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Setting up a Community of Practice for a University CubeSat programme

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INTRODUCTION

CubeSats were introduced by Robert Twiggs from Stanford University and Jordi Puig-Suari from California Polytechnic as an educational project for engineering students [1]. Their aim was to give students a practical experience of designing, building, testing and launching a real satellite. The CubeSat standard has since spread around the world and is now used not only by Universities, but also by space agencies and industry.

In previous work, the authors conducted a survey of 45 University teams on how best to set up and manage Cubesat projects [2]. One issue raised by many respondents was the difficulty of passing information and expertise between successive cohorts of students. This makes developing a CubeSat at a University uniquely challenging; for instance, requirements may have been written, or a crucial design decision made, by a student who has since left the University. Another challenge is how to pass information between students and staff in different departments. To overcome these challenges, a “Community of Practice” (CoP) approach is proposed here as a way of connecting a University CubeSat community and of encouraging better knowledge management. This approach has not, to our knowledge, been used with a CubeSat project before.

The goal of this paper is firstly to describe how the University of Bristol CubeSat project was set up as a Community of Practice and secondly to evaluate the value of Community of Practice to the participants in a qualitative way, using the concept of cycles of value [3].

In this paper, the background section provides a review of the different areas relevant to this work: CubeSats, Communities of Practice and their evaluation, and Concurrent Design Facilities. The methodology section describes how the community was established and how the evaluation interviews and survey were carried out. The results section is split into each of the cycles of value and discusses some lessons learned and recommendations for other multi-disciplinary and multi cohort student projects. The conclusions summarise the key points.

1 BACKGROUND

The educational reasons why CubeSats are interesting to Universities include the opportunities for students to innovate, to experiment, to collaborate and to acquire practical experience of building spacecraft [4]. Several Universities using 'Problem-Based Learning' philosophies have adopted CubeSats as a project which equips students with technical skills, develops their ability to collaborate and their programme management skills [5]. Research has established that CubeSat projects provide students with the experience of challenging schedules, managing subcontracts, motivating a team and interacting with a customer which prepares them well for work in industry [6]. The University of Bristol has decided to build its own series of CubeSat satellites to add an exciting challenge to student experience, actively engage student societies, increase employability through cross-disciplinary teamwork and unite different subject disciplines with an interest in space.

University CubeSat programmes can struggle with knowledge management issues, due to their transient and multi-disciplinary workforce [2]. A proposed solution comes in the form of a Community of Practice (CoP). The concept of Communities of Practice was first proposed by Lave and Wenger, who defined them as: "*groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly*" [7]. Key characteristics of CoPs include support for formal and informal interaction between novices and experts in the community, the emphasis on learning and sharing knowledge, and the investment to foster the sense of belonging amongst members [8]. However, when evaluating the CoP, there are exist fewer studies. Value creation, as defined by Wenger [3] provides a simple yet flexible framework, already used in an educational context, upon which to establish the value of the community to its participants. The value creation is divided into 5 cycles of value and these cycles define a spectrum of value creation, from everyday interactions to impacts outside the community. These cycles are described in more detail in section 3. Each of these cycles produces a distinct data stream with specific indicators that can be monitored. Value creation will be used in this work to evaluate the value of the CubeSat Community of Practice to its participants in a qualitative way.

Many activities can be offered as part of establishing a Community of Practice and one of those offered by the University of Bristol to its students was a Concurrent Design Facility (CDF) activity. These are a way of parallelising the design work on different parts of an engineering system with all participants in one room working intensively. They are used in space mission design to reduce the length of early phase spacecraft design projects. CDFs have been used for many years at the European Space Agency [9] and by the NASA Jet Propulsion Laboratory Project Design Center [10].

2 METHODOLOGY

2.1 Developing the Community

The University of Bristol Satellite programme has been set up as a Community of Practice following the workflow described in Figure 1. The programme evolved from the wish to bring together the community of space researchers within the University together on a joint project. Both students and staff wished for the majority of projects to be established within the curriculum in order for students working on the projects to have credit for the work that they did. This involved the following Electrical, Aerospace, Mechanical, Physics and Earth Sciences disciplines working together with student societies. In order to decide the 'domain of interest', the authors liaised with the Research Directors of all University Faculties in order to call for ideas. The selected mission was proposed by the School of Earth Sciences, and its ambitious scope requires a multidisciplinary team of students. Feasibility studies were carried out by students to find out the key issues and technical drivers for this mission.

