Abstract

**Purpose:** Rules of Engagement (ROE) refer to rules or directives that define the circumstances, conditions, extent, manner, etc. of the application of force or action that can be considered provocative by the armed forces. ROE do not explain how results are achieved, but rather indicate what judgments are unacceptable. Focusing this, the purpose of this study is to propose an Instructional Systems Design (ISD) configured to reflect ethics in AI’s ROE learning for future warfare.

**Method:** This study uses Development Research Method for develop and propose an ISD. ISD refers to the creation of guidelines into smaller units of teaching or learning. If some guidelines are created for such ISD, it would set the composition and application of ROE, and AI will learn that guidelines through deep learning. And the AI makes a decision with this in the hypothetical dilemma situation where the application of the ROE is requested. Finally, human experts review and supplement the learning results of these neural networks. The sophistication of the AI’s learning and applying ROE would be achieved by feeding back this result to the ISD.

**Results:** This study understands that ROE would also be essential for AI or AI-equipped military robot systems. In this process, AI performs the task of making judgments related to applying ROE, which is the principle of action in specific situations. To do this, AI’s deep learning first collects necessary information and makes decisions based on it. Next, the results of this learning are applied in a new hypothetical dilemma situation. Finally, human experts’ evaluation and feedback on the results are continuously made. This series of processes can be presented as a model of ISD oriented towards the moral development of AI.

**Conclusion:** AI’s ROE learning converges to the learning of moral values. It focuses on the cognitive aspect of morality. Therefore, it would be possible to refine the cognitive moral judgment of deep learning by applying the learning hierarchy of taxonomy of educational objects and the logical test of validity of moral judgment oriented toward social justice. And the moral development of the neural network can be performed by modifying and complementing the results of human experts and feeding them back.

**[Keywords]** Artificial Intelligence, Military, Rules of Engagement, Ethics, Instructional Systems Design

1. Introduction

Research on AI in the military domain tends to start by focusing on aspects related to the achievement of military goals or achievements through the use of military capabilities that can be obtained mainly through the application of AI. In particular, given that future wars are developed with an asymmetric and complex character, weight can be given to the Asymmetric, Hybrid, Cyber, and Unrestricted wars among their characteristics[1]. These characteristics of future warfare require consideration of very complex and diverse matters beyond the aspect of traditional warfare in the exercise of military force.
In order to respond to the request of such a complex military situation, attempts are actively being made to utilize a mechanism that allows AI to intervene in the process of making a decision by applying a certain principle to specific matters which are connected to military operations. And these attempts are not limited only to aspects related to the use of military force in a narrow sense, but are being made in a more expansive aspect. Such kinds of research shows the trend well, as examples of a study showing that the United States Department of Defense(DOD)'s considerations related to AI intervention in the military domain that are extended to the military health care sector[2], Resource Management using Smart Operating System in Future War Research that attempts to be utilized in the part of Internet of Things(IoT) and logistics in connection[3], expanding the role of military mobilization forces in the event of a national disaster situation in reserve forces[4], etc.

On the other hand, if the meaning of the Ethics is that establishing and carrying out the principles of action based on moral judgment, these kinds of Ethics could be applied to war as well. At a macro level, this Ethics could be expressed in terms of Ethics in the War or War Ethics. Also at a micro level, it could be called Ethical Rules of Engagement(ROE) as a norm of conduct to be followed in the course of combat situation. From this point of view, the aspect of future war in which AI is utilized could be understood in connection with certain research that requires consideration of the ethical aspect of AI. For example, a study that tries to establish a operation key of Field Action Manual(FAM) that works in Disaster Sites[5] could be viewed as an indirectly suggestive case of AI's ethical intervention, and a study that attempts to approach to moral injury or suffering of soldiers during war[6] implies that AI as a Moral Agent should also be take into account as an object of moral considerations at a certain level.

Based on the above mentioned problem awareness, the things which should be considered in Future War in using AI is the learning of Rule of Engagement(ROE), which AI will ultimately establish and utilize as a principle of judgment and action. This AI's ROE learning is embodied in the Instructional Systems Design(ISD). ISD for AI's ROE learning is shown in <Figure 1>. In here, ISD is to make a plan for the purpose of maintaining the flexibility of AI as a learner and producing an enhanced learning effect. Therefore, it is also aimed at improving the learning efficiency of AI and comprehensively designing a better learning environment for AI.

