

Education and Training to the Mariner of the Maritime Autonomous Surface Ships (MASS) Era

Yoshiaki Kunieda¹, Asami Shimada², Hideyuki Kashima¹, Koji Murai¹

(1. Tokyo University of Marine Science and Technology, Japan;

2. Japan Agency of Maritime Education and Training for Seafarers, Japan)

Abstract: Research of the Maritime Autonomous Surface Ships (MASS) is conducted in various places in the world. Understanding the site of the ship that sails on the sea is important for the mariner who manages and operates the MASS. Moreover, the mariner is required to respond according to a situation. To master these aspects, deep and active education and training are required. The proposed GTGP (Groupwork-Training-Groupwork-Presentation) training model is effective and using this training students can think deeply and actively. Because of conducting anchoring training according to the GTGP training model, the effect of the model on students and instructors can be shown via the following comments:

(1) Students can think more deeply by conducting dialog, discussion, and peer-learning in a group.

(2) At briefing, adequate understanding is required for the role of a captain and is effective in arranging and fixing of knowledge.

(3) Actual ship training is optimal to learn the site of sailing at sea.

(4) Debriefing in a group is the most effective in improving knowledge and technology.

(5) A presentation becomes the arrangement of knowledge and the origin of many notices

Key words: virtual reality, education, special-needs education, augmented reality

1. Introduction

Autonomous ship technology is a hot topic in the current discussion about more efficient, environmentally friendly, and safer sea transportation solutions. In the Maritime Safety Committee of June 2017, The International Maritime Organization (IMO) included Marine Autonomous Surface Ships (MASS) on its agenda (IMO, n.d.), highlighting the increasing importance of the topic in the field. Although the future of maritime industry will see an increased use of autonomous solutions, the idea of autonomous ships is not new. In fact, automatic surface vessels have existed for decades. Fully automatic vessels using dynamic positioning became common in the offshore industry in the 1970s, and the use of autonomous cargo ships in Japan was studied and put to practice in

Yoshiaki Kunieda, Ph.D., Professor, Tokyo University of Marine Science and Technology; research areas: maritime education and training. E-mail: ykunie0@kaiyodai.ac.jp.

Asami Shimada, Bachelor, Lecturer, Japan Agency of Maritime Education and Training for Seafarers; research areas: maritime education and training.

Hideyuki Kashima, Professor, Tokyo University of Marine Science and Technology; research areas: maritime education and training.

Koji Murai, Ph.D., Professor, Tokyo University of Marine Science and Technology; research areas: human factor.

the 1980s. Today, fully autonomous Unmanned Surface Vessels are widely used in ocean research, by the coast guard, and for military purposes.

The safety aspect of autonomous technology will be the most interesting and important development to study, both for its negative and positive implications. Arguably, the goal is to improve the safety of an unmanned ship, so it is safer than that of a manned ship. However, the introduction of MASS does not mean that there will be less of a human element present in the navigation process as Ahenjarvi (2016) argues:

(1) The human element plays a major role in the software development phase of MASS.

(2) The role of the human element in the remote-control center of the MASS is similar to the role it has on the bridge of a manned ship.

(3) The positive side of the human element is human creativeness and the ability to adapt to unforeseen and surprising situations.

Relling et al. (2018). argue for a systemic approach to safety using a holistic perspective: where safety is an emergent property of the system and human performance variability is essential for improving safety. Moreover, they discuss the importance of defining responsibility, authority, and control from the perspective of humans rather than that of the vessel.

Under the request of the International Chamber of Shipping (ICS), the Hamburg School of Business Administration (2018) conducted the following investigation: “Seafarers and digital disruption — The effect of autonomous ships on the work at sea, the role of seafarers and the shipping industry”. The document states the following:

- 1) Digital transformation will be a seamless process rather than a disruptive one.
- 2) There will be no shortage of jobs for seafarers in the foreseeable future.
- 3) There will be considerable additional jobs ashore.
- 4) There will be significant training needs.

