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Fundamental concepts and chemical representations on sea pollutant migration: can it be improved through RADEC

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Abstract

The purpose of this research is to improve the fundamental concept and chemical representation of sea pollutant migration through the implementation of the RADEC learning model. Pollutants are solved, ionized, even hydrolyzed in the sea. The research employed a quasi-experimental design with a one-group pre-test and post-test design. The used instrument was four-tier diagnostic tests. It was used to see the improvement of students' fundamental concept and chemical representation on the sea pollutant migration concept. At the end of the class, most of the students' level was lack of knowledge 1 even scientific conception. The statistical data showed there was a significant mean difference between the students' pre-test and post-test, It clearly stated RADEC learning model gave an impact on students' level of fundamental concepts and chemical representation. The improvement caused by the worksheet. It inspired students to create waste filters or chemical products that can absorb waste in the ocean even created sub-microscopic representations.

Keywords: *Chemical Representation, Fundamental Concept, Sea Pollutant Migration, RADEC.*

1. Introduction

For about 1.29 matrix tons of plastic waste from 150 million Indonesians are dumped into the sea every year [1]. This makes Indonesia as the world's second most-largest plastic waste contributor after China [2, 4]. In addition, the pattern of ocean currents flowing into Indonesian waters makes Indonesia an estuary of waste from various countries. There are at least three impacts caused by plastic waste in the ocean, namely, the closure of tourist destinations and coastal areas, the threats to millions of underwater lives, and the most fatal is the findings which uncovers that more than half of the three fish samples traded contain nano-plastics [5]. This act of fish consumption which contain nano-plastic content is toxic to one's body because it damages various systems in the body, including the neurological system [5-7]. In Indonesia, there are 87 cities and regencies located on the coast that contribute 80% of the volume of plastic waste to the sea [1]. The marine pollution not only affects the 87 coastal cities and regencies but other areas as well. This indicates that there has been migration of pollutants in the Indonesian sea. The cause of the migration of these pollutants is the convection of ocean currents as shown in Figure 1 [8].