Figure 1. Instructional systems design for AI's rules of engagement learning.

This study utilized Development Research Method to present a model of ISD. Development research corresponds to original research conducted mainly to acquire new scientific knowledge
for specific practical purposes and goals by using the knowledge obtained through the results of basic research. In other words, it is a research that creates the basics of a new process by applying the knowledge gained through basic research and pioneering new uses. Therefore, development research is research that produces new results using knowledge obtained from basic research, applied research, and practical experience. Development research also includes systematic activities to substantially improve something that is already in operation. Putting these points together, development research is a technological activity that establishes a new process using the results of basic research, applied research, or existing knowledge on the premise of creating new products. In this context, it would be suitable for this study, which intends to present the procedure of ISD, with utilizing Development Research Method.

By applying Development research Method, each step of ISD for AI’s ROE learning would be as follows: First, the recognition of the interrelationship between ROE and AI. This is also to reveal the meaning of ROE for AI that intervenes in judgment and operation in combat situations. Second, the relationship between AI and ROE will lead to a review of matters to be considered in the Deep Learning Mechanism used in the process of learning ROE. Third, the ROE of AI learned in this way will be refined by applying it to a hypothetical dilemma situation that may be encountered in a battle situation. For this elaboration work, it is necessary to apply the Taxonomy of Educational Objectives and the Logical Test of Validity for Social Justice. Fourth, AI’s ROE Neural Network composed of the result of such learning needs to be modified and supplemented through comprehensive judgment that reflects the affective domain that constitutes human moral characteristics. For this purpose, the intervention of Human Ethics Experts and the feedback reflecting the results should be designed to be designed so that multi-layered learning is done repeatedly.

2. Understanding the Relationship between AI & ROE in the Future Warfare

In the future warfare, the function of AI is being performed in various ways. At this time, the role of AI in military decision-making tends to be oriented towards the establishment of Military Decision Making Process (MDMP) that mainly support the execution of operations. The meaning of MDMP is that planning and scheduling the detailed tasks required to accomplish the specified Course of Action (COA), for this MDMP has the characteristics of a standardized abstract principle that serves in case of decision-making is requested. An Integrated Course of Action Critiquing and Elaboration System (ICCES) may be proposed as a method for effectively performing this. ICCES is AI-based prototype tool that helps decision-making in military operations[7]. However, in that ICCES focuses on establishing COA, conversion to ROE through supplementation in ethical aspects is required. COA is closely related to assigning missions or tasks to units by setting up a uniform pattern of actions to achieve an effective goal. However, while ROE refers to a principled and general discipline that has the character of a guideline on the use of force, it also functions as a means of controlling the use of force in policy, operational and legal terms[8].

The meaning of control in the sense of ROE is that sets methodological limits of operations for mission performance. Normally, ROE reflects legal and political concerns in the use of armed force[9]. However, the actual situation in which the military operation is deployed is premised on a very urgent conflict situation. This means that missions must be performed in situations where close communication with high-level decision makers related to military issues is not possible. In this case, in order to prevent military activity from an unintended direction, it is necessary to establish certain control over the subject of the mission that directly uses armed force. These controls encompass not only granting or restricting the authority to use certain weapons or tactics, but also presenting ethical norms related to war.

On the other hand, in the process of assigning a task and performing this task, there is a subject who grants a task and a subject who performs the task. However, the subject performing the task has a kind of autonomy to think and judge for himself in the assigned task and situation.
Therefore, each of these subjects is required to think and judge for themselves, and to act with responsibility and confidence. In terms of performing such a mission, it is necessary to consider the following two points: The first is the autonomy of thinking and judging oneself. This autonomy corresponds to one of the important characteristics of AI in particular. In relation to the situation in which military confrontation is taking place, the recent study related to the use of AI in warfare can be said to be a representative case suggesting points to be considered in this regard[10]. The second is duty and responsibility derived from autonomous judgment. In some points, these responsibilities and obligations are approached from the perspective of professional ethics[11]. However, especially with regard to AI, it needs to be connected with consideration of the ethical aspects of responsibilities and obligations. As a representative example of the recent exploration of the ethical aspects of AI, there is a study that requires an in-depth approach to establish common aims and fiduciary duties in relation to AI because Ethical Principle alone cannot sufficiently guarantee Ethical AI[12]. According to this study, direct efforts related to AI education are requested to create Ethical AI, which has been actively carried out recently, including the case of research that suggested the use of the Virtue Education Method to create Ethical AI as an Artificial Moral Agent(AMA)[13].

