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Ten Years of the Real World Design Challenge

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Preparing students to be successful in STEM careers is important to foster continued growth in the US and the world. The Real World Design Challenge is a high school design competition focused on the area of aviation. Students work in teams to solve a real world problem using professional tools. The 2018 challenge marks the tenth anniversary of this program. The first students to compete in this competition are now in the work force. This paper describes the background of RWDC, the different challenges that have been used throughout its ten years, the current precision agriculture challenges using UAS, and the judging system used in the competition. Finally, the impact of the program on the students is discussed.

I. Introduction

The Real World Design Challenge (RWDC) supports Science, Technology, Engineering and Mathematics (STEM) education in high schools through an annual competition. Students who participate are given the opportunity to apply the lessons of the classroom to the technical problems currently faced in the engineering field. Thus, the goal of the RWDC is to motivate and prepare students for the STEM workforce and teach innovation. Through their participation in RWDC, each year students are challenged to solve a problem related to aviation. For the challenge this year, students are designing an Unmanned Aircraft System (UAS) with the mission of precision agriculture. School teams of 3–7 students first compete in State Competitions where the State Champions are invited to compete in the National Challenge. Winners of the National Challenge receive a $50,000 scholarship to Embry-Riddle Aeronautical University (ERAU). The State Challenge runs from August through January, and the National Challenge runs from January through April. During the 2015–2016 competition, RWDC expanded internationally and the first International Challenge was held during the 2017 National Challenge event.

The RWDC founder created the program from two years of extensive research beginning in 2006. Around that time, a number of reports, such as *Rising Above the Gathering Storm*,[1] came out indicating that the United States was not producing enough STEM professional, particularly in areas like engineering. The consequence was that the U.S. National security and global economic competitiveness was at risk. One of the largest sectors of society that was being impacted by the lack of students in the STEM pipeline was aerospace and defense. Defense was 15% of the U.S. federal budget in 2016.[2] Another report, *Preparing for the Perfect Storm A Report on the Forum Taking Action Together: Developing a National Action Plan to Address the "T&E" of STEM*,[3] helped guide the creation of RWDC by determining the needs of companies in defense and aerospace. In general, companies want (1) employees with excellent academic credentials and (2) seven to ten years of real world experience. Therefore, RWDC has been designed to train students in a way such that they can be competitive in a global marketplace and meet companies' needs.

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It was decided that since aerospace and defense were key sectors of society that were impacted by the lack of students going into STEM fields, aviation was chosen as the topical focus for the program. A major aspect of the program is that students gain "real world experience" to cut preparation time leading to the workforce. An operational definition of "real world" was defined based on the research that was done and incorporated in the program. RWDC is real world to students in the following ways: (1) solve real problems defined by practitioners in industry, government, and higher education; (2) use real tools that are used by professionals to design aerospace systems; (3) play real roles, such as project manager, project engineer, project scientist, project mathematician, and marketing communication specialist; and (4) make real contributions by developing innovative solutions to real problems.

It became clear that it was not enough to simply prepare the next generation of STEM professionals. Innovation was a driver of wealth in society. There are many examples such as Bill Gates building a new software environment though Microsoft and Steve Jobs revolutionizing phone and computer technology at Apple. These entrepreneurs are examples of people who had a major impact on the world and generated significant wealth. The question begged by this is "How can we prepare the next generation of innovators?" RWDC designed an approach to teach innovation in the context of learning STEM. It is done using the engineering design process as a method of solving problems; using professional tools; and having students work on a challenge that is solved in the context of structure that facilitates innovation in the context of applying and learning key concepts, processes, and skills with significant scaffolding and structure. This enables students to solve problems in a "real world" context

II. Organization

The Real World Design Challenge was established with key partners from government, industry, and education. PTC was the lead organization with other partners such as the U.S. Department of Energy, the FAA, the Aerospace States Association (ASA), and partnerships with Governors and Lt. Governors in a number of states. Partnership agreements were established through the Governors' Offices. They arranged for State Coordinators who often were employees at state departments of education, state departments of transportation, not-for-profits, or universities. The State Coordinators:

- Serve as the Point of Contact (POC) for teachers and state officials to address questions.
- Serve as POC for the administrators of RWDC to obtain information and provide input on how to improve the program to meet the needs of the teachers and students in their states. This is done through periodic teleconferences.
- Help direct teachers to free on-line teacher training.
- Help organize a judging committee to evaluate the design solutions from teams within their state. The judging committee is usually composed of representatives of government, industry, and higher education.
- Attend and help organize RWDC State Award Ceremonies.
- Attend the National/International Challenge Event in Washington, DC with the winning state team in April.