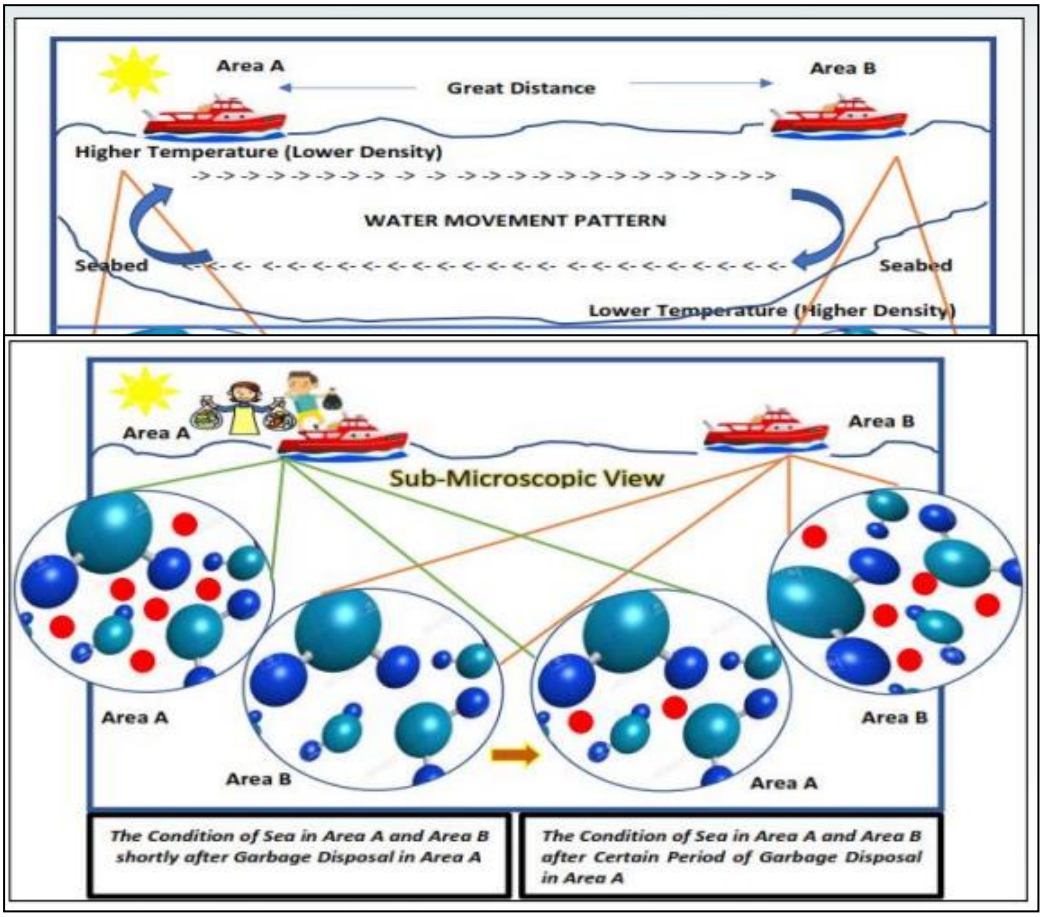

Figure 1. How sea currents move pollutant (dissolved nano-plastic) [8]

Figure 1 shows that the temperature difference between the sea surface and the seabed triggers the movement of sea currents vertically and horizontally which is called convection of ocean currents. This convection occurs due to differences in water temperature; so, water with a higher temperature (lower density) moves from the surface of the water to the seabed. This movement is also followed by lower temperature (higher density) water moving up from the seabed to the surface. The two motions travel to the great extent and create a global conveyor belt that plays a dominant role in determining climate in many regions of the Earth altogether. If seawater contains plastic waste, the movement of these water molecules will also be followed by pollutants and cause pollutant migration.

Thermal convection has strong correlation with the cooling of the ocean surface due to sensible (Q_T), latent (Q_L), and effective long-wave radiation (Q_E) heat fluxes [9]. Q_T may have either sign; its magnitude is, however, much less than that of Q_E or Q_L (except perhaps in some extreme situations). The top of the water column becomes colder and denser than the water below, and convection begins. In this case, cooling is absolutely associated with the homogenization of the water column and the deepening of the mixed layer. Warming due to radiation from sun occurs in the surface layer of the ocean and is associated with restratification and reductions in mixed layer depth. The most prominent examples of this mixing/restratification process are the diurnal cycle (nighttime cooling and daytime warming) and the seasonal cycle such as winter cooling and summer warming [9]. Besides solid plastic waste, chemical waste from industry also massively pollutes water bodies in Indonesia. One of the investigation reports related to river quality in Indonesia during 2013 showed that 75.25% of river water was polluted by heavy metal and household waste. There is only 0.49% of river water which has a suitable category for consumption and sanitation [10]. From various factory wastes that are channelled into rivers, most of them are acidic wastes that have a pH below 7 such as Hydrochloric Acid, Sulfuric Acid, Nitric Acid, and Sodium Hydroxide. Moreover, salt waste is also encountered which causes hydrolysed water to become more acidic due to the increasing concentration of $[H^+]$ or $[H_3O^+]$ in water bodies. Students' understanding of fundamental scientific concepts about pollutant migration in the ocean and their representations is crucial. This will raise students' awareness to protect the environment with logical reasons. Often times, scientific phenomena around students are usually interpreted only at the macroscopic level and at the symbolic level, so that it is not uncommon for students to comprehend basic scientific concepts only to remember facts. Sub-microscopic representations are needed by students to fully understand the concept of convection. Some research results actually show that the sub-microscopic representation ability of Indonesian students at several levels is still low, which includes undergraduate and postgraduate students [8, 11, [12]. Therefore, a learning model is needed that builds students' mastery of concepts and chemical representation abilities, especially sub-microscopic representations. Various learning strategies are applied by educators at various levels of education to elevate students' mastery of concepts and representational abilities. These strategies include discovery learning, problem solving, problem-posing learning, even metacognitive strategies [13-15]. Nevertheless, from these various strategies, teachers encounter difficulties in teaching because the teaching syntaxes are not too familiar with the conditions of students and the curriculum in Indonesia [16]. They require learning model in which the syntax is easy to understand, can develop all students' potential (attitudes, knowledge, skills), and in which its development takes into account the Indonesian context. One model that fits the above criteria is the Read-Answer-Discuss-Explain-Create (RADEC) learning model. Previous research studies has shown that this learning model is able to enhance higher order thinking skills [17, 18] and concept mastery [19-21]. However, the implementation of the RADEC learning model to build chemical representation abilities has not been carried out. Hence, this study aims to analyse the impact of implementing the RADEC learning model on the understanding of fundamental scientific concepts and the chemical representation ability of postgraduate students majoring in basic education on the process of water pollution. This experimental research is expected to be able to contribute to teaching strategies that stimulate and build students' chemical representation abilities at various levels.