In integrating the above discussion, future warfare will establish a COA where AI is actively involved. And this COA is converted to a higher ROE by reflecting consideration of ethical aspects based on responsibility and duty. In this transition process, AI plays a role in strengthening the ethical aspect of ROE by performing the function of processing information and learning to set and achieve ethically-reflective goals. Therefore, AI acts as a mechanism that forms the ethical basis of ROE. The architecture and process are proposed as shown in <Figure 2>.

**Figure 2.** The architecture and process flow of an integrated course of action critiquing and elaboration system(ICCES) and revision / transition of a specific course of action(COA) to rules of engagement(ROE).

3. **AI’s ROE Learning via Deep Learning Mechanism**

AI’s ROE learning can utilize deep learning mechanisms. As mentioned above, ethical aspects need to be reflected in ROE, which has the characteristics of a Deep Neural Network. This is an algorithm that mimics how the human brain recognizes patterns and has a certain level of complexity. Ethical decision-making can be said to be about making a judgment by confirming certain facts, searching for applicable moral principles, and making moral judgments based on this. Then, the hidden layer in the process of ethical decision-making is related to identifying the potential structure of various data related to ethical judgment. This means that various
information required for ethical judgment exists at multiple depths, and different levels of learning must be made for each layer.

These various levels of learning can be embodied as follows. For example, among various conflicting values, the utilitarian principle that judges based on the outcome and the deontological principle that judges based on the motive sometimes cause conflict. At this time, to solve this problem, mechanical application of one principle cannot solve the problem. Therefore, it is necessary to calculate by synthesizing various information necessary to interpret a given situation and various considerations necessary to apply certain ethical principles in a given situation. And in this process, by assigning weights related to specific situations to each ethical principle, the validity can be increased in solving the problem.

Such ethical decision-making requires consideration of two aspects: a given situation and an ethical principle. And this ethical decision-making does not exist alone, but develops while forming a certain correlation with the achievement of the goal of victory in battle. Therefore, ROE learning of AI is embodied in the form of learning of various non-linear relationships including multiple hidden layers. This is in the form of a deep neural network in that it includes multiple hidden layers that exist between the input layer and the output layer, and can be achieved by using deep learning’s policy network learning. These learning of polity networks can be understood by being divided into the following two aspects.

3.1. ROE learning by supervised learning of policy networks

ROE Learning by supervised learning of policy networks is connected in following two stages:

First, let the AI learn certain moral principles. This corresponds to learning a roll out policy network. There may be a method of enacting ethical principles such as the constitution applied to AI from a human point of view and guiding them to AI, or a method of guiding AI with ethical principles that exist today from a moral philosophy point of view may be used. Whatever method is chosen, it can be understood from the point of view of moral socialization in terms of moral education. Moral socialization aims to actively transmit moral values to actors so that they act in a certain direction consistent with the norms or ideals of a community. This is equivalent to learning the ethical principles that are the basis of judgment in ROE learning of AI.

Next, after learning these ethical principles, supervised learning using existing big data is made for the ethical dilemma situation, the decisions made and the results so that the optimal judgment can be made. This can be seen as supervised learning in a rather narrow sense. At this time, the source of such big data corresponds to the utilization of various data including war history that exists for various decisions made in military operational situations and the results thereof. This is to imitate human thinking to make a decision in relation to the actual application of ROE, thereby increasing the ability to predict the outcome.

3.2. ROE learning by reinforced learning of policy networks

In here, It can be said that learning is carried out to apply the principles established in the upper stage to the reality of the lower stage performing individual tasks. This can be said to enhance the performance of the policy network through supervised learning through actual practice, and it is to overcome the limitation of being optimized only for established principles. In this process, AI can create and participate in War Game Simulation to directly create a model reflecting ethical decision-making and make judgments about it.