There are currently 44 partner States and Territories. RWDC operated as a confederation until RWDC was incorporated as its own not-for-profit in 2016.

RWDC has two standing committees that are part of the organizational structure. They include

- **Administrative Committee**: The Administrative committee is a counsel consisting of key people from various organizations, which support the Real World Design Challenge. The committee manages the logistical issues surrounding the Challenge's administration.
- **Technical Committee**: The Technical Committee is composed of representatives from government, higher education, and industry that support the Challenge. This committee is the group that designs the Challenge itself and the collateral academic material.

In 2015, China became the first international partner country for RWDC. As RWDC grows internationally, two additional positions were created to coordinated the challenge outside of the US. These two positions are the International Liaison and the Country Coordinator.

The RWDC International Liaison helps to recruit and support the involvement of additional countries in RWDC. The International Liaison also works with the countries to establish the competition within each country, identify an RWDC Country Coordinator, and ensure support for the National Champion Team to attend the RWDC International Championship in Washington, DC. The International Liaison serves as the Liaison between the RWDC Staff and the Country Coordinators. The Liaison may work with one or more countries. He or she helps the Country Coordinators organize workshops, training, conference calls, marketing of the program, and recruitment of teachers and teams. He or she also helps the Country Coordinator organize and implement the State and National Challenges and the travel for the National Winning Team to come to the US to compete in the RWDC International Championship. The RWDC International Liaison attends the RWDC International Championship with the teams from the countries he or she is supporting.

The RWDC Partnership involves identifying an RWDC Country Coordinator. The Country Coordinator serves as the Point of Contact (POC) for teachers and Country officials to address questions. The Country Coordinator also serves as POC for the RWDC Teams to obtain information and provide input on how to improve the program to meet the needs of the teachers and students in the Country. He or she helps establish country RWDC websites and also RWDC presence and identity in the country. The Country Coordinator recruits teachers and students. The Country Coordinator directs teachers to the webinars for free on-line teacher and student training or work with the RWDC management to help districts set up instructor led training. He or she organizes a country Challenge Judging Committee to evaluate the Country's RWDC Teams' solutions. The Country Challenge Judging Committee is composed of representatives of government, industry, and higher education. The Country Coordinator attends the International Challenge Event in Washington, DC with the National winning team.

III. The Yearly Challenges

Throughout its ten-year history, the challenges for the RWDC competition have continuously evolved to address the needs of the aviation field. This section discusses some of the challenges that have been used in the competition and some of the changes that have been made to improve the competition.

A. The First Five Years

Since the beginning, the challenges have always focused on aviation. The topics of the earlier challenges varied and included the design of a business jet, the design of a light sport aircraft, and the design of a new wing for the Boeing 737 using aeroelastic tailoring. For the Boeing 737 wing challenge, the winning team designed the internal and external structure of a wing that outperformed the original Boeing design. However, during the National Challenge when the judges questioned the students about their design, it became clear that cost was not used as a factor. While the design worked well, the cost of the composite material the students developed was cost prohibitive. Since cost is an important factor in real world engineering design, it was recommended by the judges that cost be included as a consideration for future challenges. In later challenges, teams were required to address the issues of cost and marketing by developing a business plan in addition to the design aspect of the challenge.

