

SUBSTM in Schools Australia

**STEM 4.0
LIFE-LONG
LEARNING**



INTRODUCTORY OVERVIEW

An Introduction to SUBS in Schools, Australia

Version 1.0

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RE-ENGINEERING AUSTRALIA
FOUNDATION

AUTHORISED AGENT

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SUPPORTERS / SUPPORTERS

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WHAT IS STEM

STEM is a methodology designed to integrate the four educational disciplines of science, technology, engineering and mathematics into a learning environment based on real-world applications and real world problem solving.

STEM is not just about more mathematics and more science but rather a curriculum based on the concept of educating students in an interdisciplinary and applied learning method. STEM education has proven to create more enjoyable learning, catalysing innovation and creating more capable students.

SUBS in Schools Background

Re-Engineering Australia Foundation, in association with the Australian Department of Defence and a number of industry stakeholders have developed the SUBS in Schools program. The program is focused on engaging student interest in the technology of submersible vehicles and submarines, and is built on the fundamentals of project-based learning.

SUBS in Schools is a high level STEM project where students have the opportunity to learn about complex Engineering Systems and build an operational Remotely Operated Vehicles (ROVs) or submarine.

Four levels (4) of participation exist within the SUBS in Schools program with each level designed to help students to explore scientific, engineering, materials and manufacturing techniques, with each level focused on different levels of complexity

Underlying these activities is an educational pedagogy which develops employability skills (21st Century Skills) in students which will aid their transmission to the world or work. These skills include communication, collaboration, presentation, teamwork and entrepreneurship. All of which are highly sought after by industry and invaluable in business environments subject to disruptive technologies.

A fundamental and key differentiator of SUBS in Schools is the requirement for students to work directly with industry partners in the context of their projects.

The tasks faced by the students within SUBS in Schools are no less complex than that faced by engineers working on real marine projects and thus the opportunity to collaborate with industry, as a means of solving these problems, will help to develop the communication and collaboration skills of the students.

PROGRAM GOALS

SUBS in Schools is based on Action Learning (AL) principles, which have an extended trajectory in terms of the involvement of the students and the outcomes that are achieved. Our experience has shown that programs which engage intrinsic interest over extended periods of time achieve a much higher impact in influencing children's career decision choices.

The goals of SUBS in Schools are to:

- Bring career relevance to STEM learning activities,
- Excite and encourage students to consider careers and a learning pathway related to STEM,
- Provide an alternative learning and skills development in schools,
- Building employability skills in students which provide students with increased employment options,
- Facilitate a cross-curricular education environment to enhance the outcomes of the education system,
- Promote innovation and the development of entrepreneurship in young people,
- Develop skills in students which are directly transferable to industry roles,
- Increase the number of students taking up STEM based careers in support of satisfying the skills requirement of large-scale Engineering programs.
- Facilitate technology transfer from industry to schools and the community at large,
- Raise STEM career opportunity awareness within schools and the wider community,
- Provide a catalyst for encouraging interaction and collaboration between schools, industry and the community,
- Encourage the collaboration between schools based in metropolitan environments with schools in country areas and internationally,
- Where appropriate, use the power of role models to guide and support our youth in the process of career development,
- Ensure that Science, Technology, Engineering and Mathematics becomes a part of the everyday language of students.

SUBS in Schools is structured to allow teachers and students to develop their understanding of design and technology over time.

IMPLEMENTATION IN SCHOOL

Coordinating SUBS in Schools at your school

SUBS in Schools can be implemented in a variety of ways. It's essential to consider the learning context within your school before developing an implementation plan. There is no relationship between how schools implement the program and success at a competition level. Schools will have processes in place, which will influence implementation. It is, however, important that the school understands the value of cross-curricular STEM at the school to maximise student opportunities.

Below are some scheduling suggestions based on observations from schools currently running SUBS in Schools.

1. After School as an Extra-Curricula Activity

Many schools run the program outside school hours as an extra-curricular activity. A dedicated day every week where students can spend time in their team groups with supervision goes a long way. When it comes around to competitions, teams might need to spend more days after school or their lunchtime working on the project.

