Reducing Misconception of Force Concepts Through Learning Conceptual Change Model with Cognitive Conflict Approach

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Abstract - *This type of research is quantitative research that aims to reduce students' misconceptions through learning a conceptual change model with a cognitive conflict approach (CCM-CCA). The population in this study were students of the Physics Education Study Program, the University of Mataram, and students of the Surabaya State University Science Education Study Program. The sample in this study amounted to 56 second-semester students at both universities, each of which amounted to 29 people. The CCM-CCA used has been validated in Focus Group Discussion (FGD) activities and has been declared valid in content and construct so that it is appropriate to use. Data in this study were obtained through misconceptions tests, observations of conceptual changes and cognitive conflicts, and the interview process. Data analysis in this study used descriptive analysis by looking at the comparison of the percentage of students who had misconceptions before and after being given treatment and analyzing the level of cognitive conflict. The results of this study indicate that the CCM-CCA learning model is effective in reducing student misconceptions. Conceptual changes and cognitive conflicts that occur in students are included in the high and very high categories, and the results of structured interviews show that students experience 4 thought processes while learning CCM-CCA which helps students to change their conceptions from initially experiencing misconceptions to understanding scientific concepts.*

***Keywords**: Misconception, cognitive conflict, force, CCM-CCA*

INTRODUCTION

One of the problems that many students experience at school or university is a misconception. The term misconception is used in concepts that contradict scientifically accepted theories (Nugraeni et. al., 2013; Gurel et.al., 2015; Hidayatullah et. al., 2020). The misconception has several synonyms such as concept misunderstanding, alternative conception, naive concept, intuition, and so on (Leonard et.al., 2014). Misconceptions in students can affect their learning outcomes (Aulia et.al., 2018). Therefore, students' misconceptions need to get special attention for teachers or lecturers who teach in class because they can become obstacles for students to understand more complex physics material (Sholihat et. al., 2017). Misconceptions can also last a long time in students if handled immediately (Taufiq, 2012).

In general, students' misconceptions can be caused by many factors, one of which is the teacher teaching in the classroom (Barke et al. 2009). Teacher mistakes in teaching, wrong teacher conceptions, and inadequate teacher understanding can lead to misconceptions in students. Misconceptions caused by teacher errors are usually quite difficult to correct because students feel confident that the concepts given by their teacher are correct. Teachers who experience misconceptions have the potential to pass on the wrong conceptions to their students. Therefore, prospective teacher students who are studying at the tertiary level must ensure that they do not experience misconceptions. However, based on the results of preliminary studies at two different universities, namely

in the Physics Education Study Program FKIP Mataram University and Science Education FMIPA Surabaya State University, it was found that many students still experience misconceptions about the concept of style. The results of the preliminary study indicate that the learning process applied by lecturers so far has not been able to increase understanding of concepts or reduce student misconceptions. Therefore, learning should be focused on efforts to make conceptual changes to concepts that are still misunderstood by students.

The conceptual change will not occur easily, this is because students' misconceptions are very difficult to change. Several studies have identified four conditions that must be met for students to experience conceptual change, namely: 1) dissatisfaction with existing conceptions; 2) the clarity of the new conception; 3) Logical (reasonable); 4) new conceptions must be appreciated or assessed in a pragmatic context (Makhrus, et. al., 2014; Tlala, et. al., 2014). The use of the conceptual change learning model is one way to correct misconceptions into the right concepts. Most conceptual change models will be based on Piaget's ideas and constructivist arguments. These methods teach to create dissatisfaction with students' thinking about alternative conceptions, which in this case is called cognitive conflict, which is followed by strengthening the status of the desired scientific conception.

On the other hand, peer/social interactions and group discussions are important factors that cause conceptual changes as suggested by social constructivists. The conceptual change model is learning that connects interactions between new concepts and previous conceptions (Redhana et.al., 2017). Cognitive conflict is a situation in which a person experience doubts about his conception due to new conflicting concepts (Makhrus et al., 2014). Several studies have concluded that cognitive conflict plays an important role in conceptual change. Cognitive conflict is needed in learning to achieve conceptual change to create the conceptual understanding that follows scientific concepts (Lee et al., 2003; Lee & Yi, 2013). This conceptual change can be done using the CCM-CCA model so that students are aware of the cognitive conflict that is happening to them so that the expected process of conceptual change can occur.