Since the shore-based control of a ship requires new safety considerations, an interesting question emerges regarding the interaction of manned and unmanned ships in the same traffic area. MASS technology should therefore be mandatory in the training of seafarers.

In the present paper, a mariner is defined as any individual engaged in the maritime industry in the era of MASS, including, but not limited to, the seafarers onboard engaged in an array of jobs, the land staff supporting vessel operation, and the license owner who carries out the remote control. By this definition, a mariner in the MASS era is thus required to not only know the site where the vessel sails at sea but also know how to make the right judgment calmly and quickly in an unexpected situation. In order to do so, it needs education and training for the mariner oneself to think deeply and actively. This study aims to investigate the efficacy of the Groupwork-Training-Groupwork-Presentation (GTGP) training model in regard to anchoring training specifically.

2. The GTGP Training Model

The GTGP training model (see Figure 1) is one which incorporates group work both before and after actual ship training and concludes with a presentation.

(1) Group work consists of dialog and discussion within the team before actual ship training. In the context of anchoring training, this corresponds to group work prior to ship-handling planning. Trainees plan ship handling for anchoring and exchange opinions in groups of four members. The trainee assigned the role of the captain leads

the group by drawing up a ship-handling plan. The other trainees then express their opinions and ideas freely to contribute to the creation of the ship-handling plan. The trainees are asked to express their opinion from the point of view of their assigned role, as well as comment on the roles of others. In addition, trainees are encouraged to express opinions from completely different viewpoint. The trainee assigned the role of the captain can then perform a briefing and explain the ship-handling plan to the team members, followed by a clarification of the division of roles.

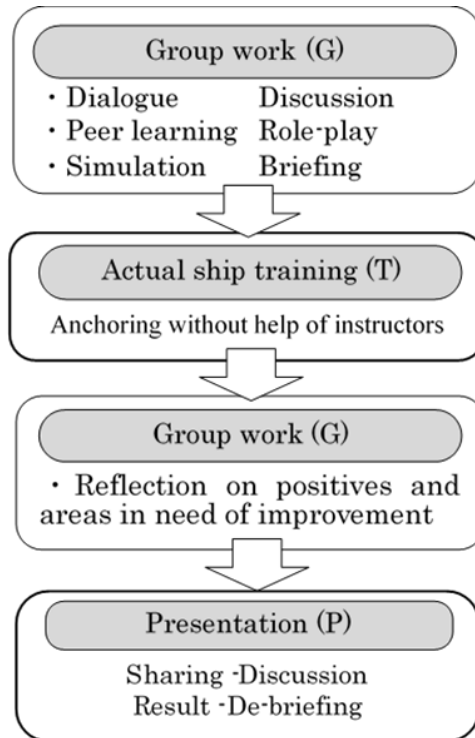


Figure 1 Composition of Anchoring Training

Yoshida (2004a, 2004b, 2004c) studied the effects of group work using free description, and the findings from the studies found group work to have a positive effect. Moreover, Nishiki (2017) found that the dialog in group work created more deep thinking about a subject.

Although trainees receive advice from an instructor as part of group work, they draw up a plan themselves actively. In the actual ship training following group work, trainees carry out their training according to the plan which they themselves drew up. Kunieda et al. (2018) reported that the planning of the anchoring training which trainees perform independently promotes their active thinking.

(2) Actual ship training is carried out exclusively by the trainees according to their plan created in the first phase, from ordering picking up anchor to anchoring and dismissing the station. Since it is a training performed on an actual ship out at sea, the necessity to react to phenomenon besides those mentioned in the plan can arise. This can include the existence of other vessels and fishing boats, as well as the influence of the wind and current. Trainees need to make quick judgments in each specific situation to both avoid collision and grounding and to anchor safely in the planned anchorage.

