B. Years of challenge

Fig.11 shows the number of years of participation. One third of teams are joined for the first time. This ratio is same for both company and student teams. On the other hand, most student teams join for second year but for third year. It is supposed that students join ET Robocon as part of PBL curriculum in their school. In addition, since 46% student teams are third and fourth year in university, they participate in the ET Robocon as a practical entry gate for a professional job opportunity.

Controversially, company teams keep challenging for more than four years. They seem challenging until getting championship title.

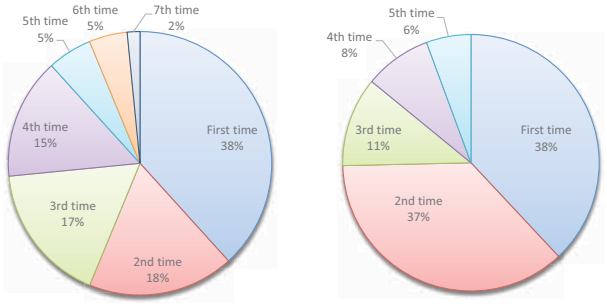


Fig.11 The number of participant times

C. Educational Effect and Satisfaction

Fig.12 summarizes the ratio of parts which the participants feel learning effect. The modeling occupies 1/3, development process is 20%, and management is 17%. 80% of participating teams are answering satisfied. The rest of 20% declared as not satisfied because of race retirement.

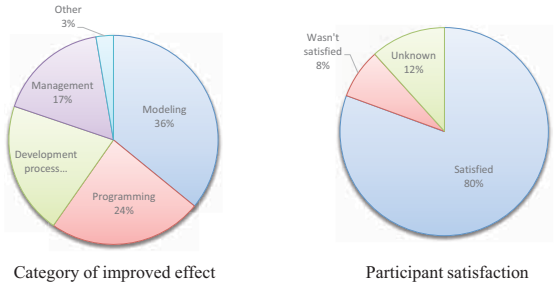


Fig.12 Category of improved effect & Satisfaction

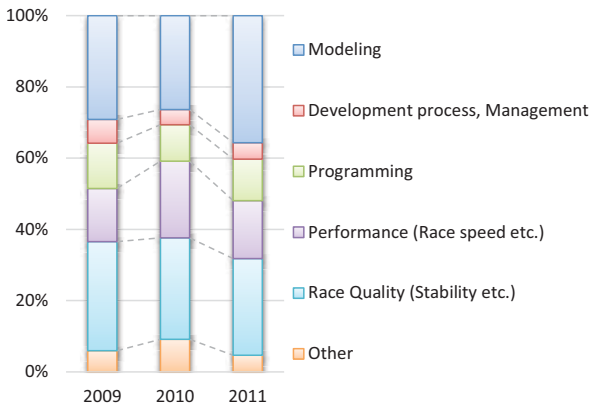
D. The Focused Area During Development

Fig.13 is trend graph showing which part participants focused as their development activity. Differences between company teams and student teams are interesting. Company teams' answer (Fig.13(a)) shows higher focus on modeling and little on programing. The company teams are supposed to already have programing skill. Conversely 1/4 of student teams (Fig.13(b)) focus on programing and quality of race i.e. how robot run the course and behave to the hazard as programed.

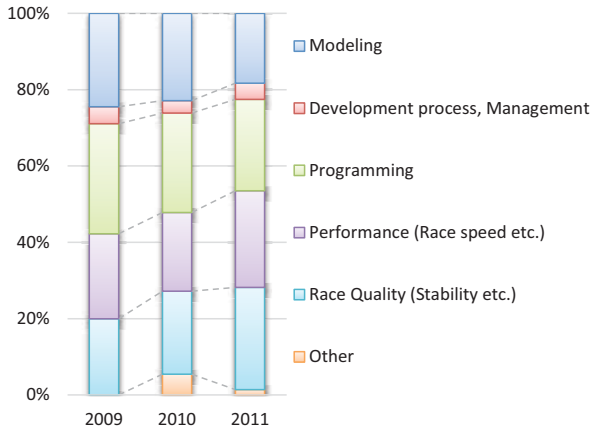
E. What was the Best Thing in This Contest?

This questionnaire is descriptive and free format to write answer. Related to the technical skill up for participants themselves was something expected answer and management issues are also answered. For example, the very specific keywords written are "Difficulty of project management" / "Toughness of make all members work together" / "Team management" / "Project management" / "Development difficulty by many persons".

Those answers suggest that ET Robocon is a PBL which offers the learning opportunity of overall process for software development. Some other answers emphasized the rare opportunity for discussion and communication with other companies, professionals, teachers, and students. ET Robocon has multiple aspects for education value as well as technical learning.



(a) Corporate team



(b) Student team

Fig,13 Most focused activity of development

V. Additional Category and Classes

A. An Additional Category from 2013

From 2013, the ET Robocon has been expanded from a single category competition into two categories, the "Developer" and the "Architect", for its purpose of software engineering education. The Developer is operated basically according to rules from the past, in which teams compete for speed and accuracy on a given course. Each team analyzes the course, designs a software model, writes a program code on the model, and run the code on a robot.