2. Sea Pollutant Migration

Several species of algae and mollusks are used for biomonitoring to track heavy metals that cause pollution of water bodies, especially in the sea. Laboratory test results show that the scattered pollutants vary greatly depending on the seasons [22]. In addition, nitrate is also found in water bodies because nitrate is a chemical element that is very soluble and very mobile. Their presence in water with high concentrations often indicates anthropogenic contamination. They

usually come from the used nitrogen fertilizers that are soluble in water bodies such as rivers or other urban sewage [23]. Decreased water quality in water bodies such as rivers and seas result in the transmission of biological and chemical diseases [24]. Besides heavy metals, the level of water turbidity and the volumes of bicarbonate ions are parameters for water quality. The main sources of waste are household and industrial. Domestic and industrial wastewater management is a concern because the wastewater still contains heavy metals and even the wastewater has a pH below 7 [25]. Heavy metals Cd, Pb, Cr, and Zn are dangerous in wastewater because most of them are usually found in organometallic compounds. One of the wastewater treatment techniques that may be implemented because of its economic value is by infiltration-percolation [26]. The technique involves the study of a number of physicochemical parameters and characteristics of the gravel package. The number of studies related to heavy metal levels in waters shows that controlling heavy metal concentrations is needed to maintain environmental sustainability [8, 25]. General analysis related to water quality involves physicochemical parameters such as pH, temperature, dissolved oxygen, salinity, and conductivity as well as microbiological and atomic absorption of heavy metal. In another term, the presence of these heavy metals will have a direct impact on microbes in seawater such as *E.coli* bacteria [25, 27]. A report related to the presence of heavy metals in Jakarta Bay showed that the levels of these metals began to increase [28]. In addition, the dynamic sea water contributes to the spread of this heavy metal waste [8]. Table 1 below shows the concentrations of several heavy metals in Jakarta Bay.

Table 1. *The heavy metals concentration in sediment of the Jakarta Bay* **[28]**

Element	Month	Maximum Value	Minimum Value	Mean	Median	SD	P*
Cd	March	1.18	0.08	0.59	0.55	0.30	0.369
	June	1.74	0.29	0.70	0.54	0.45	
Cu	March	94.80	16.40	46.90	33.6	29.20	0.992
	June	157.00	16.60	49.80	35.9	40.70	
Fe	March	62313.00	40678.00	48063.00	46292	6889	0.057
	June	60300.00	39573.00	51800.00	51114	6186	
Ni	March	38.40	13.70	24.70	23.60	6.10	0.438
	June	75.80	15.90	29.40	26.70	16.00	
Pb	March	41.70	8.10	23.70	21.90	9.80	0.401
	June	89.40	7.80	31.40	28.80	21.70	
Zn	March	503.00	72.10	206.00	144.00	137.00	0.196
	June	1270.00	85.30	408.00	241.00	398.00	

Based on Table 1, statistically, metal concentrations showed a non-significant difference between March and June indicating that the metals were distributed in the same way. Although they are not significantly different, the amount of these metals must be watched out for because they will have an impact on the environment. The spatial distribution of metals (Cd, Cu, Fe, Ni, Pb, and Zn) in Jakarta Bay sediments tends to change due to hydrodynamics, one of which is ocean currents. One of the causes of these ocean currents is convection where water with higher temperature (lower density) moves to lower temperature (higher density). It creates great movement and distances. Water moves both vertically and horizontally [8].