ROE Learning by reinforced learning of policy networks reflecting the ethical aspect is an international standard interworking that enables the interworking of military war game simulation models, and can be achieved through design and introduction of Parallel Simulation Engine while having a High Level Architecture structure[14]. This can be specified from the design stage of the scenario through a different set of reaction based on it, which has the characteristic that it can be used as a material for learning military ethics[15]. In this process, each choice of AI carries a reward, and the list of options they made would be listed and rated against the different factors including ethical aspects that determined its payoff.
The learning of the policy network as described above can be viewed as having the following three advantages in ethical judgment. The first is the ability to self-learn important characteristics from a low level to a high level. Second, when a new ethical problem arises, it is possible to identify and learn characteristics on its own. Third, there is an appropriate interaction with the intervention of an ethics expert. This means leveraging expert intervention, but maintaining some level of balance in the sense that it doesn't mean that the expert must identify a feature and input its variables every time.

4. Applying AI’s ROE Learning Results to Hypothetical Dilemma Situation

The learning of the policy network as described above is connected to the reinforced learning of the value network in Deep Learning. Reinforcement learning of the value chain is a method of assigning weights based on data accumulated through one's own matches to proceed with the next match, and corresponds to the stage of reinforcing the prediction of results. Learning through this policy network can be applied through a hypothetical dilemma situation. This hypothetical dilemma situation allows us to predict and anticipate real life aspects so that we can focus on issues on moral stage and moral orientation[16]. In addition, the hypothetical dilemma situation works as a mechanism for adopting the role of making decisions by directly participating in non-linear decisions that cannot be calculated through calculating[17]. Having the opportunity to adopt these roles functions as an important factor in self-sustaining moral development[18]. Together with the effect of direct instruction of moral principles, these cases are also partially confirmed through discussions about the results that can be achieved in moral development by participating in the moral dilemma discussion[19]. Hence, this hypothetical dilemma is mainly used in the cognitive development theory of morality.

At this time, it can be said that the criterion for weighting in ROE learning of AI is a part related to the cognitive aspect of morality. In relation to human ethical judgment, the part related to moral development starts from the aspect of cognitive judgment. This is embodied through the theory of cognitive development on morality, which means understanding and analyzing moral development as a step-by-step deepening of cognitive judgment. Approaching AI’s ROE Learning in this cognitive aspect has an advantage in that it can apply various research results of cognitive development theory. On the other hand, understanding human cognitive development in direct contrast with that of AI may be viewed as somewhat less plausible from an epistemological point of view because structural differences exist. Therefore, rather than trying to approach it from the perspective of developmental psychology, it is judged that it is more appropriate to evaluate AI learning by applying the criteria related to the evaluation of values and goal setting methods in the educational aspect related to human learning. Therefore, for the aspect related to goal setting, the Taxonomy of Educational Objectives of education theory and the Logical Test of Validity for Social Justice can be used for value evaluation.

4.1. Utilizing the taxonomy of educational objectives

The meaning of the Taxonomy of Educational Objectives is that systematically categorize and categorize the goals of education. This taxonomy serves the function of making it easier to understand systematic assessments surrounding the entire domain of cognitive processes. This Taxonomy is originally created by Benjamin Bloom for categorize the levels of reasoning skills required in classroom situations, and there are six levels which requires a higher level of abstraction from the students[20]. However, it is appropriate to understand this taxonomy as meaning a classification constructed according to a set of principles rather than a strict structure[21]. The classification of this cognitive domain consists of six cognitive levels based on a series of basic principles. In particular, the classification in the cognitive domain has been revised as follows[22]. As these contents are summarized, it can be presented as <Table 1>.
contents can be presented in combination with Factual, Conceptual, Procedural, and Metacognitive factors if it is needed.

Table 1. Measurement tools and the questions’ structure with taxonomy model in the cognitive process dimension.