2. As an In-Class Activity

Many schools will run the program within their teaching faculties. For example, a Technology faculty might make one of their junior projects the SUBS in Schools program and all students in the cohort will form groups to design and build a Submarine or ROV. The program has a natural fit as a cross-curricular teaching platform as it fits comfortably with Design, Art, Science and Maths. Cross-faculty collaboration however, can be challenging to achieve, but the benefits for the students are numerous.

For students to succeed in competitions, being able to collaborate is an essential skill and a mandatory task. If they can work in an environment where they see teachers collaborating, it can be inspiring for the students. Students taking on the program do much better when they drive decision making via collaboration.

3. Running a Dedicated Subject

Running the program as a dedicated subject is something that has been taken up by several schools. Fortunately, some schools are moving away from the siloed style of education and recognise that showing the practical applications of STEM subjects benefits students when they go back into individual subject lessons. Cross-Curricular education can be a challenge and requires a broader school commitment to the program for timetabling.

Note: The WA School Curriculum and Standards Authority has endorsed REA's SUBS in Schools STEM challenge and students completing this program from 2020 can count this learning towards their Western Australian Certificate of Education (WACE) and have the achievement reported on their WA Statement of Students Achievement .

FUNDAMENTAL TASKS - THE BASICS

Stepping Stones

SUBS in Schools is a multi-disciplinary challenge in which teams of school students between ages 11 - 18 have the opportunity to design and build mini remotely operated Vehicles (ROV's) and submarines. The program has been designed in a number of stages with each stage facilitating an increase in students' interaction with the concepts involved in under water vehicles allowing students to grow their knowledge and understanding over time.

Levels of Participation

There are four levels you can choose from. You can implement one or more levels depending on how you want to structure the program within your school but when entering the competition, you need to ensure compliance with any eligibility criteria. Some levels of the competition such as Level 2 Large ROV, support a Development and Professional Class.

Each level of the program, whilst having specific outcomes, is designed not to be overly prescriptive in terms of implementation. Teachers are encouraged to implement learning processes that work within their own educational environment.

1. Level 1: Mini ROV

Is designed for students in years 5-8 as an introduction to STEM and underwater vehicle operation. The task is to build and operate a Mini ROV with the focus being on learning the principles of buoyancy, propulsion and control. Small ROV model kits, together with instructions, are made available to the schools.

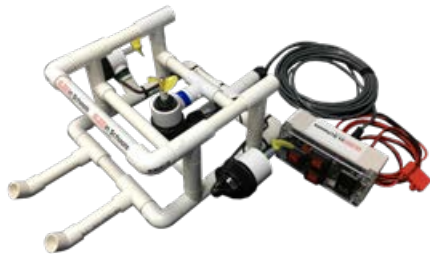


Level 1 - Mini ROV

2. Level 2: Large ROV

This is aimed at students in years 6-12 and involves a much larger component of design and construction. Students are required to build a larger scale ROV, able to support ancillary items such as cameras, robot arms and the like and able to undertake specific underwater tasks. At this level the students will be required to extend their understanding of the maths and science around underwater operation together with robotic control.

Development Class: Students in years 5-9 only build their ROV from a standard development class kit. Students must focus on buoyancy, performance and the addition of cameras and devices that allow them to pick up objects during the trials.



Professional Class: Professional class is an open design category where the students in years 7-12 have the freedom to design and build their own ROV in compliance with the Technical Regulations.



Level 2 - Large ROV

3. Level 3 - Spatial Design

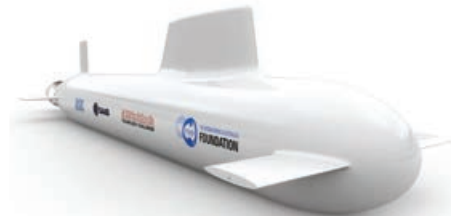
The task is to form a virtual design company, which will make a bid for the design of an accommodation space on-board a future submarine project. The students will then bring this design into a virtual reality environment to demonstrate their design. This level is designed for students in years 7-12 and is well suited to schools who do not have a significant workshop facility.