3. Methods

3.1. Research Design

This research employs quasi-experimental design with a one-group pre-test and post-test design. A particular class was observed to understand the scientific fundamentals and their representational abilities before and after the implementation of the RADEC learning model. Essentially, this research looks at the effect of a treatment on a variable [29]. Meanwhile, the participants in this study were seven master students majoring in basic education who took an interest in science. They have diverse backgrounds in their Undergraduate studies. They were selected based on a purposive sampling technique with the condition that they were committed to being involved in all science lectures.

3.2. Procedure

The stages of implementing the Read-Answer-Discuss-Explain-Create (RADEC) model are listed as follows:

1. Students are given pre-learning questions related to the concepts of greenhouse gases, global warming, nano-plastics, salt hydrolysis, and chemical waste and their representations at the Read and Answer stages.
2. At the Discuss stage, students are divided into three groups to agree on joint answers to these questions.
3. At the Explain stage, students present group answers. Students present arguments regarding their answer choices to optimize and stimulate students' thinking skills.
4. In the Create stage, students are inspired to produce a creative product that is able to overcome pollution in water bodies.

3.3. Instrument

There are two types of instruments utilised in this study. The first is pre-learning questions and students' worksheets which are used as learning media. Then the second is the four-tier diagnostic test. Students got four questions. The first, they were asked regarding their opinion towards the migration ability of both solid and liquid pollutants in the sea, the second they were asked regarding the rationale, the third they were asked students to describe their representation, and the fourth they were asked about their level of belief.

3.4. Data Collection and Analysis

The data were taken twice from the students, that is at the starting and ending process of learning in class. The data were then processed using the rubric developed by Sopandi and Sukardi [8]. The understanding of scientific fundamentals and students' representational abilities were analysed, grouped, and scored as shown in Table 1 below:
The next step was to present the percentage number of categories of students based on their level in the chart, both before and after the implementation of the RADEC learning model. To ensure that this learning model has an impact on increasing the category of scientific fundamental understanding and its representation, normality tests, paired sample statistics, and paired sample tests were carried out. The data were later processed and analysed using SPSS ver.26.

Table 1. ***Combination answers and decisions in the four-tiers***

Decision	Answer Combination	Score

	1st tier	2nd tier	3rd tier	4th tier	
Scientific Conception	Know / Correct	Correct	Connected -Sub- Microscopic	Sure	2
Lack of Knowledge 1	Know / Correct	Correct	Connected Macroscopic/Symbolic	Sure	2
	Know / Correct	Correct	Unconnected	Sure	
Lack of Knowledge 2	Know / Correct	Correct	Unconnected	Not Sure	
	Know / Correct	Partly Correct	Connected Macroscopic/Symbolic	Sure	1
Misconception	Know / Correct	Incorrect	Connected Macroscopic	Sure	0
	Know / Correct	Incorrect	Unconnected	Sure	
Have No Conception	Know / Correct	Incorrect	Unconnected	Not Sure	0
	Know / Correct	Incorrect	Unconnected, abstract	Sure	
	Know / Correct	Incorrect	Unconnected, abstract	Not Sure	
	Doesn't know / Incorrect	Incorrect	Unconnected	Sure	
	Doesn't know / Incorrect	Incorrect	Connected	Sure	
	Doesn't know / Incorrect	Incorrect	Unconnected	Sure	
	Doesn't know / Incorrect	Incorrect	Unconnected	Sure	
	Doesn't know / Incorrect	Incorrect	Unconnected	Not Sure	

5. Results and Discussions

The result shows that at the end of the lecture, the percentage of students with scientific conceptions, lack of conceptions I, and lack of conceptions II has increased. This is a positive signal that the RADEC learning

model has an impact on elevating the level of students' understanding of fundamental concepts and the representation as shown in Table 2.