(3) The second round of group work gives trainees the opportunity to reflect on their actual ship training and discuss what worked and what needs improvement. Trainees can cultivate their understanding through dialog and

hear other trainees' perspectives on what worked and what requires improvement. The effects of reflection have been studied extensively by Goto et al. (2009) and others (Murakawa et al., 2013; Oshima et al., 2007), and their findings can be summarized as follows:

1) Reflection can both confirm and strengthen good points (i.e., what works).

2) Reflection can help better grasp what requires improvement, as well as the consideration of adequate measures.

3) Reflection can improve the motivation to learn.

By carrying out reflection in a group setting, trainees can notice what they could not alone. By this process of dialog and discussion, trainees can thus notice new things and create new ideas. Moreover, trainees can recognize their own role and teamwork clearly, as well as obtain a sense of security. By considering what requires improvement and the adequate measures that need to be taken to implement them, new ideas can be created and trainees' creativity can also improve.

(4) The presentation requires trainees to summarize the results of their reflection in group work as a presentation to all the other trainees. In preparing the presentation, the aim is for trainees to deepen their understanding of the purpose and contents of the training. According to Miyachi's findings (1998) about the effects of presentation (Mori, 2017; Arai et al., 2014), presentations can be seen as another form of group work as trainees can improve their knowledge by listening to the presentations of others. Furthermore, when instructors summarize trainees' presentations and advise on any possible additions, the trainees are given another opportunity to learn new knowledge and skills.

The GTGP training model can thus give trainees the opportunity to better understand the site of ship handling effectively, to learn in an active and in-depth fashion, and to practice quick thinking and making the right decisions.

3. Anchoring Training

The anchoring training using the GTGP training model was conducted as follows:

3.1 Planning the Ship-Handling Plan (Group Work)

An instructor issued trainees with prior information before the actual ship training, including good targets on land and points to be careful of. Trainees then drew up a ship-handling plan by considering nautical charts and other publications. Trainees then showed their ship-handling plan to the instructors using nautical charts in order to receive more advice and make any appropriate changes. The trainee assigned the role of the captain then explained the corrected ship-handling plan to both team members and instructors. This was followed by instructors explaining the main points and notes of ship handling. In this way, all team members were given the opportunity to participate actively by explaining a ship-handling plan and to think more deeply about the matter.

3.2 Actual Ship Training

As part of actual ship training, trainees had to pass the training ship through predetermined way points to a planned anchorage in order to practice using sternway, stopping the speed of a ship, and to anchor. The trainee who assigned the role of the captain leads and it carries out only by trainees until he dismisses the anchoring station after anchoring. Only when there was a danger of collision or grounding did an instructor step in to advise the trainee acting as captain. Since this part of training is carried out exclusively by trainees, a considerable

responsibility is required as trainees have to think for themselves.

3.3 Reflection (Group Work)

After anchoring training, trainees discussed as a group what aspects worked and what required improvement. Some issues discussed included: How was this performance result different to prior ship-handling plans? What is the cause? And how was the response to this difference? What was the response to any phenomena which they didn't consider in a prior plan? Was the response to a fishing boat suitable? Was the response to the other vessels suitable? Was the response to a wind and tidal current appropriate? The result examined within the group from various angles is released. Exchange of opinions is carried out within a group, and an improvement proposal is made.

3.4 Presentation

The trainee assigned the role of the captain presented a summary of the last group session regarding what aspects of the actual ship training worked and what required improvement that were discussed in the final group work session. The other trainees also gave similar presentations. The good points in the actual ship training were introduced to everyone, and trainees presented the points which should be improved. These good points and improving points lead to improvement in trainees' knowledge and skill, and their ship-handling will be improved. Finally, instructors presented their comments and further instructions about the ship-handling results.