Level 3 - Spatial Design

4. Level 4 - Design an Operational Submarine

At Level 4, students in years 7-12 take on the design of an operating scale submarine. The task is to form a new design company from 3-5 students to design and build a new remotely operated submarine. The submarine must work within an operating environment defined by a set of rules. Q



Level 4 - Submarine

COMPETITIONS

Does a school need to compete externally?

Entering external competitions is not critical in running the SUBS in Schools program. Internal school competitions may be as far as you would like to take the process initially as you build skills in the school.

Running this project in your school and using the resources does require schools to register at no cost. The School Registration process will allow REA to understand the communications protocol and points of contact within your school. It will enable REA to keep you briefed about upcoming competitions, public exposure events, government grants and opportunities for support and collaboration with industry.

Once students step above the in-school competition, they enter a very competitive market. Competing outside of the school provides a platform where students have to operate outside their comfort zone. The number of competitors increases as does the quality of the competition. They can compare their progress against others outside their environment, which is no different from the real world where they will soon be competing for places at University and jobs. The better they can be prepared to take on the fierce competition, the better they will be able to make the transition to the world of work.

SUBS in Schools is the academic equivalent of team sports which provides an opportunity to undertake competition based on an academic pathway.

Students are required to adhere to strict rules and regulations, documented in two separate documents, the Technical Regulations and the Competition Rules. These documents, while extensive, can be simplified for internal school competitions but should form the basis for implementing SUBS in Schools internally.

What's involved in competitions?

There are many levels and classes of competitions through which teams can progress. To participate in tournaments, teachers must register their teams. Team Registration is independent to school registration and is only for teams looking to compete in State or National events. Progression to a National final is dependent on a team's performance in the State finals. The top teams progress based on performance with some 'wildcard' opportunities offered to teams with the potential or capacity to step up and operate at a higher level.

Competition Deliverables

There are several deliverables required for competition. An overview of these deliverables follows. The judging criteria for each of these deliverables are set out within rubrics contained in the Australian Competition Regulations.

1. Portfolios

Students produce portfolios outlining both their Engineering and Enterprise processes, decisions and learnings. The production of high-quality folios is a critical component of the program. They should evidence a wide range of topics including career development, marketing, collaboration, project management and budgeting.

Well produced portfolios have assisted students in gaining subject credits at University and be the differentiator in job applications.



2. Trade Display

In the real world, many great ideas fall if not presented adequately to the audience. Students produce a trade display and marketing material designed to pitch their team to prospective sponsors and investors. Visual articulation via the trade booth also drives a critical reflection of their engineering processes as students sell their ideas and concepts to an outside audience. Trade booths should articulate details about the team, the process they followed, and provide an opportunity to deliver a return on investment (ROI) for sponsors and collaborators. They should be structured to captivate an onlooker who is not familiar with their project.



3. Verbal Presentation

Developing a capacity to communicate effectively is one of the two essential Life-Long STEM skills. The verbal presentation process provides a platform for students to develop these skills. Students deliver a 10-minute oral presentation where they get to tell the story of their team and their project to a panel of industry judges. They also cover the skills and passions they have discovered in themselves and how these relate to their career pathway.

4. Collaboration with Industry

Students are required to collaborate and partner with industry and outline how they achieved these in both their portfolio and oral presentation. Industry collaboration can involve a diverse range of interactions which could include Defence Industries, large engineering firms, print shops, accountants, project managers and independent graphic designers.

5. Finding sponsors and collaborators

To fund their project students are encouraged to collaborate with their community, a fundamental skill required for any entrepreneurial activity, but can be a challenge for students to undertake for the first time. Once mastered however, it can be highly rewarding when students succeed. Funding and budgeting is a vital part of the project, and the activities undertaken in this area should be highlighted in their portfolios and oral presentations.

Funding can come from industry sponsorship, simple fundraising activities, government grants or from the school's P&C.

6. Judging

Unique to SUBS in Schools is that judges from industry are used where possible. Students often find they perform at a higher level and grow as individuals when compelled to operate in a commercial environment. Industry judges contribute to student learning, providing direct feedback to the students in a way that matches the real world, helping prepare students for life after school.