The Conceptual Change Model with the Cognitive Conflict Approach, abbreviated as CCM-CCA, is a learning model developed to facilitate students' concept change by reducing misconceptions. The CCM-CCA learning model was developed by referring to the CCM that was developed by Stepans (Moreno, 2010). The CCM-CCA learning model has passed content and constructs validity. The CCM-CCA learning model is transdisciplinary because it was developed based on the results of studies of various disciplines, such as basic physics, learning theory, conceptual change models, cognitive conflict approaches, and other disciplines that are integrated to solve problems that occur in physics learning and are theories or models. new learning to facilitate conceptual change in students (Arends, 1997; Makhrus, 2018b).

The CCM-CCA learning model encourages conflict in the cognitive structure followed by strengthening the status of the desired scientific conception so that it is expected to facilitate students in the process of conceptual change towards alternative conceptions (Makhrus, 2018b). The CCM-CCA learning model helps students improve their conceptions by providing correct information but contradicting students' initial conceptions. CCM-CCA learning places

students in an environment that encourages them to confront their prejudices and then work towards conceptual change and resolution. This learning model can make students feel satisfied with the learning carried out (concept changes can occur) because of detailed discussion of confusing phenomena and shows how scientific conceptions can be applied so that in the end the learning carried out does not leave any impression.

RESEARCH METHODS

This type of research is quantitative research. The population in this study were all students of the Physics Education study program PMIPA FKIP Mataram University and Science Education FMIPA Surabaya State University. The sample in this study amounted to 56 second-semester students at both universities, each of which amounted to 29 people. Misconceptions are determined from the results of the initial test (pretest) equipped with the CRI (Certainty of Response Index) instrument which is used to determine the quality of certainty of the respondent's answer. The level of cognitive conflict is determined from the measuring instrument for the amount of cognitive conflict in the form of a checklist filled in by students. Conceptual changes that occur in students will be observed directly using observation sheet instruments during learning and direct interviews after learning. The observation sheet instrument refers to the thought processes that students must experience as a condition for conceptual change.

The percentage of the thinking process experienced by students is obtained from the final score multiplied by 100%. The final score is the total score divided number of descriptors (indicators) of each thought process experienced by students during learning.

Table 1. Conceptual Change Criteria

Percentage (%)	Category
$0 < P \leq 25$	Low
$25 < P \leq 50$	Moderate
$50 < P \leq 75$	High
$75 < P \leq 100$	Very High

Learning with the CCM-CCA was carried out in 5 meetings (lessons). The first meeting (analyzing the forces acting on objects that are rest), the second meeting (the amount that affects the inertia of an object), the third meeting (analyzing the forces acting on an object). objects that move upwards after being thrown upwards), the fourth meeting (analyzing the effect of the level of smoothness and surface roughness of the object on the magnitude of the friction force), and the fifth meeting (analyzing the forces acting on the object pulled by a horizontal rope in such a way so that the object moves on the floor at a constant speed).

RESULTS AND DISCUSSIONS

Observations of the conceptual changes experienced by students during the learning process are carried out by using observation sheets that are filled in by the observer with attention to possible behaviors that arise during the learning process. Students who are observed are students who have low ability and high ability. The results of the conceptual change observation are presented in the following Table 2.

Table 2. Observation Results of Conceptual Change

Student Abilities	Conceptual Change Score	Category
High Ability	83.60	Very High
Low Ability	80.00	Very High

Based on the Table above, it can be seen that the results of observations of conceptual change in low-ability and high-ability students show very high conceptual changes in learning with CCM-CCA. This shows that both students generally still have wrong conceptions at the beginning of learning or even have misconceptions about the concepts being taught. The percentage of conceptual change that occurs in high-ability students is greater than in low-ability students. This occurs because students who have high abilities tend to have an imbalance of cognitive structures that is stronger than students with low abilities.

The level of conceptual change that occurs in students for each meeting (lesson) during the learning process using CCM-CCA can be seen briefly in the following graph (Figure 1).