The next step after this, was to raise funding for physical infrastructure. Staff and students worked together to request funding. This included building a ground station and a satellite laboratory with test equipment, cleanroom and mission control but also procuring funds for student societies to provide training activities and competitions. This domain and key issues then established, it was then possible to identify the methods, tools and resources necessary to establish the community. In terms of tools, one of these was the online platform used as the main method of communication between the members of the community. Initially, the online platforms selected by the community, for their familiarity and ease of use, were a combination of the University of Bristol Virtual Learning Environment (Blackboard) and Google Drive. The following year, a different platform was provided based on Microsoft Outlook Teamsites/Sharepoint. This provided an internal website for students and staff, with a shared drive and easy way of communicating via the website and email.

Various different activities and tools were used to help build the community. Staff and students jointly organised an extra-curricular 'CanSat' competition to enable teams of students to build a miniature satellite in a soda can and drop it from a drone. This was aimed at encouraging novices or new students to join the community. This was a practical project which developed student skills in soldering, 3D printing, laser cutting, electronics testing and flight testing.

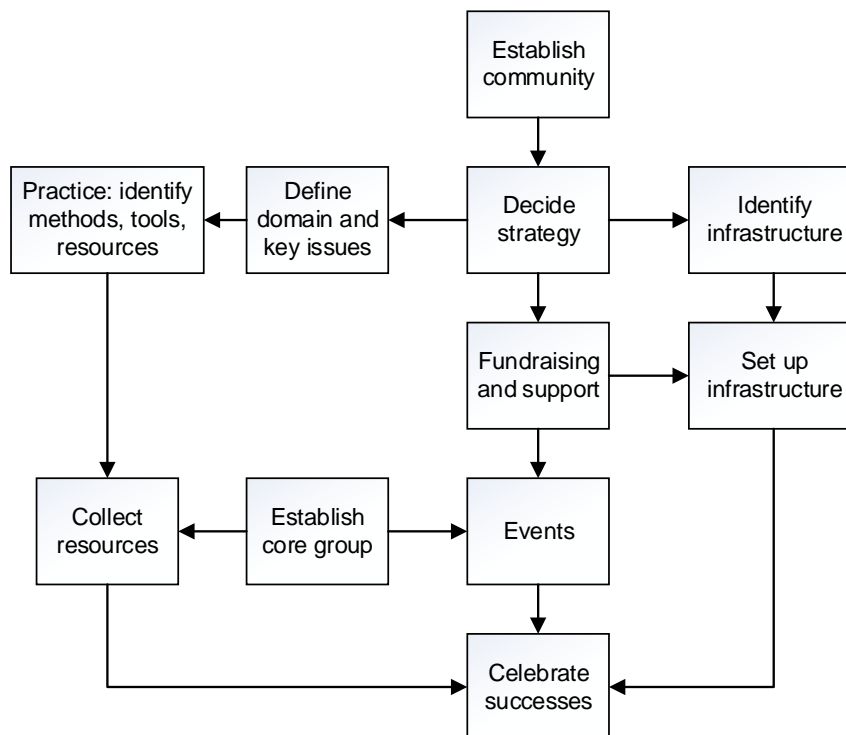


Figure 1: The process used to set up the University of Bristol Satellite programme as a Community of Practice

Social events included pizza evenings for students to get to know each other. Workshops were run to encourage all students working on curriculum-based projects to share their ideas and ask for advice from other students and staff. Three workshops were held for 20-30 students and 5-8 staff. At these, students presented and discussed their work in groups. An accelerated concurrent design facility (CDF) activity was run over 2 days in June 2017 for 4 staff and 13 students participating in projects. This was mentored and run by RALSpace Ltd, a world class Space laboratory.

2.2 Evaluation

The aim was to identify the value gained from activities such as the workshops, CDF and communication tools. So, at the end of the academic year, after all activities had been finished, a series of semi-structured interviews were held with 3 focus groups of students. The students were selected by availability. Nine students from 2nd, 3rd and

4th years were interviewed in 3 separate groups about their views of the Community and what value it might have contributed to their experience of the CubeSat project. The questions were based on the cycles of value concept developed by Wenger, Trayner, de Laat [3]. Ethics committee approval was sought and obtained for these interviews which were carried out according to University data and confidentiality regulations.