7. Trials

Watercraft trials is where the excitement happens. Trials are time limited events in which teams will be required to perform certain tasks or manoeuvres with their water craft in order to score points. Trials are generally conducted in swimming pools with maximum depths of approximately 2 metres.

Competition Levels

There are currently two levels of competition beyond an internal school competition. The following describes each of these steps.

State Finals

State Finals are organised by REA and are held late in term three and early to mid term 4 each year. Teams must be registered to be eligible for this level of competition. Event schedules can be found on the REA website using this link:

<https://rea.org.au/events-calendar-and-information/>

National Final

An REA organised event, students from all over Australia gather to compete for the opportunity to crowned National Champions in their representative class of competition.

It is intended in the future, there will be an opportunity for students to participate in this competition at the international level.

<https://rea.org.au/events-calendar-and-information/>

Competition Structure

All competition requirements are outlined in the SUBS in Schools Australian Competition Regulations which can be found within the Resources page of the SUBS in Schools website. Please be sure to read this document and the Australian Technical Regulations.

<https://rea.org.au/subs-in-schools/resources/>

IMPLEMENTATION & TECHNOLOGY REQUIREMENTS

The technology required in a schools to implemet SUBS in Schools is the following.

Access to a CAD Package

Students will be required to design elements of their watercraft components in a CAD package. Most schools will already have a CAD package being used by technology teachers and it is likely that will be adequate for SUBS in Schools. REA is able to extend our relationship with Dassault Systemes to provide schools with state of the art CATIA software through Dassault Systemes' 3D Experience Platform.

To access this free software click on the following link and select SUBS in Schools from the list.

<https://academy.3ds.com/en/challenges/3DEXPform>

CFD, FEA, PLM and simulation platforms are also accessible.

Access to 3D Printing Technologies

Some levels of the competition such as Levels 2 and 4, will require teams to design and manufacture components of their ROV and Submarine using 3D printing technologies. REA can help with this.

FEES & COSTS SUMMARY

The funding required by schools to participate, will vary depending on the level at which they enter the program. It will also vary depending upon the financial status of the school.

The following is an estimate of expense involved at each level of the competition.

1. Kits: Used in Level 1, 2 & 4
2. Additional Components and 3D printing: Used in Level 2, 3 & 4
3. Participation Fees: There are NO fees associated with schools registering to deliver the SUBS in Schools competition.
4. Team Registration Fees: At State and National Finals, REA will charge team participation fees. These fees will assist in funding the running of events including the provision of expo style booths for displays where relevant. Go to the Fees and Registration page of the SUBS in Schools website for our fee structure.
5. Competition Costs: Travel and accommodation costs associated with participating in any event. All travel and accommodation costs are the responsibility of teams and teachers.

Teams have the responsibility to raise sponsorship for all levels of the project including registration fees associated with participating in the Australian National Competition.

REGISTRATION

Schools delivering the SUBS in Schools Technology Challenge regardless of whether they intend on entering teams in the competition **MUST** register their school on-line via the REA website by the advertised deadline. There is **NO COST** for registering schools.

For competition planning purposes, teachers wishing to enter student teams in the SUBS in Schools competition **MUST ALSO** register their team/s on-line via the REA website by the advertised deadline.

To register your school and team, go to: <https://rea.org.au/subs-in-schools/fees-and-registration/>

CALENDAR OF EVENTS

To access information on SUBS in Schools events around Australia, go to: <https://rea.org.au/events-calendar-and-information/>

State Finals may **NOT** be scheduled in all States around Australia. This will be based on the number of registered teams from each state.

TEACHER FEEDBACK

Stephen Read: Brighton SS, SA

The SUBS in Schools program has proven to be an initiative of significant potential. I have been able to conduct a 'pilot' class with three Yr. 12 students this year, who all will receive passing grades, and in two cases, 'A' grade results. The students appreciated the diversity and challenge within the task, and responded diligently to be able to design and realise a functioning RC boat.

The learning opportunities abound in this context, for example designing a vessel to explore/monitor the Great Barrier Reef, including the work stations for the scientists on board, toilet and kitchen facilities, control systems for the crew etc. The imagination runs free!!