Table 2. ***Students' understanding of fundamental concept and the representation***

Test	Level				
	Scientific Conception	Lack of Conception 1	Lack of Conception 2	Misconception	Have No Conception
Pretest	0%	0%	28.57%	0%	71.43%
Posttest	28.57%	57.14%	14.29%	0%	0%

In the post-test students' answers with levels of *misconceptions* and *have no conceptions* are not found because of the role of pre-learning questions at the Read and Answer stage that guide students to understand the basic concepts of greenhouse gases, global warming, nano-plastics, salt hydrolysis, and chemical waste as well as their representations. This pre-learning question is able to make the time more effective so that there is no reason that learning activities would exceed the specified time limit [30]. Meanwhile, some students' answers indicate that there has been an increase in the level of students' understanding of fundamental concepts and the representation from the level of *has no conception* to the level of *lack of conception 1* and even *scientific conception*. The following are some of the students' post-test answers which are shown in Figure 2**.**

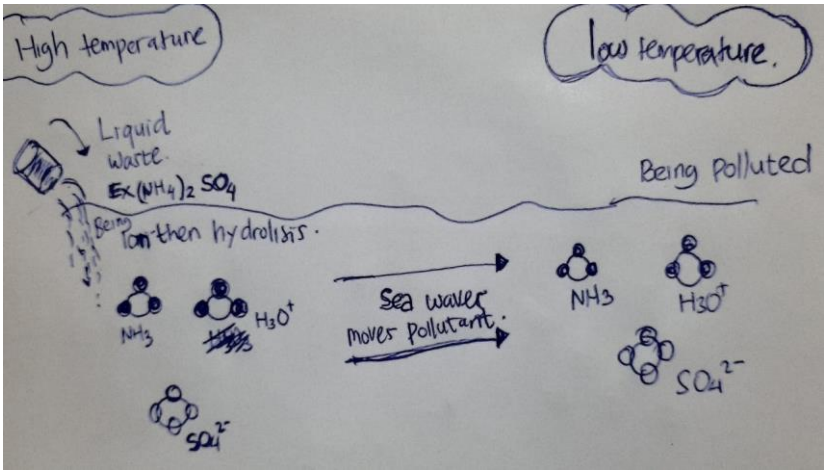

Figure 2. 1st student's answer on chemical representation

Figure 2 shows a student's answer which is categorized as *scientific conception level* where the student is able to describe the sub-microscopic representation correctly. The student understood that pollutants migrate from one place to another because they are carried by waves or ocean currents. This ocean current itself occurs due to several factors, one of which is the difference in temperature and pressure between two places that triggers the displacement of the volume of water in the sea [31-33]. In addition to understanding how waste can be carried away by ocean currents and spreads, students also explained how the pH of seawater tends to be more acidic due to the hydrolysis of salt $(NH_4)_2SO_4$ which causes the formation of NH_3, H_3O^+, and SO_4^{2-}. The student explained that it was this H_3O^+ that caused seawater to turn more acidic. $(NH_4)_2SO_4$ is one of the industrial raw materials which is usually reacted with NaCl to produce NH_4Cl commercially [34]. The existence and nature of $(NH_4)_2SO_4$ are not necessarily the waste that is found in marine waters, but that is only one example presented by the student. Meanwhile, Figure 3 shows the answers of other students which are included in the *scientific conception level.* They both understood that sea water

will move due to ocean currents caused by differences in temperature and pressure. Sea water will eventually mix with each other even though the source of pollution is from a very distant place. Although Pb is known as a heavy metal that pollutes water bodies, only a few students gave examples of Pb^{2+} ions. They understand that these ions dissolve in seawater and migrate under the influence of ocean currents. One of the students' answers stated that the heavy metal Pb could be an organometallic compound or also called alkyl-lead. This compound is lipophilic so that it can penetrate the skin and respiratory tract [35].