To ensure that the challenges stay relevant to the trends in aviation, the judges are often asked what areas of innovation they would like to see addressed. One of the biggest areas that the judges mentioned was Unmanned Aircraft Systems (UAS). Since the 2013 challenge, the focus of RWDC has been on designing UAS. The first UAS challenge involved designing a small fixed-wing unmanned aerial vehicle (UAV) to aid in the search and rescue of a small child lost in a forest. As part of this challenge, students were provided background information on the FAA requirements for operating small unmanned aircraft within the national airspace system. A small catalog of different aircraft components that can be used for their designs was also provided to the students. This catalog included different cameras, propulsion systems, ground station equipment, and communication equipment.

Figure 1: UAS design approach through the five major elements.

B. Precision Agriculture Challenges

An important area that UAS has the potential to make a significant impact is precision agriculture. With precision agriculture, farmers can use data collected about their crops to better monitor the crop health and more effectively take action, such as applying pesticide or additional irrigation, when required. Using precision agriculture, the farmer has the potential to increase the crop yield of their farm while minimizing the use of resources. With an estimated population increase of an additional 2 billion people by 2050, 70% more food will be required.[4] The use of precision agriculture is one method to help with this demand. Starting with the 2014 challenge, the focus of the RWDC competition has been to design a UAS for precision agriculture.

Around the time that precision agriculture became the focus of the challenges, Embry-Riddle Aeronautical University became more involved with RWDC. ERAU professors volunteered to lend their expertise in aeronautics and UAS to help design the challenges. The use of inquiry-based learning was emphasized where the students learn how to find and apply knowledge rather than report on what they know. In designing the UAS, teams were shown how to view the whole system by needing to select and integrate the five major UAS elements: (1) payload, (2) platform, (3) command, control, and communications, (4) support equipment, and (5) operational and support personnel (Fig. 1).[5] In addition, a series of webinars were created to provide background information on UAS, engineering design, aeronautics, precision agriculture, and business models.[6]

The first precision agriculture challenge was for the 2014 competition. The purpose of challenge was to design a UAS that can monitor a field of corn and detect an infestation of the European Corn Borer. With successful detection, the farmer will be able to treat the crop and increase the yield of the field. For this challenge, the teams could design a fixed-wing, rotorcraft, or hybrid aircraft. To aid the students, information about engineering design methods, FAA regulations, and business modeling were given in more detail than previous years. The catalog of UAS components was also significantly expanded. In addition, five basic UAS configurations with detailed specifications were provided as examples. The configurations were a fixed-wing pusher, a fixed-wing tractor, rotary-wing, multirotor, and hybrid multirotor/fixed-wing. Details about each configuration included the aircraft material, flight control specifications, propulsion system

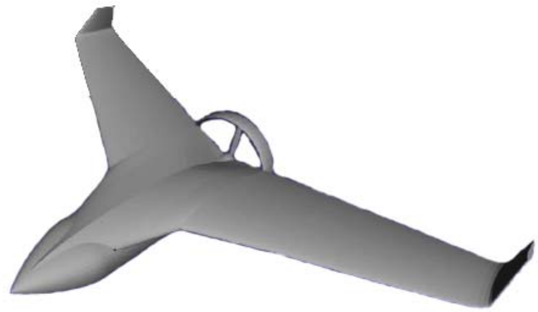


Figure 2: Winning design for the 2014 National Challenge by team Next Level from South Burlington High School in Vermont.

Figure 3: Winning design for the 2015 National Challenge by team Aeronautical Dolphins from Marianas High School in the Commonwealth of the Northern Mariana Islands.

specifications, weight, payload, flight speed, and endurance. Teams needed to research the European Corn Borer to determine how infestations affect the crop and what sensors could be used to detect the pest. During the competition, students were to operate from the perspective of a small business seeking funding to developed a prototype. As part of their design, they had to develop a business plan. During judging, teams were assessed on their team engagement, design methodology, mission plan, and business case. The national winner was the Next Level team from South Burlington High School in Vermont. A picture of their design is shown in Fig. 2.