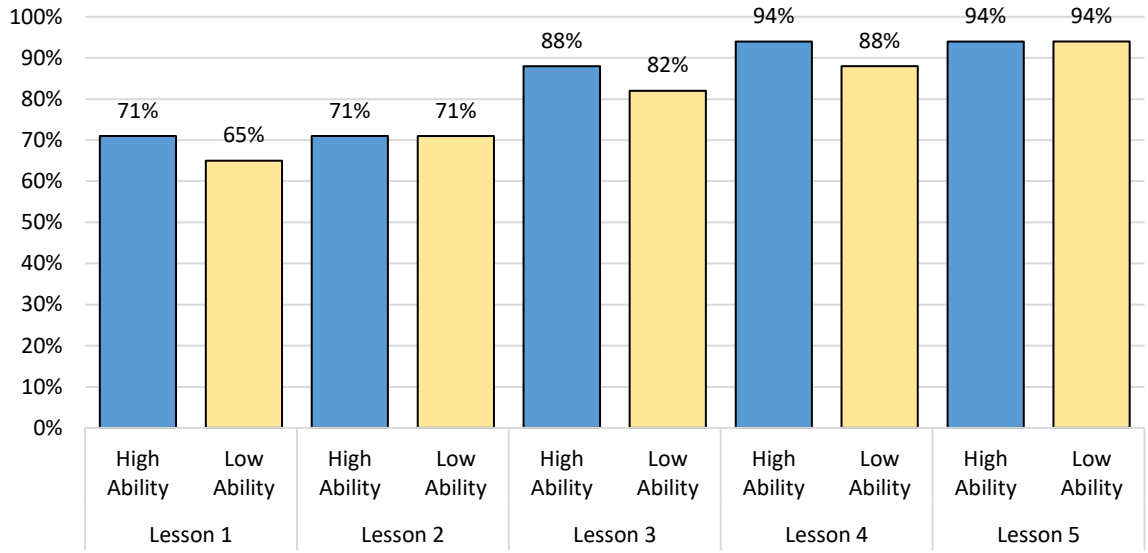

Figure 1. Levels of Conceptual Change That Occurred in Students during Five Lessons

The results of the assessment of the level of cognitive conflict that occurs in students during learning using the CCM-CCA learning model can be briefly seen in the following Table 3.

Table 3. Cognitive Conflict during Learning

Class	Total Students	Average Percentage of Cognitive Conflict	Category
A	29	88,08%	Very High
B	29	86,98%	Very High

Based on the table above, it can be seen that all students give a very high assessment of the cognitive conflicts that occur to them. This is because the learning syntax that is carried out using the CCM-CCA learning model is designed to generate cognitive conflict in students by conveying problems that are indeed contradictory to their conceptions. The stronger the level of student confidence in the correctness of the concepts they have, the higher the cognitive conflict that occurs in students.

Conceptual changes and levels of cognitive conflict for each group of students grouped based on their conceptions (M1 is the student who does not understand the

concept, M2 is the student who understands the concept, M3 is the student who does not know the concept, M4 is the student Misconception) in the two classes (class A and class B) can be seen in Table 4 below.

Table 4. Conceptual Changes in Students

Subject	Conceptions	Conceptual Change		Cognitive Conflict Level	
		Percentage	Category	Percentage	Category
Class A	M1	80,0%	Very High	90,0%	Very High
	M2	83,6%	Very High	93,3%	Very High
	M3	77,6%	Very High	87,8%	Very High
	M4	75,4%	Very High	80,0%	Very High
Class B	M1	80,0%	Very High	87,8%	Very High
	M2	83,6%	Very High	82,2%	Very High
	M3	77,6%	Very High	74,4%	High
	M4	75,4%	Very High	74,4%	High

The data in the table above shows that the four groups (M1, M2, M3, & M4) experienced a conceptual change with very high and high categories. Most students have a wrong conception before being treated with CCM-CCA. The level of cognitive conflict experienced by the four class groups in Class A also shows in a very high category.

Research on learning shows that misconceptions will serve as a barrier to achievement. These misconceptions are often based on personal experiences and will be difficult to change and will prevent them from having a meaningful understanding in other areas (A'yun, Harjito, & Nuswowati, 2018). Although post-learning activities have been designed to relate to scientific areas where these misconceptions will be held by students, many students do not rebuild/reconstruct their thinking. Students will be able to deconstruct their knowledge and reconstruct it using critical thinking and logical reasoning and those who can do this will appear to have few misconceptions after receiving quality teaching.