Figure 3 shows that students understood that HCl solution will completely ionize in water into H^+ and Cl^-. According to the students, the movement of these ions will tend to be faster when the temperature increases due to the high intensity of sunlight during the day. This argument actually still has to be tested for coherence, but what is of concern is that students began to show the thinking process in answering questions. Meanwhile, related to the issue of nano-plastics found in fish that are traded, none of the students answered that the plastic that was carried into the sea was decaying. They knew certainly that plastic is a non-organic material that takes a long time to decompose. Understanding how nano-plastic particles can appear in the body of fish is a complicated matter for students but this fact is informative for them as common knowledge.

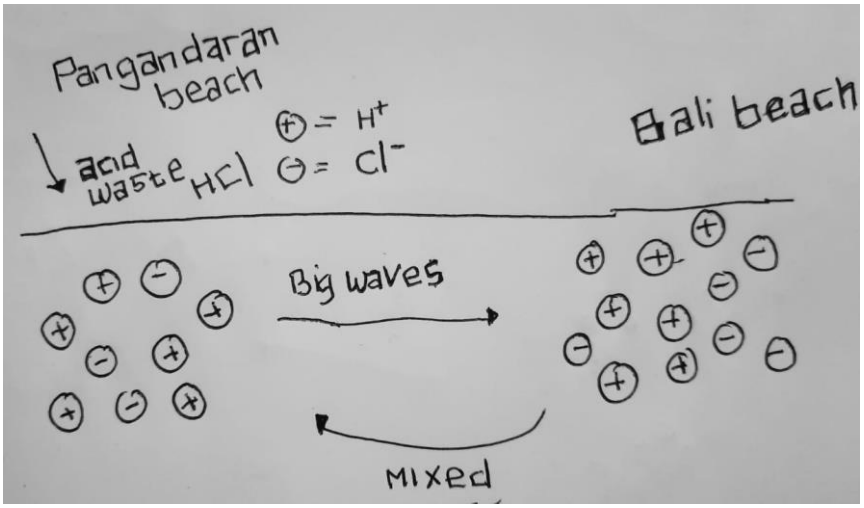

Figure 3. 2nd student's answer on chemical representation

To ensure that the RADEC learning model could enhance students' understanding of fundamental concepts and the representation, a series of statistical tests were conducted using SPSS ver.26. The first step was to conduct *test of normality* as shown in Table 3 below. Value of Sig. using the Shapiro-Wilk method, the pretest variable value is 0.306 (30.6%) and the postest variable value is 0.337 (33.7%). This indicates that H_0 is accepted because the value of Sig. more than 0.05 (5%) so that the data could be tested by paired sample t-test.

Table 3. ***Test of normality***

	Kolmogorov-Smirnov[a]	Shapiro-Wilk

	Statistic	Df	Sig.	Statistic	Df	Sig.
Pretest	.230	6	.200*	.903	6	.306
Postest	.150	6	.200*	.908	6	.337

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 4. ***Paired samples statistics***

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	**Pretest**	3.3425	7	.34661	.12254
	Postest	4.0550	7	.30090	.10639

Table 4 shows that the mean value of the pre-test items is 3.34. Meanwhile, the mean items of post-test value is 4.05. Since the average pre-test is 3.34 < post-test 4.05, it can be interpreted that there is a difference in the average value between the pre-test and post-test. To prove whether or not the difference is truly significant, it is necessary to interpret the paired sample t test as shown in Table 5 below.