For the 2015 challenge, teams were tasked with designing a UAS to precisely apply pesticides. With targeted pesticide application, only areas that are affected by pests are sprayed reducing the negative effects of blanketed, broad-based application. An emphasis was placed on the feasibility of the design within a realistic economic scenario. The business aspect of the design was increased to include analyzing, documenting, and addressing the challenges associated with application, productivity, costs, and business profitability. To aid the teams, the UAS catalog and FAA rules were updated. An infestation map with different levels of predation was also provided. If desired, teams were allowed to use multiple unmanned aircraft as well as use unmanned ground vehicles (UGV). Teams were assessed based on their team engagement, design methodology, application plan, and business case. The Aeronautical Dolphins from Marianas High School in the Commonwealth of Northern Mariana Islands was the national champion. Figure 3 shows the winning design.

The 2016 challenge returned to a survey type mission similar to the 2014 challenge. During 2015, a severe drought affected a large part of the United States, so the 2016 challenge was designed around a UAS that would monitor crop health through measuring moisture content. Teams would be required to research the methods used to measure moisture content in crops and design a system that could operate efficiently. Unlike previous challenges, teams were allowed to select a crop of regional significance to their area. The only limitation to the crop was that it had to be food producing. For the 2016 challenge, teams were limited to fixed-wing designs and had to follow the FAA Small UAS Notice of Proposed Rulemaking. A few of the proposed rules were that the aircraft must weigh less than 55 lb, have a maximum airspeed of 100 mph,

Figure 4: US winning design for the 2016 National Challenge by team Xaverian Engineerings from Xavier High School in Connecticut.

Figure 5: Chinese winning design for the 2016 National Challenge by team Zero from Jianping High School in Shanghai.

fly within visual line-of-sight only, and have a maximum altitude of 500 ft above ground level. Designs were judged based on the team engagement, design methodology including how crop choice and moisture detection procedures affected the design, detection plan, and business case. The national winner from the US was the Xaverian Engineers from Xavier High School in Connecticut (Fig. 4). During the 2016 challenge, RWDC expanded internationally to China. The national winner from China was team Zero from Jianping High School in Shanghai (Fig. 5).

For the 2014–2016 challenges, the teams were designing a UAS and business plan where they were selling a service to the farmer. This service was either surveying the crop or spraying pesticide. For the 2017 challenge, the teams were tasked to design a multipurpose UAS that would be sold to farmers to use themselves. The UAS had to be able to perform three required missions that could be useful for a farmer. These missions were a payload ferry, a survey, and a dash. Teams were encouraged to develop even more missions to highlight the versatility of their design. For each mission, teams were required to define its purpose based on the type of farm common to their region. For the 2017 challenge, teams were not limited to plant-based agriculture and could design for a farm raising livestock or even aquaculture. Another major constraint for the UAS design was that it had to follow the FAA Part 107 regulations.[7] A few of the major regulations are that the aircraft must weigh less than 55 lb, stay within line of sight, fly only during daylight hours, have a maximum speed of 100 mph, and have a maximum altitude of 400 ft above the ground. The main focus of the business plan was to sell the aircraft for a profit; however, the teams were encouraged to consider other revenue sources by selling services such as training, maintenance, and data analysis. For the competition, teams were judged on team engagement, design methodology, mission design, and business case. The 2017 challenge marked the first international competition between the US national winner and the Chinese national winner. Team Pulse from Jianping High School in Shanghai was the Chinese national winner (Fig. 6). Team Andover Blueprints from the Phillips Academy Andover from Massachusetts was the US national winner and the first international winner (Fig. 7).

At the time of publication for this paper, RWDC is midway through the 2018 challenge. The focus of the 2018 challenge is the effect of the Part 107 regulations on the performance and profitability of UAS. Teams are operating as a small research group in a larger company. The goal is to design a UAS that can survey a field of corn for pests and also spray a field with pesticides if necessary. Since Part 107 does not cover the carrying or dispersing of hazardous material, the teams can assume that they have received the necessary waivers to carry and disperse pesticides. Teams need to design a system that will perform the surveying