<table>
<thead>
<tr>
<th>Bloom’s taxonomy</th>
<th>The Revised taxonomy</th>
<th>Meaning</th>
<th>Dimensions of sub categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Remember</td>
<td>Retrieving relevant knowledge from long-term memory</td>
<td>1.1 Recognizing 1.2 Recalling</td>
</tr>
<tr>
<td>Comprehension</td>
<td>Understand</td>
<td>Determining the meaning of instructional messages, including oral, written, and graphic communication</td>
<td>2.1 Interpreting 2.2 Exemplifying 2.3 Classifying 2.4 Summarizing 2.5 Inferring 2.6 Comparing 2.7 Explaining</td>
</tr>
<tr>
<td>Application</td>
<td>Apply</td>
<td>Carrying out or using a procedure in a given situation</td>
<td>3.1 Executing 3.2 Implementing</td>
</tr>
<tr>
<td>Analysis</td>
<td>Analyze</td>
<td>Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose</td>
<td>4.1 Differentiating 4.2 Organizing 4.3 Attributing</td>
</tr>
<tr>
<td>Synthesis</td>
<td>Evaluate</td>
<td>Making judgments based on criteria and standards</td>
<td>5.1 Checking 5.2 Critiquing</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Create</td>
<td>Putting elements together to form a novel, coherent whole or make an original product.</td>
<td>6.1 Generating 6.2 Planning 6.3 Producing</td>
</tr>
</tbody>
</table>

This taxonomy evaluates the level of cognitive judgment made by AI in a hypothetical dilemma situation, and plays a role of guiding it to make higher-level judgments. If moral development is an activity oriented toward a higher cognitive level, performing higher-level judgments means that moral development has been achieved. If this perspective is applied to AI’s ROE learning, it will be possible to make reinforcement learning of the value chain so that AI can perform higher-level moral judgments while considering various factors as well as simply in terms of results.

4.2. Verifying through logical test of validity for social justice

As mentioned above, if the ethical aspect must be considered in the ROE learning of AI, the consideration of the ethical aspect is characterized not only by personal judgment, but also in the context of social justice. Some attributes have been identified as defining social justice which is Equality, Reciprocity, Benevolence, Liberty, etc [23]. And it is needed that the treatment of such principles as principles that are distinct from the expectations and rules of AI’s ROE Learning. On the other hand, these factors are the basis of a cognitive and rational approach to understanding values. And this understanding of value performs the function of justifying it by presenting rational and valid reasons related to moral judgment.

This value analysis is understood in terms of two aspects: the value criteria applied to the context of making a value decision, and the value principle that results from that decision. In this context, a number of different value criteria can be applied to a single value judgment. Certain criteria and conditions exist for such rational value analysis. This means that the meaningful facts supporting a judgment must be true or well verifiable, that the facts must be appropriate to be true and be meaningful for the subject making the actual judgment, other things being equal. The larger the range of facts involved, the more appropriate, and the value principle implied in the judgment must be acceptable to the subject making the judgment. The procedure and conflict resolution for the rational value analysis task made based on this are to review and defend the logic and legitimacy of the value. This makes it possible to provide sufficient reasons through scientific method for a value selected by a subject, and at the same time to apply an
analytical process in the process of making a value-related decision[24]. Based on this, the procedure for the rational value analysis task is presented as shown in <Table 2>.

Table 2. Procedures for rational value analysis task and conflict resolution related to value analysis.

<table>
<thead>
<tr>
<th>Procedures for rational value analysis task</th>
<th>Procedures for conflict resolution related to value analysis</th>
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<tbody>
<tr>
<td>Identifying and clarifying the value question</td>
<td>Seeking common ground for acceptable interpretations of value questions, seeking common consensus on values and morality</td>
</tr>
<tr>
<td>Assembling purported facts</td>
<td>Reducing differences between meaningful facts gathered through the distinction between fact and value</td>
</tr>
<tr>
<td>Assembling the truth of purported facts - Particular facts</td>
<td>Understanding the differences between causation and correlation between events and reaching consensus on the standards of evidence to support the facts</td>
</tr>
<tr>
<td>- General facts</td>
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<tr>
<td>- Conditional facts</td>
<td></td>
</tr>
<tr>
<td>Clarifying the relevance of facts</td>
<td>Reducing differences in the relevance of facts, taking into account differences that arise between diverse political, economic and cultural positions on a phenomenon</td>
</tr>
<tr>
<td>Arriving at a tentative value decision</td>
<td>Reducing differences in provisional value determinations, isolating various factors related to inconsistencies in value determinations resulting from differences in characteristics or terminology</td>
</tr>
<tr>
<td>Testing the value principles implied in the decision - New case test</td>
<td>Reducing differences in tests of acceptability of value principles, taking into account new cases, new roles, and new consequences of value judgments</td>
</tr>
<tr>
<td>- Subsumption test</td>
<td></td>
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<tr>
<td>- Role exchange test</td>
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<tr>
<td>- Universal consequences test</td>
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</table>