4. Evaluation of Training According to Trainees' Comments

Trainees' comments were collected at the end of the whole anchoring training. We classified trainees' comments into the following five kinds.:

- (1) Contents about prior group work
- (2) Contents about actual ship training
- (3) Contents about the group work of reflection
- (4) Contents about a presentation
- (5) Contents other than the above, and contents about the whole

The following procedures were used to analyze trainee comments:

- ① The text document of the comment
- ② The main opinion in a text
- ③ Other opinions besides ② in a text
- ④ The factor of each opinion
- ⑤ Evaluation obtained from each opinion and factor including other text documents

Table 1 Contents About Prior Group Work (Extract)

① The text document of the comment	② The main opinion in a text	③ Other opinions besides ② in a text	④ The factor of each opinion
A ship-handling plan, team dialog, a briefing, debriefing, and I got to know their importance	· An understanding about the importance of dialog in a team (importance of debriefing as reflection)	· The effect of prior preparation and reflection in group work · Effect of a plan explanation and opinion exchange	· Promotion of an understanding of ship handling through dialog, · Providing awareness · An understanding of reflection · Recognition of the effect of preparation

Education and Training to the Mariner of the Maritime Autonomous Surface Ships (MASS) Era

			<ul style="list-style-type: none"> · Reflection on insufficient preparation · The plan drawn up by students · Promotion of understanding through an exchange of opinions
⑤ Evaluation obtained from each opinion and factor including other text documents	<ul style="list-style-type: none"> · The positive effects of group work (a dialog, a discussion, an explanation, questions and answers, etc.) · An understanding of the importance of advance preparations (plan) · The positive effects of active participation · The positive effects of a briefing · The positive effects of a pre-meeting 		

Table 2 Contents About Actual Ship Training (Extract)

① The text document of the comment	② The main opinion in a text	③ Other opinions besides ② in a text	④ The factor of each opinion
Since only trainees operated the training ship, I thought strongly that I will carry out this improvement to the good portion and the bad portion.	<ul style="list-style-type: none"> · The beneficial effects of actual ship training which trainees conduct actively 	<ul style="list-style-type: none"> · The effects of improvement through reflection after being on an actual ship 	<ul style="list-style-type: none"> · Motivation, responsibility, and feeling of tension, etc. which arises when trainees carry out the plan actively
⑤ Evaluation obtained from each opinion and factor including other text documents	<ul style="list-style-type: none"> · The positive effects of training when trainees can actively perform the required tasks · The positive effects of practicing on an actual ship (a feeling of tension, responsibility, etc.) · The positive effect of improvement 		

Table 3 Contents About Group Work of Reflection (Extract)

① The text document of the comment	② The main opinion in a text	③ Other opinions besides ② in a text	④ The factor of each opinion
After the end of actual ship training, when I carried out reflection, I found what worked and what needed improvement. Although I was not able to think calmly in the midst of actual ship training, given a time for reflection I could think calmly and have more awareness	<ul style="list-style-type: none"> · The effect of reexamination through reflection 	<ul style="list-style-type: none"> · Importance of thinking calmly 	<ul style="list-style-type: none"> · Thinking by reflection · Awareness by reflection · The dialog and the discussion in a group
⑤ Evaluation obtained from each opinion and factor including other text documents	<ul style="list-style-type: none"> · The effect of awareness through reflection · The positive effects of group work (awareness, promotion of understanding, etc.) · Expectation of improvement through reflection 		

Table 4 Contents About A Presentation (Extract)

① The text document of the comment	② The main opinion in a text	③ Other opinions besides ② in a text	④ The factor of each opinion
Listening to the presentation of others, I thought that what needed improvement was the same as the other trainees. On the other hand, I thought that I could harness this in the next ship handling since I had obtained a new awareness	<ul style="list-style-type: none"> · Leading to an improvement through others' presentations 	<ul style="list-style-type: none"> · Ability to recognize similar points of improvement and new awareness 	<ul style="list-style-type: none"> · Listening to presentations · Thinking of improvement · Motivation for improvement
⑤ Evaluation obtained from each opinion and factor including other text documents	<ul style="list-style-type: none"> · The effect of improvement through presentations · The effect of awareness through presentations · The effect of presentations in motivation to improve 		

Table 5 Contents Other Than the Above, and Contents About the Whole (Extract)