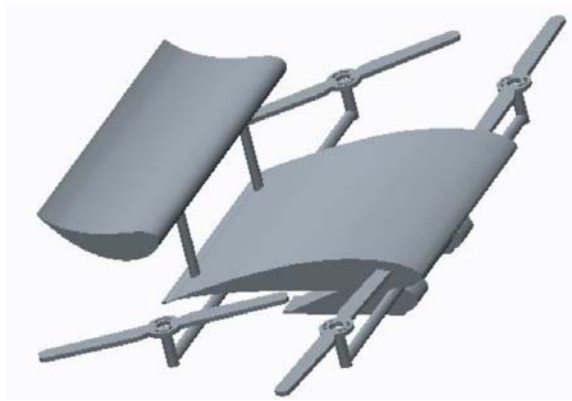


Figure 6: Chinese winning design for the 2017 National Challenge by team Pulse from Jianping High School in Shanghai.

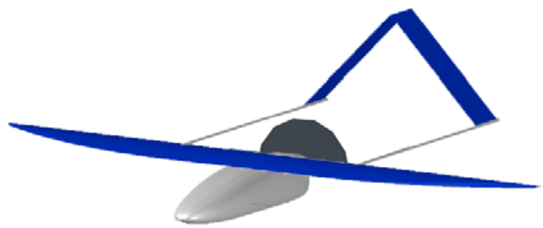


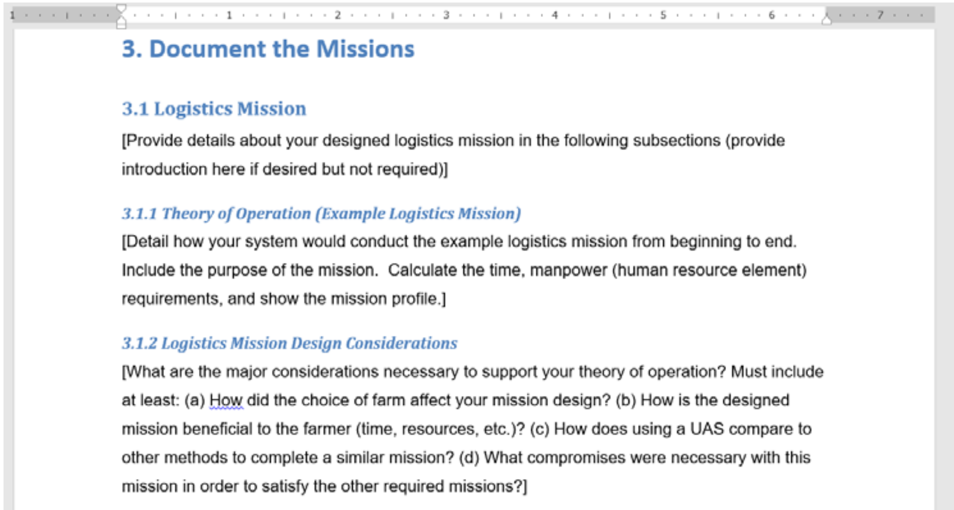
Figure 7: US and international winning design for the 2017 National Challenge by team Andover Blueprints from the Phillips Academy Andover in Massachusetts.

mission at least as well as the eBee SQ agricultural drone[8] and the spraying mission at least as well as the DJI Agras MG-1.[9] Based on weight and performance characteristics, the eBee SQ and DJI Agras MG-1 can fall under Part 107. The new design by the teams may go outside of the Part 107 regulations in order to increase performance, increase profits, or both. If the design does go outside of Part 107, the team must provide sound reasons on why it is needed and must ensure that the aircraft will still be safe. For the design, teams are allowed to use multiple designs and unmanned ground vehicles. For the business plan, the goal is to sell a service to farmers. Teams need to develop a plan that will create a profit for their company but still create a service that will be affordable to farmers. Teams will need to estimate the increase in revenue that farmers may see if they use the UAS service. At the time of publication, 130 teams from 33 States and Territories have signed up for the 2018 challenge in the US. For China, the 2018 challenge is the first that will have teams from outside of Shanghai. There are over 15 high schools from four cities in China participating.