Table 5. ***Paired samples test***

		Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	**Pretest - Postest**	-.71250	.25833	.09133	-.92847	-.49653	-7.801	6	.000

Based on the table above, it is known that the value of Sig. (2tailed) is 0.000 < 0.05. This indicates that H_0 is rejected and H_1 accepted. Thus, it can be concluded that there is an average difference between the results of the pre-test and post-test, which means that there is an influence of the RADEC learning model on students' understanding of fundamental concepts and the representation. Further investigation showed that the students' worksheet used in the Create stage had a dominant role in shaping the understanding of fundamental concepts and chemical representations. The worksheets inspired students to create waste filters or chemical products that can absorb waste in the ocean. Because of this inspiration, students began to look for not only the physical and chemical properties of materials, but even their sub-microscopic representations**.** Based on the data above, it was found that the teacher has a duty to provide questions that serve to focus students on the material that must be mastered based on the demands of the curriculum. Teachers are facilitators in learning who are able to motivate, activate students in discussions, improve students' work ethic in communicating, work in teams and even make decisions, and also to prepare students for global competition in the world of work [36-40]. The teacher is the controller of the learning atmosphere in the classroom who is able to create effective learning by involving students for hands-on and mind-on together.

The implementation of learning models such as RADEC was able to increase the mastery of chemistry fundamental concepts and the representation because in the syntax there were discussion and argument sessions that were able to build students' scientific imagination in representing concepts sub-microscopically

[41]. Students were forced to think critically and creatively regarding scientific phenomena around them. Pre-learning questions that were not prepared properly often caused cognitive conflicts for students and often formed misconceptions. Pre-learning questions that were prepared to build students' prior knowledge will help students to determine changing concepts into visual sub-microscopic representations [42].

Conclusion

The result shows that the RADEC learning model is able to improve understanding of basic concepts and student representation related to marine pollutant migration. This is supported by statistical results which show that there is a significant mean difference between the students' pre-test and post-test, namely the value of Sig. (2tailed) is 0.000 < 0.05.

References

[1] E.S. Soegoto, J.M. Ramana, L.S. Rafif, *ASEAN Journal of Science and Engineering Education*. 1(2) (2021), 125-130

[2] M.R. Cordova, I.S. Nurhati. *Sci. Rep*, 9(1) (2019).

[3] D.M. Sodik. *Int. J. Mar. Coast. Law*, 36(1) (2020) 114–135.

[4] U.Y. Prisandani, A. L. Amanda. *Yuridika*, 35(1) (2020).

[5] H. Jacob, M. Besson, P. W. Swarzenski, D. Lecchini, M. Metian. *Environ. Sci. Technol*, 54(8) (2020) 4733–4745.

[6] Kabir, M. H., Islam, M. S., Tusher, T. R., Hoq, M. E., Al Mamun, S. *Indonesian Journal of Science and Technology*, 5(3) (2020), 395-409..

[7] M. Capolupo, P. Valbonesi, and E. Fabbri. *Nanomaterials*, 11(3) (2021).

[8] W. Sopandi, R. R. Sukardi. *Rev. Int. Geogr. Educ. Online*, 10(2) (2020) 13–29.

[9] A. Soloviev, B. Klinger. *Encyclopedia of Ocean Sciences*, (2001) 2015–2022.

[10] K. Pareta, U. Pareta, *Indonesian Journal of Science and Technology*, 2(1) (2017), 26-49.

[11] M. Pikoli. *Int. J. Act. Learn*, 5(1) (2020) 1–10.

[12] S. Rahayu, M. Kita. *Int. J. Sci. Math. Educ*, 8(4) (2010) 667–688.

[13] I. Farida, D. H. Widyantoro, W. Sopandi, L. Liliasari, D. H. Widyantoro. *Proceeding 4th Int. Semin. Sci. Educ*, 4, (2010) 1–7.

