In track maintenance work, driving and other accidents related to human errors occur at a certain rate every year. Since work involving maintenance vehicles in particular has a high probability of leading to serious accidents such as derailment and collision with trains, there is strong demand for preventing human errors of personnel involved. Prevention of serious accidents requires both physical approaches such as safety systems and applicational approaches to prevent human errors, as well as training tools that personnel could learn about the human errors they likely make in their jobs and master the skills to prevent such errors. Thus, from the perspective of human factors, we have started the development of training tools. With those tools, personnel could learn about the human errors they likely make in using maintenance vehicles and master skills that prevent such errors.

We conducted a survey of the status of safety education in conjunction with regular discussions with representatives from branch offices and partner companies. The education programs surveyed were the training program for maintenance vehicle managers at the JR East General Education Center and maintenance vehicle driving accident prevention programs at the Maintenance Technology Centers and partner companies. We also had discussions with instructors and trainees to exchange opinions. Based on the results of those surveys and discussions, we identified points to consider and issues to improve on in the process of development.

• For reasons such as instructors being out of touch with the worksite, programs focus on direct causes of and countermeasures for accidents, seldom taking into account psychological factors. There is thus a need for a system where trainees can effectively experience the psychological state of the personnel involved in the errors before and after occurrence.
• It is difficult for trainees to actively participate, recognizing that they themselves may fall into such a situation. It is thus necessary to study a training method where trainees can actively learn and create a system that enables them to retain the lesson.
• An approach is needed where trainees can recognize the possibility that they themselves may make errors and the horror of a serious accident and make them understand the error mechanism, importance of rules and countermeasures.
• An approach is needed where maintenance vehicle personnel can share their knowledge and experiences to broaden and deepen their view and thought.

In order to select situations that require caution in using maintenance vehicles where human errors likely occur, we analyzed driving and other accidents attributable to maintenance vehicles (“maintenance vehicle accidents”) over approx. 20 years from April 1988 to December 2008 (Fig. 1).

Furthermore, from the 373 maintenance vehicle accidents that maintenance staff caused due to human errors, we organized situations where human errors are likely to occur and the points to prevent common errors based on the frequency of occurrence and the following selection criteria (Table 1).

(1) Many incidents that lead to serious accidents have been caused by similar factors, and those have a close background relation to human weakness.
(2) Serious errors that can affect safe and stable transport occurred.
(3) The accident is related to the rules and the “accidents to eliminate” and “accidents to minimize” action points specified by the head office.
As much work using maintenance vehicles is increasingly outsourced, there is more original education and training courses conducted by partner companies.

In light of those, we prepared two learning modes. Those make the training tools meet a wide range of usage environments of trainees, from individualized learning such as on-the-job training (OJT) at partner companies to group learning at general education centers (Table 2).

Table 2 Learning Mode and Use Environment

<table>
<thead>
<tr>
<th>Learning mode</th>
<th>For group learning</th>
<th>For individualized learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended number of trainees</td>
<td>Eight or more</td>
<td>Less than eight (usable even for just one trainee)</td>
</tr>
</tbody>
</table>
| Usage environment | • JR East General Education Center  
                      • Large-scale education program (organized by the head office)  
                      • Learning without instructor  
                      • Small-scale education program (organized by a branch office) |
| Examples of programs | • Maintenance vehicle manager training  
                          • Education on preventing accidents related to maintenance vehicle driving  
                          • New personnel education  
                          • Department etc. start-up education  
                          • OJT |

5.2 Structure of the Training Tools

To enhance the sense of participation in safety education and the effects of the training, we adopted a training method that encouraged active learning by trainees. That method employs a system to stimulate trainees’ initiative, encouraging active learning by trainees by thinking and taking on tasks.

In conventional training such as safety education, instructors often gave lectures one-sidedly. By centering on such information presentation training, it was often difficult for trainees to keep their motivation for learning. In order to solve this problem, we need to encourage trainees’ active learning. In that, we promote noticing things and learning on one’s own instead of undergoing traditional passive learning, and we build up a system where trainees can undergo training in a reasonable manner.

Many research results have proven that active learning brings higher effects than passive learning. It is even reported that trainees can retain as high as 90% of the training effects when they come to the level where they can be instructors for others (Table 3).

Table 3 Comparison of Retention of Training Effects

<table>
<thead>
<tr>
<th>Comparison of retention of training effects</th>
<th>Retention rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive learning</td>
<td></td>
</tr>
<tr>
<td>Taking courses mainly with lectures</td>
<td>5%</td>
</tr>
<tr>
<td>Reading a book</td>
<td>10%</td>
</tr>
<tr>
<td>Undergoing audio-visual education</td>
<td>20%</td>
</tr>
<tr>
<td>Receiving a demonstration</td>
<td>30%</td>
</tr>
<tr>
<td>Having group learning</td>
<td>50%</td>
</tr>
<tr>
<td>Having an experiential lesson</td>
<td>75%</td>
</tr>
<tr>
<td>Instructing others</td>
<td>90%</td>
</tr>
</tbody>
</table>

Source: Tatsuo Kawashima, Professor, Graduate School of International Cooperation Studies, Institute for Promotion of Higher Education, Kobe University

5 Selection of Points to Learn in the Training

In order to prevent accidents by improving ability of personnel, they should learn the following points from the perspective of human factors, in addition to direct causes of and countermeasures for accidents.