Learning through the CCM-CCA is learning that can help students build their own knowledge, because of student involvement during the learning process. This learning makes students experience a process of assimilation and accommodation so that students build their knowledge at any time until the concepts they understand do not conflict with scientific concepts. For the process of assimilation and accommodation to truly satisfy students, cognitive conflict stimulation is needed. These stimuli can be in the form of explanations and demonstrations in the form of examples that contradict student understanding. Furthermore, students are allowed to do scientific thinking activities and carry out investigations through experiments to prove the truth of the concepts they already have and concepts that contradict their conceptions in the hope that students can rebuild/reconstruct their thinking so that the misconceptions they have can be eliminated.

The CCM-CCA can facilitate educators to carry out learning to make conceptual changes to wrong conceptions (misconceptions) that are owned by students into correct conceptions (scientific conceptions). Educators in the first phase must be able to present cognitive conflicts by conveying information and carrying out demonstrations that are contradictory to the students' initial conceptions. This is what makes students dissatisfied with the conceptions they have (dissatisfaction) and are interested in new information or conceptions conveyed by educators because of the clarity of the new conception

(intelligibility). This situation makes students motivated to accommodate concepts from literature books and discuss to discuss problems presented by educators so that students get an idea that the new conception does contain elements of logic (plausibility) and this new conception can be used to solve problems that have been conveyed by educators (fruitfulness). Generally, students have understood the concept of a phenomenon. The student's conception can change if educators use the CCM-CCA and give different views so that students hesitate and even leave their belief in the old conception.

Observation of the occurrence of conceptual changes to reduce misconceptions experienced by students during the learning process can be done by using observation sheets that are filled in by observers by paying attention to possible behaviors that arise during the learning process. The results of the observations on the conceptual understanding test and the level of certainty of student response responses (CRI) in the two classes above showed the same observation results. The four students in each class showed an increase in the results of the conceptual understanding test and the scale of the level of certainty of student response responses. At the beginning of learning (based on the results of the pretest), the four students in each class had different criteria for concept understanding and CRI tests, namely M1: not understanding the concept, M2: understanding the concept, M3: not understanding the concept, and M4: experiencing misconceptions. After learning with the CCM-CCA, the posttest experienced an increase in test results and the level of confidence in the correctness of the answers given, that is, all students understood the concept well. This shows that learning using the CCM-CCA learning model can reduce student misconceptions by changing student conceptual. Also, all students have experienced high cognitive conflict during learning, so it can help the process of conceptual change in students.

Another way that researchers do this is to use structured interview guidelines to determine the occurrence of conceptual changes in students. This interview guide is used to find out firsthand the thinking processes experienced by students as a condition for conceptual change, besides that it can also be used to strengthen the results of observations made by observers about student misconceptions. This interview was conducted on 8 students who were the subject of observations of conceptual change. This interview was conducted after the learning ended and was conducted by the researcher himself. At the beginning of the interview, the researcher asked about the student's opinions regarding the concepts that had been conveyed by the educator at the beginning of the lesson. In general, students say that the concepts conveyed by educators are very different and contradict the conceptions they have. This is what makes students experience an imbalance in their cognitive structure due to a contradiction between existing conceptions and new information faced in learning. This situation ultimately makes students feel dissatisfied with the conceptions they have and this recognition motivates them to try to resolve conflicts (dissatisfaction).

When students feel dissatisfied with the conception they have, researchers ask about student opinions related to the clarity of new information conveyed by educators. Students say that the information conveyed by educators has clarity regarding the concepts being taught, so they directly integrate the new information into an existing scheme (Intelligibility). In the next

stage, the researcher asked students about the logic of the new information or conceptions conveyed by the educator. All students said that there was a logical element related to new information or conceptions conveyed by educators. Students feel that the new information conveyed by educators at least seems to have the ability to solve problems generated by the predecessor concept. This is what makes students willing to change the information they have with this new information (Plausibility).

In the final stage, all students said they had found answers to the problems that had been presented by the educator. Students are satisfied with the educator's detailed discussion of confusing phenomena and show how scientific conceptions can apply. Students also said that the new conception has the potential to be expanded, so that it can be tested on other problems related to the new conception (Fruitfulness).