IV. Judging

A. State Challenge

The State challenge officially starts when the Challenge Statement and supporting documents are made available in August.[6] The teams have until the beginning of January to design a solution to the State challenge and submit an Engineering Design Notebook. As part of the supporting documents, a template is provided for the design notebook along with a copy of the rubric that will be used to score the notebook. The template and rubric are very specific in the information required for each section. The rubric also provides the point value for each section. An example from the notebook template and the corresponding section in the rubric are provided in Figs. 8 and 9, respectively.



3. Document the Missions

3.1 Logistics Mission

[Provide details about your designed logistics mission in the following subsections (provide introduction here if desired but not required)]

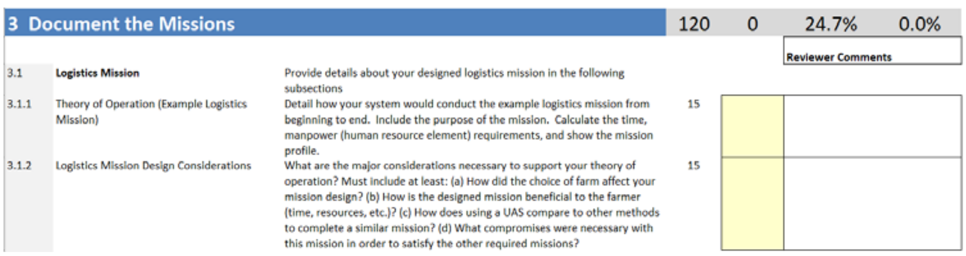
3.1.1 Theory of Operation (Example Logistics Mission)

[Detail how your system would conduct the example logistics mission from beginning to end. Include the purpose of the mission. Calculate the time, manpower (human resource element) requirements, and show the mission profile.]

3.1.2 Logistics Mission Design Considerations

[What are the major considerations necessary to support your theory of operation? Must include at least: (a) How did the choice of farm affect your mission design? (b) How is the designed mission beneficial to the farmer (time, resources, etc.)? (c) How does using a UAS compare to other methods to complete a similar mission? (d) What compromises were necessary with this mission in order to satisfy the other required missions?]

Figure 8: Sample selection from the Engineering Design Notebook for the 2017 State Challenge.



3	Document the Missions		120	0	24.7%	0.0%
						Reviewer Comments
3.1	**Logistics Mission**	Provide details about your designed logistics mission in the following subsections				
3.1.1	Theory of Operation (Example Logistics Mission)	Detail how your system would conduct the example logistics mission from beginning to end. Include the purpose of the mission. Calculate the time, manpower (human resource element) requirements, and show the mission profile.	15			
3.1.2	Logistics Mission Design Considerations	What are the major considerations necessary to support your theory of operation? Must include at least: (a) How did the choice of farm affect your mission design? (b) How is the designed mission beneficial to the farmer (time, resources, etc.)? (c) How does using a UAS compare to other methods to complete a similar mission? (d) What compromises were necessary with this mission in order to satisfy the other required missions?	15			

Figure 9: Sample selection from the Rubric for the 2017 State Challenge.

Once the State challenge notebooks are submitted, the State Coordinator decides how the notebooks from his or her State will be scored. In some States, the State Coordinator organizes judges that will score the notebooks from their State. Other States will have their notebooks scored by the RWDC network of volunteers. The volunteers come from industry, government, and academia and have a large range of backgrounds including aviation, engineering, and business. Many of the volunteers are adjunct faculty members of Embry-Riddle Aeronautical University - Worldwide. At least three judges score each notebook with the average of all the judges' scores being the final score for that notebook. Judges are encouraged to leave comments to the teams in the scoring rubric to provide guidance on how to improve their work and to mention what was done well. The team with the highest notebook score from a State is deemed the winner for that State and invited to continue on to the National challenge.

B. National Challenge

Immediately after the announcement of the State winners, the National challenge begins with the release of the National Challenge Statement, a new Engineering Design Notebook template, and a new scoring rubric. While based on the State challenge, the National challenge is nevertheless modified to make the design competition more difficult. For the National challenge, the teams are judged not only on the design notebook, but also on a presentation they give at the National Challenge event held in Washington, DC during April. Teams submit their design notebooks at the beginning of April, and the RWDC network of volunteers score all the reports. Judging of the design notebooks is completed before the National Challenge event is held in mid-April.