① The text document of the comment	② The main opinion in a text	③ Other opinions besides ② in a text	④ The factor of each opinion
I was able to confirm the importance of a plan and the importance of reflection. Surely, this training has realized the ideal PDCA cycle, and I think that the work of the Captain and the officer's truth was able to be known	· The whole training consists of a PDCA cycle and it is effective training	· Being able to understand the importance of plan and reflection in the PDCA cycle	· Things that were felt by trainees in the whole training · An understanding of the effect of a PDCA cycle · The active group work of only the student in the planning and the reflection
⑤ Evaluation obtained from each opinion and factor including other text documents	<ul style="list-style-type: none"> · The whole training contained an effective PDCA cycle · The positive effect of experience on an actual ship and practical business · Effective training which emphasizes the importance of planning and reflection 		

5. Consideration

From trainees' comments in each step of the training model, as well as comments taken from the training as a whole, the evaluation of the training was considered as follows.

Trainees understood the importance of prior planning well by carrying out the actual ship training. Where prior preparations were made, trainees were able to do well and vice versa. As for the group work in prior planning, the findings show that trainees' understanding was promoted through dialog and discussion. Since a motivation improves when trainees draw up a plan actively, we think that trainees' understanding will lead to promotion. Moreover, since trainees get awareness when instructors give suitable advice, we think that trainees' understanding promotes. Furthermore, the opportunity for trainees to explain the drawn-up plan to instructors and team members also improved trainees' understanding.

In actual ship training where the anchoring was carried out only by trainees, the trainees were found to think earnestly and fulfil their duties. This process was found to improve trainees' knowledge and skill vastly and lead to greater confidence. Although it was a small training ship of about 50 meters in length, it still helped develop a feeling in the trainees of responsibility, tension, and finally a sense of fulfilment after the execution of this stage. Moreover, training in an actual ship allows for encounters with other unexpected boats and obstacles, as well as the influence of the wind and current, and requires trainees to respond accordingly. The trainees thus recognized the necessity for clear judgment for each situation, especially since they were thinking for themselves and acting on their own judgments.

In the reflection group work after training, each one of the trainees was found to grasp the present condition of their own knowledge and skill through reflection. Trainees were found to obtain a new awareness through both individual reflection and dialog in a group. By discussing what worked and what required improvement, the former was strengthened, and the latter is achieved.

When the trainee assigned the role of the captain was able to explain their thinking to the other trainees, this allowed for a greater understanding of their own ship handling, including the possibility to think about any possible improvements. Trainees were found to either obtain a new awareness by listening to presentations or were impressed when the contents of the presentation matched their own conclusions. Moreover, the trainees' motivation to improve was found to increase after performing a presentation.

As for the training as a whole, the GTGP model was expected to have the same effect as a PDCA cycle. This model was used to create effective training where trainees can experience the practical business of an actual ship as part of their whole training. Prior planning and reflection were especially found to be effective steps in the training because of the opportunity to correct knowledge and skills. For trainees in leadership roles, the effect of group work was found to be larger. Groups that had active dialogs were found to reflect more and vice versa. For this reason, the authors of this paper recommend that a teaching assistant be enlisted to help achieve more active dialogs in group work.

As for the instructors' comments, they were more likely to mention the GTGP training model, although no comments were made regarding the presentation phase of the model. The following are the main contents of instructor's comments:

- In prior ship-handling plan creation, trainees discuss it over many hours late into the night, they are drawing up the plan hard, I think that it has a good effect on the acquisition of knowledge and skills.
- Trainees have been able to draw up the general plan themselves. However, since a situation changes in practice, they should consider their response according to specific situations. I think that trainees were insufficiently prepared in this respect.
- It is the first time that almost all the trainees anchor by themselves. They were fairly tense, but I think that they were able to tackle the task earnestly.
- It is necessary to have more active group work.

Instructors were comment good about a GTGP training model, although there was no comment about a presentation. Especially they had described the good training effect of the group work performed before and after the actual ship training.