The description of the interview results above shows that all students have experienced 4 thought processes as a condition for conceptual change. Students have experienced a conceptual change from misconceptions to correct conceptions (scientific conceptions), starting with dissatisfaction with the conceptions they have because of new information delivered by educators where the new information does contain elements of logic or makes sense at first and In the end, through learning that requires students to conduct discussions and experiments, clarity is finally obtained about the success of new information or new conceptions in solving existing problems.

The stronger the level of student confidence in the correctness of the concepts they have, the higher the cognitive conflict that occurs in students. This fact is what causes all students in class A and class B to give a very high assessment of the cognitive conflicts that occur to them. The assessment is given by students in class A and class B is in line with the results of the analysis of changes in student opinion on the truth of a concept, the results of the analysis of observations of conceptual changes in students, and the results of the analysis of interviews conducted to see the conceptual changes that occur in students. college student. The suitability of these results shows that it is true that the condition for conceptual change is a cognitive conflict experienced by students so that it can reduce student misconceptions.

This fact shows that learning using the CCM-CCA learning model is effective for creating cognitive conflict as the first step in the process of reducing misconceptions by changing student conceptual from wrong conceptions to correct conceptions. Learning by using the CCM-CCA learning model has made students from the beginning of learning admit that there is a cognitive conflict (disequilibrium) with their initial conceptions. This recognition motivates students to try to resolve conflicts. Demonstrations that have been carried out by educators are very effective in creating cognitive conflicts because they are simple so that students can easily understand the situation and the questions raised by educators related to demonstrations. This situation makes students have the potential for high enthusiasm and motivation to try to solve problems raised by educators and try to reorganize the knowledge they already have. Students are more challenged to prove the truth of new information conveyed by educators through literature study, discussion, and proof through experiments. These results are following the opinion of Makhrus (2018b) which states that the CCM-CCA learning model is effective for making conceptual changes in students from misconceptions to scientific conceptions.

CONCLUSION

Learning using the CCM-CCA has made students acknowledge the existence of cognitive conflict (disequilibrium) with their initial conceptions (on average students experience high cognitive conflict during learning) so that students experience 4 thought processes in conceptual change. The greater the conceptual changes that occur, the greater the possibility of eliminating misconceptions among students. This fact also shows that reducing student misconceptions with conceptual changes requires stimulation of cognitive conflict. Learning with CCM-CCA can link conceptual change and cognitive conflict so that it can reduce misconceptions.

REFERENCES

Arends, R.I. (1997). *Classroom instructional and management*. New York: Mc Graw-Hill Book Companies, Inc.

Aulia, S., Diana, N., & Yuberti. (2018). Analisis Miskonsepsi Siswa Smp Pada Materi Fisika Analysis of Misconception of Junior High School. *Indonesia Journal of Science and Mathematics Education*, 1 (2), 155–161. Doi: https://doi.org/10.24042/ijsme.v1i2.3516

A'yun, Q., Harjito, & Nuswowati, M. (2018). Analisis Miskonsepsi Siswa Menggunakan Tes Diagnostic Multiple Choice Berbantuan CRI (*Certainty Of Response Index*). *Jurnal Inovasi Pendidikan Kimia*, 12 (1), 2108–2117. Doi: https://doi.org/10.15294/jipk.v12i1.13302

Barke, H.D., Al Hazari, & Yitbarek, S. (2009). *Misconceptions in Chemistry. Addressing Perceptions in chemical Education*. Berlin: Springer.

Fariyani, Q., Rusilowati, A., & Sugianto, S. (2017). Four-Tier Diagnostic Test to Identify Misconceptions in Geometrical Optics. *Unnes Science Education Journal*, 6 (3), 1724–1729. Doi: https://doi.org/10.15294/usej.v6i3.20396

Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2015). A review and comparison of diagnostic instruments to identify students' misconceptions in science. *Eurasia Journal of Mathematics, Science and Technology Education*, 11 (5), 989–1008. Doi: https://doi.org/10.12973/eurasia.2015.1369a

Hidayatullah, Z., Jumadi, Nadhiroh, N., Kartika, E., Nuha, A. A., & Erlangga, S. Y. (2020). Identifikasi Miskonsepsi Dan Konflik Kognitif Fisika: Kasus Terkait Perubahan KonseptuaL. *EDUSAINS*, 12 (1), 64–71. Doi: https://Doi.Org/Http://Doi.Org/10.15408/Es.V12i1.13504