Scores for the design notebooks are not released to the teams, but the scores are used to organize the teams into presentation rooms at the National Challenge event. The top-ranking teams, based on their notebook scores, are distributed among the presentation rooms. During the National Challenge event, each presentation room will have up to four teams.

The National Challenge event is held on one day during which each team presents their design solution in the morning, and the top teams present their design solution again in the evening to a panel of Blue Ribbon judges. During the morning session, teams are divided into groups of four and assigned a presentation room. As mentioned earlier, the top teams, based on the notebook scores, are distributed among the presentation rooms. Each presentation room has at least three judges that will score the teams based on a presentation rubric. Care is taken to ensure that the expertise of the judging volunteers is distributed as evenly as possible between the presentation rooms. Each team has 15 minutes to present their design solution with a 10-minute question-and-answer session from the judges afterwards. The judges then move to a caucus room where they have 10 minutes to discuss the presentation and finalize their individual scores. After the final team in the room has presented, the judges have the opportunity to modify any scores from earlier teams if they deem necessary.

After all the judging from the morning session is complete, the judges have a break for lunch while their scores are compiled and added to the design notebook scores. The final score for each team is based on 70% from the design notebook and 30% from the presentation. Once the judges reconvene, they have two jobs to do: determine the top three teams and determine the merit award winners. All scores (both notebook and presentation) are presented to the judges with the current team rankings. The judges are then asked to discuss and finalize the ranking of the top three teams. Design notebooks with the judges' comments are available if requested. To have a more organized discussion, the judges from each presentation room are asked to select one judge to be their Master Judge. The role of this person is to be the spokesperson for that presentation room. The Master Judges will explain the reasoning behind the presentation score for a team within their room if needed. The first job of the judges is complete once the top three teams are agreed upon. For the National Challenge events, up to and including 2016, these three teams then proceeded to the Blue Ribbon session where they presented their design solutions again. With the growth of RWDC to include international teams, the format has changed slightly. These changes are discussed in a later section. Once the top three teams have been agreed upon, the judges are tasked with determining the merit awards. The nine possible Merit Awards are

- Innovation
- Design Viability
- Team Work and Collaboration
- Effective Mentor Collaboration
- STEM Interest Impact
- Most Creative
- Against All Odds
- Best Business Case
- Best First Year Team

The top three teams are not eligible for a Merit Award, and not all Merit Awards are required to be given. A ceremony is held shortly after the judging has been completed to announce the Merit Awards and the top three teams. No rankings are given to the top three teams, as that will be determined during the Blue Ribbon judging.

The Blue Ribbon session is held in the evening. A new panel of judges are used that include leaders in government, industry, and academia. The judges are briefed about the design competition and are given the presentation rubric. During the Blue Ribbon session, the rubric is used as a guide for the judges and as a place to write notes. The judges are asked not to discuss the presentations among themselves. Each team is given 15 minutes to present their design with 10 minutes afterwards for the judges to ask questions. Once all three teams have presented, the Blue Ribbon judges are moved to a caucus room to determine the final rankings of the teams. The first step to determine the final rankings is for the judges to vote for the team that they thought was the best. Those who did not agree with the majority are given an opportunity to voice their opinion with the goal of making sure everyone is comfortable with the group's final decision. A second vote or more can be called upon by the group to see if anyone changes his or her mind. After the first-place team is determined, the process is repeated to determine the second and third places.

C. International Challenge

Starting with the 2016 challenge, teams from China have competed in RWDC. In the 2016 challenge year, five teams from Shanghai participated in the State level and four of the teams traveled to Washington, DC for the National Challenge event. For the 2017 challenge, 16 teams from Shanghai participated in the State level and seven traveled to Washington, DC. During both years, the RWDC network of volunteers scored the design notebooks from the Chinese teams. The RWDC Country Coordinator in China determined the number of teams that traveled to Washington, DC for the National Challenge event.