3 RESULTS AND DISCUSSION

3.1 Value Creation

The results from the interviews have been analysed through the lens of 'value creation', which is formed of 5 cycles of created value [3]. The interviews have been analysed qualitatively in the following sections, looking for comments which correspond to the different cycles of value.

Cycle 1: Immediate value - activities and interactions

In cycle 1, value is created by any connections made within the community. There was interaction between students from different years in the different activities, notably the workshops, competitions and CDF. Students commented that they gained: "more information about the whole picture that we want to achieve." Conversation during workshops was about solving problems or exchanging information. Students stated that a CDF set up was different to a university learning experience as: "there's no set right answer and it's really nice that ideas come and just get pinged around" where "everybody learns together" creating a "dynamic process for everyone's learning".

Cycle 2: Potential value — knowledge capital

In cycle 2, value created by the learning which has not yet been applied, is also known as 'knowledge capital'. The workshops and CDF allowed the application of lecture material theory to practical or theoretical projects. One student commented: "I can finally connect the lecture material ... with some calculations that I've been doing, which I think is very useful because I knew on paper how it worked but now I think I understand it as well". Also, the Community of Practice way of working gave students an insight into how projects may be completed outside an academic setting; "I've never had the experience of working with ... people who are way more qualified than I am in something, ... yesterday I felt a bit useless". A student commented that the CDF "doesn't give you a sense of completeness or correctness." This lack of 'completeness' is a new feeling for students used to marking schemes and solutions. This may be their first taste of working in industry on a real problem. Another summarised: "It gives a perspective of how engineers in this sector work".

Cycle 3: Applied Value – changes in practice

The third and fourth year students could apply their knowledge in workshops as they already had experience of the project in previous years. Of the CDF, one commented: “Everyone is working in such close proximity, it doesn’t really leave too much time for you to be twiddling your thumbs. It’s almost like a series of mini deadlines.” This meant “productivity is high.” The ‘mini deadlines’ were a different way of working to what these students were used to, but it had the outcome of changing how they worked and producing high productivity.

Cycle 4: Realised Value – Performance improvement

This describes the impact of the CoP on achieving what matters to the stakeholders. Students commented that being able to communicate in a setting like the workshop made the design process more efficient and improved the overall performance. A problem that took months to solve before just took a few days. The students felt “having everyone in the same room at the same time allows you to talk to people, get work done and I think it’s quite time efficient in terms of getting things done”.

Cycle 5: Reframing value: changing frameworks

Changing frameworks is the process of re-evaluation of the task and how the direction of the programme might be changed by the community. Examples of this included: “I think most people haven’t really considered how much we actually need to do for calibration”. This new understanding and redefinition of the programme is critical to the success of the project. Experts and more experienced students were more likely to gain this level of value.

3.2 Analysis and Themes

It appears from the analysis of the focus groups, that higher levels of value were created for students in higher years. This was perhaps because they had previous experience of the satellite programme to draw upon. This would have meant a more sophisticated understanding of the project and therefore more ways to extract value from the community. Students in lower years were ‘novices’ to the project and therefore had a steeper learning curve when they participated in the community. Novices found that the joint workshops were a good introduction to the project and useful for an overview of the CubeSat project. The CanSat competition was also popular with novice students and was considered a rewarding way of developing practical skills and getting ‘hands on’.

The 2-day CDF was considered by participants as both challenging and rewarding. The novices in earlier years found the learning curve challenging and sometimes felt a bit ‘useless’, but they benefited from the mentoring by the other students and industry experts. The 4th year students shared a frustration in feeling like they were repeating work that they had already done in their projects. However, many positives were noted by them including that design decisions could be made more efficiently as the

information was easily accessible. Other value created by the CDF included reframing of the mission and identification of future work.

Tools and communication were one of the most problematic areas of the community. Encouraging the students to communicate with each other sometimes felt like an uphill task for the authors. This may have been because the participants did not wish to rely on others for critical parts of their assessed work. However, during the workshops, students often realised that there were others working on associated areas, or that there was previous work which might be useful. This was vital for the continuity of the programme.

3.3 Celebrating Success

The last stage of the diagram in Figure 1 is 'celebrating success' and there have been many successes in the satellite programme. 70+ students have been involved with the community over the past 2 years. Many of those have gone on to jobs in the space industry with this relevant experience. Several students have won prizes at prestigious international conferences for reporting on their work and many more have gained awareness of workplace techniques and practical skills.