Hidayatullah, Z., Makhrus, M., & Gunada, I. W. (2018). Identifikasi Tingkat Konflik Kognitif Materi Gelombang Mekanik Melalui Pembelajaran Dengan Pendekatan Konflik Kognitif. *Konstan - Jurnal Fisika Dan Pendidikan Fisika*, 3 (2), 66–73. Doi: https://Doi.Org/10.20414/Konstan.V3i2.10

Lee, G., Kwon, J., Park, S. S., Kim, J. W., Kwon, H. G., & Park, H. K. (2003). Development Of An Instrument For Measuring Cognitive Conflict In Secondary-Level Science Classes. *Journal Of Research In Science Teaching*, 40 (6), 585–603. Doi: Https://Doi.Org/10.1002/Tea.10099

Lee, G., & Yi, J. (2013). Where Cognitive Conflict Arises From?: The Structure Of Creating Cognitive Conflict. *International Journal Of Science And Mathematics Education*, 11 (3), 601–623. Doi: https://Doi.Org/10.1007/S10763-012-9356-X

Leonard, M. J., Kalinowski, S. T., & Andrews, T. C. (2014). Misconceptions yesterday, today, and tomorrow. *CBE Life Sciences Education*, 13 (2), 179–186. Doi: https://doi.org/10.1187/cbe.13-12-0244

Makhrus, M. (2018a). Peranan Konflik Kognitif Terhadap Perubahan Konseptual Pada Mahasiswa Tentang Konsep Gaya. *Konstan - Jurnal Fisika Dan Pendidikan Fisika*, 3 (1), 1–8. Doi: https://Doi.Org/10.20414/Konstan.V3i1.1

Makhrus, M. (2018b). Validitas Model Pembelajaran Conceptual Change Model With Cognitive Conflict Approach. *Jurnal Ilmiah Profesi Pendidikan*, 3 (1), 62–76. Doi: https://Doi.Org/10.29303/Jipp.Vol3.Iss1.55

Makhrus, M., Nur, M., & Widodo, W. (2014). Model Perubahan Konseptual Dengan Pendekatan Konflik Kognitif (Mpk-Pkk). *Jurnal Pijar Mipa*, *9* (1), 20–25. Doi: https://Doi.Org/10.29303/Jpm.V9i1.39

Moreno, R. (2010). *Educational psychology*. New York: Joh Wiley & Sons Inc.

Nugraeni, D., Jamzuri, J., & Sarwanto, S. (2013). Penyusunan Tes Diagnostik Fisika Materi Listrik Dinamis. *Jurnal Pendidikan Fisika*, 1 (2), 12–16. Retrieved From http://Jurnal.Fkip.Uns.Ac.Id/Index.Php/Pfisika/Article/View/2796

Redhana, I. . W., Sudria, I. B. N., Hidayat, I., & Merta, L. M. (2017). Identification Of Chemistry Learning Problems Viewed From Conceptual Change Model. *Jurnal Pendidikan IPA Indonesia*, 6 (1), 16–22. Doi: https://Doi.Org/10.15294/Jpii.V6i1.9594

Sholihat, F. N., Samsudin, A., & Nugraha, M. G. (2017). Identifikasi Miskonsepsi dan Penyebab Miskonsepsi Siswa Menggunakan Four-Tier Diagnostic Test Pada Sub-Materi Fluida Dinamik: Azas Kontinuitas. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *3* (2), 175–180. Doi: https://doi.org/10.21009/1.03208

Taufiq, M. (2012). Remediasi miskonsepsi mahasiswa calon guru fisika pada konsep gaya melalui penerapan model siklus belajar (Learning cycle) 5E. *Jurnal Pendidikan IPA Indonesia*, 1 (2), 198–203. https://doi.org/10.15294/jpii.v1i2.2139

Tlala, B., Kibirige, I., & Osodo, J. (2014). Investigating Grade 10 Learners' Achievements In Photosynthesis Using Conceptual Change Model. *Journal Of Baltic Science Education*, 13 (2), 155–164. Retrieved From Http://Oaji.Net/Articles/2015/987-1437062876.Pdf