During the 2016 National event, the four Chinese teams' presentations were judged during the morning session. These presentation scores along with their design notebook scores determined the first-place winner. Since there were only four teams, second and third place were not determined; however, each team was recognized with a Merit Award. The Merit Awards presented to the Chinese teams were separate from the Merit Awards given to the US teams during the same year.

For 2017, the format of the National event was modified in order to have the first International winner of RWDC. The seven Chinese teams were judged separately from the US teams during the morning session. After the morning presentations, the judges met to determine the top three US teams, the top three Chinese teams, and Merit Award winners for each country. Both countries had their own set of Merit Awards. From the top three teams of each country, the third-place winner for each country was determined. The remaining top two teams from each country then advanced to the Blue Ribbon session.

During the 2017 Blue Ribbon session, the four teams (two from the US and two from China) presented their designs to the Blue Ribbon judges. When the judges caucused after the four presentations, the first vote was for the international winner. For the 2017 competition, one of the US teams was voted to be the international winner, which automatically made that team the first-place US team. The judges then voted on the best Chinese team to determine the first-place Chinese team. At the end of the Blue Ribbon caucus, the judges had determined the second-place US team, the first-place US team, the second-place Chinese team, the first-place Chinese team, and the international champion.

As RWDC is expected to add additional countries in the near future, the format of the National and International Challenge events will need to change. The format for the expanded event has not been formalized but will be determined by the Administration Committee and Country Coordinators when more countries become partners.

V. Impact of RWDC

Experience shows, preparing students for the complex requirements of a career in STEM fields requires more than the learning of a fixed body of knowledge. Application and adaptation skills, creativity, critical thinking, and flexibility are as much required as the familiarity with specific formulas and proven methods. Additionally, attitudes have to be developed that allow students to independently engage with and research additional content when faced with new problems and novel challenges. Thus, the application of knowledge, skills, and attitudes[10] towards unfamiliar situations and problems is a main focal point of the learning process in STEM education. Therefore, the RWDC aspect of self-engaged, problem-/project-based, outcome-oriented learning aligns closely with the principles of Experiential Learning Theory[11] within the broader theme of constructivist learning. With an increased focus on the processes involved rather than just the content, the acquisition of specific factual knowledge becomes a by-product of the challenge process, required to solve the given problem, but not the main focus of the assessment. Additionally, real-world relevance and the ability for students to relate to the practical outcomes of the RWDC, both for the desired design results of the challenge, as well as the personal gain from participation, increase the level of internalization of behavioral regulation, moving it closer towards intrinsic motivation.[12,13] Thus, the principles applied in the design of the RWDC also embody the best practices of learner-centric educational approaches such as the Pedandrous framework.[14]

The team character of the RWDC introduces yet another educational aspect into the mix: social learning. Consistent with social constructivist theory[15] and social cognitive theory,[16–18] students are working in collaboration with their peers and self-direct their learning processes. Through social construction, co-participation, group reflection, and socially situated cognition during the team exchange and regulation processes, higher levels of self-efficacy and learning transfer can occur.[15,19] Furthermore, the assignment of relevant roles for team members, as well as roles for mentors, subject matter experts (SMEs), judges, etc., are consistent with the ideas of social learning and helps students in their self-regulation processes.

VI. Summary

Ten years of the Real World Design Challenge has made a contribution in preparing high school students for the STEM field. Due to the importance of aerospace and defense, the competition has always focused on aviation challenges. Most recently, the design challenges have revolved around UAS design and its use in precision agriculture. By being involved in this program, students gain real world experience by solving a real world challenge. The use of inquiry-based learning in this competition has the students learn how to solve design problems to be better prepared for future STEM careers. Besides gaining technical skills and knowledge, students practice team skills and have the opportunity to interact with mentors who are experts in their fields. With ten years of competitions, the RWDC team is now focusing on using the lessons learned to expand the scope of the project. One current plan is to create a curriculum based on the competition. This curriculum could then be used by teachers as a method to teach not only the technical knowledge such as engineering design and aeronautics, but also professional skills such as teamwork and written and oral communications.

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