If the above procedures are interpreted in direct connection with the aspect of AI’s ROE learning, it is, on the one hand, to analyze the cognitive aspect of morality and, on the other hand, to suggest the direction of the development of morality. These procedures act as a reference and play an evaluating role for AI learning. This analysis is especially analyzed in connection with Kohlberg’s Moral Development Stage[25], and it is also a factor in the investigation of morality in AI[26]. This value analysis was developed to solve a position that requires a choice in relation to public policy or social value, and it can be evaluated as useful in solving problems caused by the relativistic nature of values or excessive autonomy. However, this model of value analysis has a problem in that it does not deal with the emotional aspects of moral issues as a logical and cognitive approach to values. This part needs to be addressed through the complementation of Human Ethics Experts.

5. Conclusion: Complementing AI’s ROE Neural Network with Human Ethics Experts

A study that predicted the aspects of future wars operated by AI predicts that future wars will show the following three trends: the acceleration of multi-domain battle, the generalization of cognitive-centered operations, and the Acceleration of Human-machine Fusion and increased ambiguity of blurring distinction between combatants and non-combatants. And The Regulation of the Use of Artificial Intelligence in Warfare needs to be approached in terms of laws that guarantee human rights and meaningful human control over them[27]. What we can pay attention to in this aspect is that military operations are conducted with a focus on the cognitive aspect. This means that, while AI has a certain level of access to the cognitive part of the human internal thinking process, a sufficient level of access to the part related to the comprehensive judgment that reflects the emotional part has not yet been made. will be. If so, it is concluded that it is necessary to take an approach, especially from a standard point of view, when the Human Ethics Experts approach this part. In particular, the case[28], where an emotional aspect is requested in education using AI tools, shows these characteristics.
The approach to perform correction by reflecting the emotional aspect in AI's ROE learning is an attempt to solve problems that may occur when cognitive results are linked to immediate actions. This starts from acknowledging that there are cases where conclusions that can be analyzed as cognitively valid in relation to moral decision-making often do not coincide with human moral sense. This also means that, in morality, cognitive and emotional elements can be distinguished, but cannot be separated. If that is the case, it can be analyzed that the emotional factor not being dealt with in AI learning is inherently error-prone. This kind of issues are being raised sensitively now, especially that AI as an Artificial Moral Agents (AMA) gain capacity to do things that are harmful to humans and other sentient beings [29], like military warfare.

Resolving these problems requires that the ability of AI to consider ethical considerations should be expanded in proportion to its ability to perform its tasks. This expansion needs to be extended not only in the cognitive aspect, but also in the moral sentiment possessed by humans. And it is expected that the formation of this ability can be achieved through AI's deep learning that follows the mechanism of moral development and human learning about morality in AI's behavioral norm learning [30]. In particular, the formation of ethical norms of AI related to combat situations can be linked to learning the emotional aspects of humans through the process of being corrected by human experts. And This will be feed back to the Deep Learning Mechanism and need to be continuously developed through refinement work.

6. References

6.1. Journal articles


7. Appendix

7.1. Authors contribution

<table>
<thead>
<tr>
<th>Initial name</th>
<th>Contribution</th>
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<tr>
<td>HK</td>
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<tr>
<td></td>
<td>- Set of concepts ☑</td>
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<tr>
<td></td>
<td>- Design ☑</td>
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<td></td>
<td>- Getting results ☑</td>
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<td>- Analysis ☑</td>
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<td>- Make a significant contribution to collection ☑</td>
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<td>- Final approval of the paper ☑</td>
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<td></td>
<td>- Corresponding ☑</td>
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<td></td>
<td>- Play a decisive role in modification ☑</td>
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<td></td>
<td>- Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑</td>
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<td>- Participants in Drafting and Revising Papers ☑</td>
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<td>- Someone who can explain all aspects of the paper ☑</td>
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7.2. Funding agency

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