The software education based on software modeling is getting better results year by year. A code based on a better model is getting the better record in racing. It means the contest has become good training for model designing skill, but it does not mean it gives a good opportunity to enhance originality in model design. The committee of the ET Robocon believes that it is hard to win the global competition of software design only applying routine problem solving techniques. Creating some original technology is a must item to win the game.

As result, the Architect category has been started from 2013. As it focused planning and presentation skills, the Architect category is not position like a high rank of the Developer category. The purpose of the Architect category is human resource development for increasing the planning capabilities and presentation skills.

When the Developer category is compared to speed skating, it may be understood easily that the Architect category is compared to the figure skating of the free performance.

As for the Architect category, a participating team performs original performance on the white performance stage which is placed at latter half of the racing course. At that time, there are no restrictions for the performance except for the danger act. The participant itself plans the theme and the subject that is made to say "Excellent" from audiences. And while performance is performed, participant itself makes a presentation and description of performance.

It is admitted to place the devices and fixtures (called a gadget), other than standard robot on the performance stage. So participant can show performance with various idea and technic. Also, participant must submit a proposal paper instead of a model. And proposal is evaluated by judges as well as the models.

Regarding judgment method, 25% is the examining of contents of proposal and 25% is the examining of the result of performance whether it corresponds to the proposal. And remaining 50% is examined the result of performance by special and general audiences.

The first contest of the Architect category in 2013, in all 363 teams, 294 teams entered to the Developer category, and 69 teams entered to the Architect category. As a result, 13 teams were selected from the Architect category in the championships, and the company team and the technical junior college team won the same score.

The concept of the two teams is very different. Concept of company team was cleaning robot, and it look for objects in the room and put away. On the other hand, concept of technical junior college team was entertainment, robot is coalesced into the big one and rescued a princess. It is interesting that both teams of the different concept got the same number of votes from the special and general audiences.

B. New classes from 2014

The Architect category that began in 2013, raised the great achievements than we had imagined. However, as mentioned before, the difference of the level was expanded between the team which participated with a beginner and many times in the Developer category. So, the Developer category was divided into two classes, "Primary Class" and "Advanced Class", from 2014.

Contents of the Primary Class follow the Developer category of generally conventional one. It continues to hold as "a place of learning for beginners" which requires easy-to-understand model description and accurate acquisition of elemental technologies.

On the other hand, the Advanced Class provides a place to compete skills and study advanced technology. For the class, the authors have developed a new robot called "NXTrike" shown in Fig.14.

Fig.14 The "NXTrike" which will be used in from 2014

It would be possible to capture the choke point high degree of difficulty and advanced control strategies than traditional robot. This robot is a trike type, so the torque dividing of the left-and-right drive wheels is usually performed using the differential gear. However it needs to carry out a traction control by controlling the motor which achieved left-and-right independence like the in-wheel motor used with newest electric vehicles.

Moreover, the trailing wheel is attached to the body back upper part, and a run in the handstand state is possible with carrying out the wheelie of the robot. If using this, for instance, even if there is a tight curves which cannot be turned by minimum turning radius in three-wheel driving, if robot does not decelerate, it can change to a handstand state quickly and

can also take the strategy of turning at that place and quickly escaping from a corner.

It is almost impossible to create such bodies in actual vehicles size, and to use it by 400 teams. However, in the ET Robocon using a unified teaching material, LEGO Mindstorms series, it is possible to prepare a robot having a new mechanism every year.

Thus, by dividing class, a function as newcomer education which is the purpose from the beginning for ET Robocon is maintained by the Primary Class. The additional class, the Advanced Class, will create an environment that can be updated without hesitation and suited to the latest technology trends. This addresses continuous development of human resources which can play an active part in the embedded system development field.

VI. Summary and Perspectives

The present paper introduces our activity of a software design robot contest for educating embedded systems engineers, the ET Robocon, and reports its educational effects.

The ET Robocon is centered on the software, where participants compete with one another to model and implement technologies used in robot control. Software design, maneuver control and running performance are evaluated.

The contests were held annually and continued for 12 years. Through the feedback from participants, the authors assure that this robot contest provides very good opportunity for educating embedded software development skills for both students and professional engineers.

To broaden the spectrum of embedded software engineering skills, the developer category will be divided into the Primary Class and Advanced Class. With the introduction of the category of the two, it makes "human image" nurturing through the ET Robocon clear. A target of “human image” is a little different in the Developer category and the Architect category. Therefore, the contents of requirement of two categories are also different. Of course, elements of both are important, so it is better that participants will be able to have the skills of both in the future.

The Developer category.
It aims at rising of the ability to solve a given problem with quick, accurate and high quality.

The Primary class (for bingers)
- It is intended for beginners and carried out as usual engineering education.
- It provides an opportunity to learn the basics challenge of technology.

The Advanced class (for expert)
- The class which the person who graduated from the Primary class challenges.
- It provides an opportunity to hone the skills that can be applied technology.

The Architect category.
It aims at education of the engineer who can play an active part in 5 or 10 years. It provides an opportunity to hone the skills to plan and develop products.

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