6. Summary

Although knowledge about artificial intelligence will become indispensable in the MASS, this will not suffice by itself. Mariners will still require to know the site of a ship, to think for themselves, and to apply the right judgment quickly according to the situation at the time. In performing management on land of MASS, and remote control, such capability is needed for Mariners. To effectively improve such capabilities, the present paper focused on the GTGP training model to meet these requirements. By combining actual ship training, group work, and a presentation, the GTGP training model gives trainees the opportunity to think for themselves and was found suitable in improving trainees' capabilities. The present paper highlighted the effects of the GTGP training using anchoring training as an example, but the authors believe that this training model is applicable to other maritime education and training. We aim at the personnel training which masters A.I. rather than were used for A.I. by this training model. The aim of future research in this topic is in improvement and its application to other education and training.

Acknowledgment

Profound gratitude is expressed to the students who cooperated with the investigation of this research.

References

- Ahvenjärvi S. (2016). “The human element and autonomous ships”, *International Journal on Marine Navigation and Safety of SEA Transportation*, Vol. 10, No. 3, pp. 517–521.
- Arai H., Yamamoto H., Wakita K. and Itoh H. (2014). “A study to improve level of understanding through presentation”, *Report of Chiba Institute of Technology*, Vol. 61, pp. 45–52.
- Goto M., Tsuda T., Yokoyama K., Nakai K., Yokoya S. and Takemura Y. (2009). “Educational effectiveness of early clinical exposure with reflection: The 1-year early clinical exposure for education in professionalism”, *Medical Education*, Vol. 40, No. 1, pp. 1–8.
- Hamburg School of Business Administration (2018). “Seafarers and digital disruption — The effect of autonomous ships on the work at sea, the role of seafarers and the shipping industry”.
- IMO. 98th session, available online at: <https://docs.imo.org/Category.aspx?cid=49&session=98>.
- Kunieda Y., Murai K. and Kashima H. (2018). “Study on education of seamanship in the anchoring training”, in: *Proceedings of the International Association of Institutes of Navigation 16th World Congress*, pp. 77–82.
- Miyaji I. (1998). “Learning effect of reading English on computer science by presentation style”, *Journal of Japan Society of Educational Information*, Vol. 15, No. 2, pp. 21–32.
- Mori S. (2017). “The effect of oral presentation on EFL learners’ improvement of English four skills: Research reports of Fukui Technical College”, *Humanities and Social Sciences*, Vol. 51, pp. 19–46.
- Murakawa H., Shirouzu H. and Suzuki K. (2013). “The effect of reflection of strategy in a game for motivation — An example of card game type learning materials math speed”, *Journal of Japan Society of Educational Technology*, Vol. 37, pp. 109–112.
- Nishiki E. (2017). “The effect of conversation activities with ‘run Melos!’ — Achieving classes with conversational and deep learning”, *Bulletin of the Graduate School of education Hiroshima University*, Vol. 7, pp. 161–167.
- Oshima Y., Sano Y., Tamura Y. and Muramatsu S. (2007). “Effects of the experiences at the marine sports practice on the students: To deepen their experiences through written reflection”, *Journal of the Tokyo University of Marine Science and Technology*, Vol. 3, pp. 51–60.
- Relling T., Lützhöft M., Ostnes R. and Hildre H. P. (2018). “A human perspective on maritime autonomy”, in: *International Conference on Augmented Cognition*, pp. 350–362.
- Yoshida M. (2004). “The effect of group work in the post-training for student-teacher (1)”, *Bulletin of Center for Educational Research and Training Faculty of Education Kumamoto*, Vol. 21, pp. 103–112.
- Yoshida M. (2004). “The effect of group work in the post-training for student-teacher (2)”, *Bulletin of Center for Educational Research and Training Faculty of Education Kumamoto*, No. 53, pp. 65–74.
- Yoshida M. (2005). “The effect of group work in the post-training for student-teacher (3)”, *Bulletin of Center for Educational Research and Training Faculty of Education Kumamoto*, Vol. 22, pp. 91–99.