My year has been challenging, but so exciting. The science, mathematics and general staff are also excited, as SUBS in Schools is truly a significant STEM program.

Barbara Hender: St Peters Girl's School, SA

The SUBS in Schools program has been an innovative and exciting program to be involved with in 2014. The school commenced the pilot program in Semester 2 with fourteen Year 10 girls and we have enjoyed the challenge of learning new skills, applying mathematical and scientific concepts to practical tasks and working in teams.

The students enjoyed the interaction with industry (both industry visits and working with 'real' engineers); the opportunity to share their learning with engineers and others; and, to find out the pathways available into engineering. The strength of the course was that it was a STEM program that combined elements of many subjects, and had a practical hands-on approach with diversity to allow everyone to find their strengths, have an opportunity to be successful or challenge themselves with an area new to them.

As an all girl's school, students had no previous experience with design technologies. They learnt from first principles how to design using Autodesk 3D Inventor, Adobe Illustrator, PiktoChart, 3D Printing and Adobe InDesign software. This was a huge undertaking but their approach was determined and resilient. Likewise with construction technologies, the girls learnt how to solder and construct mini ROVs, and some indicated that this was one of the highlights of the program – testing buoyancy and determining ballast in the pool was enjoyed by everyone.

The girls enjoyed assembling the mechanical parts and remote operating the components. At times it was awkward assembling within the 3D printed parts and we were very grateful that the parts had been sourced and tailored to our design by our industry partner, Saab. Without instructions, what seemed obvious to engineers - they needed to decompose a problem into segments – was picked up by the students came to understand was a new way of thinking for the students. This helped them understand how the components worked together.

The biggest change in pedagogy was the requirement to work as a member of a team and focus on marketing, team management and portfolio design.

This needed to be balanced with the practical components and as we only had one semester; the course was somewhat rushed as we tried to meet all requirements. We got a working remote operated model submarine (almost) but had not time to work with the pressure cylinder, water-proofing, testing and controlling the submarine. Most of the girls have stated that, given another semester, we would probably have got there with assistance.

In terms of potential, the following evaluations from my students provide insight:

What did you learn about yourself and your learning? "I learnt that I could achieve things that I never thought I would be able to. I learnt that I can be a more independent worker."

What were the strengths of the SUBS program? "The strengths are that it teaches you to be confident when talking to people of higher authority, it teaches you how to work as a group, it teaches you how to do a task when there are no set instructions and teaches you how to problem solve under pressure."

How would you market the program to future students? "I would say that the SUBS program is a very valuable program and will teach you about yourself, improve your confidence, improve your teamwork skills. It is a program that will change your view on engineering and you will have experiences that will impact you in the future." As the teacher of the program, it has challenged and extended my knowledge and skills and my teaching practice in how I can design and deliver a successful program to my students. Specialised support has been available, however, the challenge for the teacher, is how to source and intertwine the theory and the practical, what level to pitch it at and make those links for the students between disciplines - all without any course material. On personal reflection, I have thrived on the challenge and wholly enjoyed the program and its potential for development now and for the future, and I look forward to 2015.

Brad Huggins: Noosa District SHS, QLD

The Submarines in Schools program has provided opportunities for Noosa District State High School's brightest Year 11 students to apply their academic prowess to a real world situation.

Some of these students had participated in the F1 in Schools™ program in Years 8, 9, 10 and felt that the SUBS in Schools™ program was a natural progression for them and pushed the boundaries in their understanding of STEM.

Due to our location on Queensland's Sunshine Coast, we have not enjoyed the opportunity to have access to industry collaborations that some of the other Pilot schools have had. Despite this, Noosa District has delivered several well-researched and thoroughly evaluated prototypes, two operational submersibles with cameras. A fully operational submarine should be completed in the very near future.

My personal opinion as the project coordinator is that this program has the potential with additional, on-going support could lead a world of new aspiring Engineers toward a multitude of disciplines through its scope of engagement and problem-solving analytical processes whilst expanding the possibilities of creativity, innovation and a brighter future.

INQUIRIES

All inquiries regarding the SUBS in Schools Technology Challenge should be directed to:

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