciplines: a Tribute to Barry J. Zimmerman*. Charlotte, NC: Information Age Publishing (2013).
10. Zimmerman, B.J. and Schunk, D.H., Motivation: an essential Dimension of Self-Regulated Learning. In: Schunk, D.H. and Zimmerman, B.J. (Eds), Motivation and Self-Regulated Learning: Theory, Research, and Applications. Mahwah, NJ: Lawrence Erlbaum Associates, 1-30 (2008).
11. Abidin, Z., Bachri, A., Laksono, A.B. and Afandi., Mitigasi bencana dan sosialisasi perawatan tanggul desa tegalsari kec. widang kab. tuban. *MATAPPA: J. Pengabdian Kepada Masyarakat*, 1, **2**, 1-6 (2018) (in Indonesian).
12. Laksmi, I.A.A., Putra, P.W.K., and Artawan, I.K., Penerapan pelatihan siap siaga bencana (SIGANA) dalam meningkatkan kesiapsiagaan bencana pada pecalan. *MATAPPA: J. Pengabdian Kepada Masyarakat*, 2, **2**, 24-28 (2019) (in Indonesian).
13. Arends, R., *Learning to Teach*. New York: McGraw-Hill (2012).
14. Daud, R., Sari, A.A., Milfayetty, S. and Dirhamsyah, M., Penerapan pelatihan siaga bencana dalam meningkatkan pengetahuan, sikap, dan tindakan komunitas sma negeri 5 banda aceh. *J. Ilmu Kebencanaan (JIKA)*, 1, **1**, 26-34 (2014) (in Indonesian).
15. Kirschner, F., Paas, F., Kirschner, A.P. and Janssen, J., Differential effects of problem-solving demands on individual and collaborative learning outcomes. *Learning and Instruction*, **21**, 587-599 (2011).
16. Utami, T.N. and Nanda, M., Pengaruh pelatihan bencana dan keselamatan kerja terhadap respons persepsi mahasiswa prodi ilmu kesehatan masyarakat. *J. JUMANTIK*, 4, **1**, 84-100 (2018) (in Indonesian).
17. Pratiwi, E. and Prihatiningsih, D., *Pengaruh Pelatihan Penanggulangan Bencana Gempa Bumi Terhadap Kesiapsiagaan Palang Merah Remaja (PMR) SMAN 1 Pleret Bantul Dalam Menghadapi Bencana*. Universitas Aisyiyah: Yogyakarta (2016) (in Indonesian).
18. Havwina, T., Maryani, E. and Nandi., Pengaruh pengalaman bencana terhadapkesiapsiagaan peserta didik dalam menghadapi ancaman gempabumi dan tsunami. *J. Pendidikan Geografi*, 16, **2**, 1-5 (2016) (in Indonesian).
19. Widjanarko, M. and Minnafiah, U., Pengaruh pendidikan bencana pada perilaku kesiapsiagaan siswa. *J. Ecopsy*, 5, **1**, 1-7 (2018) (in Indonesian).

20. Eggen, K., *Strategy and Model for Teacher: Teaching Content and Thingking Skills*. Boston: Pearson Education (2012).
21. Gregory, E., Hardiman, M., Yarmolinskaya, J., Rinne, L. and Limb, C., Building creative thinking in the classroom: from research to practice. *Inter. J. of Educational Research*, 6, **2**, 43-50 (2013).
22. Keller, M.J., *Motivational Design for Learning and Performance the ARCS Model Approach*. USA: Springer (2010).
23. Woolf, B.P., *Building Intelligent Interactive Tutors: Student-Centered Strategies for Revolutionizing E-Learning*. MA: Morgan Kaufmann (2010).
24. Arnold, S.R., Padilla, M.J. and Tunhikorn, B., The development of pre-service science teachers' professional knowledge in utilizing ICT to support professional lives. *Eurasia J. of Math., Sci. and Tech. Educ.*, **5**, 91-101 (2009).