3.4 Lessons learned

The following are a list of lessons learned through the experience of setting up and running this community:

1. **Choose your tools wisely:** it is best to let the community decide the tools together. The authors have found an internal website with document storage very useful, but social media tools, such as Slack, failed due to lack of use.
2. **Attract in novices:** new members are the lifeblood of the community, but they need to be attracted in via competitions, workshops and exercises such as CDFs and then mentored. It is then important that they can access easily the legacy of previous work through summary documents, wikis, reports etc.
3. **Ensure regular access to experts:** access to expertise via supervision, workshops and CDFs is extremely helpful as students may go beyond the knowledge covered in their degree course.
4. **Use workshops:** these bring the community together; they provide a perspective of the direction and current status of the project, as well as motivation for all students.
5. **Communities boost skills:** the community activities helped students gain new skills including technical ones, such as 3D printing, Arduino programming and soldering and non-technical ones, such as programme management, peer to peer mentoring and time management.
6. **Consider whether to run as curricular or extra-curricular:** Embedding projects in a curriculum can be challenging: students can become driven by the format of the deliverable and the type of assessment. The advantages are that the students are rewarded for the time invested and have an

incentive to properly document their work. Extra-curricular activities need to have other incentives, such as gaining skills or prizes and deadlines.

4 CONCLUSIONS

In this work, the setting up of a Community of Practice has been used as a tool for the establishment and management of the University of Bristol Satellite Programme. In this work, the process of setting up the Community of Practice for this satellite programme has been described. This has provided a framework upon which to build a community of diverse stakeholders including local industry, students and academic staff. In order to evaluate the value of the community to its participants, semi-structured interviews with students from different years have been conducted. These have been analysed qualitatively using the concept of cycles of value. This identified the different levels of value gained by the students through these events. Overall, there was a pattern of the students in higher years gaining higher levels of value. Communities of Practice are a useful tool in multi-disciplinary long duration programmes such as CubeSat projects and lessons learned are provided to others contemplating similar projects.

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6 REFERENCES

- [1] H. Heidt, J. Puig-Suari, A. S. Moore, S. Nakasuka, and R. J. Twiggs, "CubeSat: A new Generation of Picosatellite for Education and Industry Low-Cost Space Experimentation," *AIAA/USU Conf. Small Satell.*, pp. 1–19, 2000.
- [2] S. Berthoud, L. Berthoud, and M. Schenk, "How to set up a CubeSat Project – Preliminary Survey Results," *AIAA/USU Conf. Small Satell.*, 2016.
- [3] E. Wenger, B. Trayner, and M. De Laat, "Promoting and assessing value creation in communities and networks: A conceptual framework. Report 18, Ruud de Moor Centrum, Open University of," *wenger-trayner.com/documents/*, 2011.
- [4] R. Twiggs, B. Malphrus, and J. Muylaert, "SSC10-XII-3 The QB50 Program , the first CubeSat Constellations doing Science," in *24th AIAA/USU Conference on Small Satellites*, 2010, vol. 12.
- [5] L. Alminde, M. Bisgaard, D. Vinther, T. Viscor, and K. Ostergard, "Educational value and lessons learned from the AAU-Cubesat project," in *RAST 2003 - Proceedings of International Conference on Recent Advances in Space Technologies*, 2003, pp. 57–62.
- [6] T. Hevers, E. Daehler, and M. Peck, "Applying University Small Satellite Program

- lessons to a career in the aerospace industry,” in *Small Satellite Conference*, 2013, p. SSC13-IX-6.
- [7] J. Lave and E. Wenger, “Situated learning: Legitimate peripheral participation,” *Learn. doing*, vol. 95, p. 138, 1991.
- [8] L. C. Li, J. M. Grimshaw, C. Nielsen, M. Judd, P. C. Coyte, and I. D. Graham, “Evolution of Wenger’s concept of community of practice,” *Implement. Sci.*, vol. 4, no. 1, p. 11, 2009.
- [9] M. Bandecchi, B. Melton, and F. Ongaro, “Concurrent engineering applied to space mission assessment and design,” *ESA Bull.*, vol. 99, pp. 34–40, 1999.
- [10] B. Sherwood, M. Adler, and R. Wheeler, “The New Team X: concurrent engineering advancement at JPL,” in *58th International Astronautical Congress*, 2007.