(1) Situations requiring caution where errors can easily happen
(2) Factors inducing common errors and human weakness
(3) Impact of errors
(4) Skill to prevent errors
(5) Meanings, purposes and backgrounds of rules
Inspired by those research result reports, we have introduced to the program for the training tools many ideas for enhancing retention of training effects. In the development, we focused on the following three points to heighten effect retention.

(1) Encouraging activeness
We have defined the status where a person can receive information as an "open mind". In order to make trainees retain the lesson of the training and practice it, we designed the program with the process "open mind → greater motivation → learning → action". This process would bring out interest and motivation of trainees and help them to accept the lesson of the training. In the program, trainees have training, such as pair and group discussion and presentation, which creates an environment where all the trainees participate in the activities voluntarily and proactively.

(2) Stimulating initiative
The learning program includes time for trainees to think on the given issue for themselves. Thinking for oneself and taking action makes them recognize that they themselves might make the error, and pair and group discussion gives them the chance to know each other's thoughts. Those bring about a high effect of "noticing", which leads to understanding of one's own ability and stronger self-confidence.

(3) Deepening understanding
For higher retention of lessons of the training, it is very important to immediately put the learned skills into practice. Based on the training, each trainee addresses different issues to deepen his or her understanding of the lesson ahead of putting that into practice at the worksite. In the training, actual accident cases are introduced to make trainees understand the importance of the rules and skills.

Average time for a scenario is approx. 30 minutes, with some difference according to the learning mode and the scenario selected. That does not include the time for assistance by navigators (following up by the narration, explanation of special education etc.).

The following is an example of the details of the program composition for group learning.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill Improvement 1</td>
<td>Communication</td>
</tr>
<tr>
<td>Skill Improvement 2</td>
<td>“Good call” activities</td>
</tr>
<tr>
<td>Skill Improvement 3</td>
<td>Safety and stability</td>
</tr>
<tr>
<td>Skill Improvement 4</td>
<td>Input with ATOS terminal</td>
</tr>
<tr>
<td>Skill Improvement 5</td>
<td>Handling of set-off mechanism</td>
</tr>
</tbody>
</table>

6.1 Mind Opening Question

What does the above picture show?

This is an example of a topic in mind opening questions. Before starting the main course, a common and well-known subject in daily life is shown to trainees as the issue, and trainees have a short pair or group discussion on that. The aim of the mind opening question is to stimulate trainees’ interest and drive and to motivate trainees to prepare to accept information by giving new information in a quiz-like manner that surprises and convinces them.

The subject seems to have no relation to maintenance vehicles; however, it actually has relation to the main issue of the training.

The topic above is an example of mind opening questions at the stage of “Skill Improvement 1, Communication”. Answering to the question “what does the picture show?”, trainees will find that the interpretation varies from person to person. The reason of
difference is judgment only on the fragmentary information given just by viewing a picture. Fragments of information often lead to misinterpretation. In this way, trainees are led to training about communication errors.

6.2 Case Study
After preparing for the training by answering mind opening questions, trainees watch a case study movie. The case is shown in a three-dimensional computer graphics movie depicting the changing thoughts and psychological state of the main character as the situation changes (Fig. 4).

6.3 Error Finding
As trainees simply keep watching the movie at the case study stage, they will return to a passive state. In such a state, going on to a case explanation movie will probably not give them high training effects such as understanding the explanation.

Error finding will turn them an active state to stimulate their initiative for promoting deeper understanding of the explanation to follow and a higher retention effect. At this stage, each trainee thinks of the cause of and countermeasures for the error by reviewing the case study, and he or she learns different views through discussion amongst the trainees. The purpose of this stage is to make them understand themselves in comparison to other people on points such as their view of safety and appropriateness of their judgment and view.

6.4 Case Explanation
At this stage, trainees receive a detailed explanation from the perspective of human factors. For example, they learn while reviewing the case study in which mechanism the human error occurred and what kind of skills have to be mastered to prevent human errors.

6.5 Experience Sharing
At the experience sharing stage, trainees review their own close calls similar to the case and other valuable experiences. Based on the case explanation, they have discussions amongst themselves to share individual experiences. The purpose of this stage is to make trainees recognize that human errors are close by and also to enhance safety consciousness and team consciousness by widening their sense of risk prediction.

6.6 Experiential Lesson
In the experiential lesson stage, trainees undergo training with their actual jobs in mind. Immediate practice by role-playing of the skills to prevent human errors they learned in the case explanation will improve the retention of the effect of the lesson.

In order to make trainees continue practicing the learned skills, the aim of this stage to give them concrete image of applying those. Specifically, they learn in which cases what skills are important and how they can practice that, strengthening their self-confidence for practice.

6.7 Closing
At the closing, cases from actual serious accidents related to the training are introduced. Trainees will recognize that such accidents are close at hand and might occur with them. The cause and impact of errors is driven home to make them understand the importance of the lesson of the training.

The developed training tools are new education materials. In the tools, we have added the viewpoint of human factors to the existing safety education, and we have imported practical training programs that were difficult to implement up to now. They further include training methods to improve the retention of the lesson of the training course (Fig. 6).

We aim to utilize the tools as a maintenance vehicle driver skill improvement program at the JR East General Education Center and field departments from November 2009.