[14] K. B. Sujak, E. G. S. Daniel. *Malaysian Online Journal of Educational Sciences*, 5 (3) (2017) 83-96

[15] N. Y. Indriyanti, S. Saputro, R. L. Sungkar. *EDUSAINS*, 12 (1) (2020)

[16] W. Sopandi, H. Handayani. *Advances in Social Science, Education and Humanities Research*, (2019) 7-11

[17] H. Handayani, W. Sopandi, E. Syaodih, I. Suhendra, N. Hermita. *J. Phys. Conf. Ser.*, 1351 (2019) 012074

[18] Lukmannudin, W. Sopandi, A. Sujana, R. R. Sukardi. *J. Phys. Conf. Ser.*, 1013 (2020) 012084

[19] F. N. Fuadi, W. Sopandi, A. Sujana. *J. Phys. Conf. Ser.*, 1806 (1) (2021) 012140

[20] L. S. Siregar, W. Wahyu, W. Sopandi. *J. Phys. Conf. Ser.*, 1469 (2020) 012078

[21] D. Setiawan, W. Sopandi, T. Hartati. *J. Phys. Conf. Ser.*, 1521 (2020) 042113

[22] S. Boucetta, W. Benchalel, S. Ferroudj, Z. Bouslama, H. Elmsellem, *Moroccan Journal of Chemistry*, 7(3) (2019), 7-3.

[23] N. Aziane, M. Larif, A. Khaddari, M. E. Touhami, M. E. Touhami, A. Khaddari. *Moroccan Journal of*

Chemistry, 8 (4) (2020)
[24] A. W. Rashid *et al.*. *Moroccan Journal of Chemistry*, 2 (2) (2014)
[25] I. Bazzi, K. El Mouaden, A. Chaouay, A.A. Addi, M. Hamdani, S. El Issami, M. Hilali, B. Hammouti, K. Abbiche, R. Salghi, *Indonesian Journal of Science and Technology*, 5 (3) (2020), 463-469
[26] R. Aba-aaki, M. Ez-zahery, S. Et-Taleb, A. Bousskri, M. Abbaz, S. Lhanafi, N. Alem, *Moroccan Journal of Chemistry*, 2(5) (2014), 2-5.
[27] R. E. Caraka, R. C. Chen, H. Yasin, S. Suhartono, Y. Lee, B. Pardamean. *Indonesian Journal of Science and Technology*, 6 (1) (2021)
[28] F. Budiyanto, L. Lestari. *Bull. Mar. Geol.*, 32 (1) (2017)
[29] C.V. Ahmad, *ASEAN Journal of Science and Engineering Education*, 1(1) (2021), 47-62.
[30] R. Sukardi, W. Sopandi, and R. Riandi, *J. Phys. Conf. Ser.*, 1806 (1) 012142
[31] S. J. Woolnough, J. M. Slingo, B. J. Hoskins, *Journal of Climate*, 13 (12) (2000) 2086–2104
[32] S. Lestari, A. King, C. Vincent, D. Karoly, and A. Protat, *Weather Clim. Extrem.*, 24 (2019) 100202
[33] T. Izumo, J. Vialard, M. Lengaigne, I. Suresh, *Geophys. Res. Lett.*, 47 (3) (2020)
[34] M. Nadeem, J.I. Qazi, S. Baig, Q.U.A. Syed, *Food Technology and Biotechnology*, 46(4) (2008), 388-394.
[36] A. M. Lolos, A.P. Lorio, C.L. Martinez, H.P. Abusama, K.Y.M. Tangkli, M.N.J.S. Falsario, Z.A.K.F. Consebit. *ASEAN Journal of Science and Engineering Education*, 1 (2) (2021) 81-86.
[37] H. Rosina, V. Virgantina, Y. Ayyash, V. Dwiyanti, S. Boonsong. *ASEAN Journal of Science and Engineering Education*, 1 (2) (2021) 105-110.
[38] N. A. M. Jizat, M. S. Sulong. *Indonesia Journal of Educational Research and Technology*, 1 (1) (2021) 23-26
[39] C. V. Ahmad. *Indonesian Journal of Educational Research in Technology*, 1 (2) (2021) 51-56
[40] E. A. Morbo. *Indonesian Journal of Educational Research and Technology*, 1 (2) (2021) 67-70
[41] R. R. Sukardi, H. R. Widarti, L. Nurlela. *Proceeding AES*, 2 (2017) 178–183
[42] N. M. Tajudin, M. Chinnappan. *International Journal of Instruction*, 9 (2) 199-214