25. Bingimlas, K.A., Barriers to the successful integration of ICT in teaching and learning environments: a review of the literature. *Eurasia J. of Math., Sci. and Tech. Educ.*, **5**, 235-245 (2009).
26. Jimoyiannis, A. and Komis, V., Examining teachers' beliefs about ICT in education. Implications of a teacher preparation programme. *Teacher Develop.*, **11**, 149-173 (2007).
27. Du Plessis, A., Student-teachers' pedagogical beliefs: learner-centred or teacher-centred when using ICT in the science classroom? *J. of Baltic Science Educ.*, 15, **2**, 140-158 (2016).
28. Sang, G., Valcke, M., van Braak, J. and Tondeur, J., Student teachers' thinking processes and ICT integration: predictors of prospective teaching behaviors with educational technology. *Computers and Educ.*, 54, 103-112 (2010).
29. So, H.J., Choi, H., Lim, W.Y. and Xiong, Y., Little experience with ict: are they really the net generation student teachers? *Computers and Educ.*, 59, **4**, 1234-1245 (2012).
30. Avsec, S., Self-directed learning of engineering design by pre-service teachers using innovative ICT-based approaches. *World Trans. on Engng. and Technol. Educ.*, 16, **4**, 344-350 (2018).
31. Hrast, Š., and Savec, F.V., ICT-supported inquiry-based learning. *World Trans. on Engng. and Technol. Educ.*, 16, **4**, 398-403 (2018).
32. Al-Yahya, M., George, R. and Alfaries, A., Ontologies in e-learning: review of the literature. *Inter. J. of Software Engng. its Application*, 9, **2**, 67-84 (2015).
33. Rajapriyan, R. and Kumar. N., Effectiveness of e-learning in adult education. *Inter. J. of Emerging Technologies in Learning*, 8, **3**, 999-1006 (2017).
34. The, M.M. and Usagawa, T., Effectiveness of e-learning experience through Online. *Inter. J. of Emerging Technologies in Learning*, 13, **12**, 157-176 (2018).
35. Junus, I.S., Santoso, H.B., Isal, Y.K. and Utomo, Y.A., Usability evaluation of the student centered e-learning environment. *Inter. Review of Research in Open and Distributed Learning*, 16, **4**, 62-8 (2015).
36. Siagian, S., Sinambela, P.N.J.M. and Wau, Y., Effectiveness and efficiency of e-learning in Instructional Design. *World Trans. on Engng. and Technol. Educ.*, 18, **1**, 73-77 (2020).
37. Ramananda M.K., and Srinivasan, B., Effect of cloud based mobile learning on engineering education. *Inter. J. of Mechanical Engng and Technol.*, 10, **3**, 614-621 (2019).
38. Hariadi, B., Sunarto, M.J.D., Sudarmaningtyas, P. and Jatmiko, B., Hybrid learning by using BRILIAN applications as one of the learning alternatives to improve learning outcomes in college. *Inter. J. of Emerging Technologies Learning*, 14, **10**, 34-45 (2019).
39. McCarthy, D.S. and Burns, B.A., Mathematics Teacher Education and edTPA: Complex Assessing. In: Management Association (Ed), K-12 STEM Education: Breakthroughs in Research and Practice. USA: IGI Global (2017).
40. Savec, V.F., Hrast, Š., Šuligoj, V. and Avsec, S., The innovative use of ICT in STEM teacher training programmes at the University of Ljubljana. *World Trans. on Engng. and Technol. Educ.*, 16, **4**, 421-427 (2018).
41. Flogie, A. and Aberšek, B., Transdisciplinary approach of science, technology, engineering and mathematics education. *J. of Baltic Science Educ.*, 14, **6**, 779-790 (2015).
42. Purwaningsih, E., Wasis, Suyatno and Nurhadi, D., Innovative lesson study (LS) to improve the pedagogical content knowledge (PCK) of STEM teacher candidates in Indonesia. *Global J. of Engng. Educ*. 20, **1**, 39-47. (2018).