

Integration of a Short-term International Humanitarian Engineering Experience into Engineering Undergraduate Studies

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Abstract

Many of the humanitarian engineering education initiatives in Australia are developed and supported by Engineers Without Borders Australia (EWB-A). These include the EWB Challenge, an embedded first year coursework program, and the Undergraduate Research Program, providing service-learning opportunities for later year individual or group projects. These represent the extremes of an undergraduate degree, leaving a significant gap in the program for a student interested in humanitarian engineering. A link is required to support student learning in humanitarian engineering between these extremes. To fill, the EWB Humanitarian Design Summits were developed. These are two-week international experiences combining facilitated workshops, cultural experiences and a community visit. They provide opportunities for students to engage in a scaffolded community based humanitarian engineering experience. They are available to mid-program students to optional take and are designed to be a lead into later year service-learning projects. At one Australian university a range of curriculum methods have been used to incorporate the experience into students' formal program including work experience, research projects and a for-credit course. These have created different outcomes, with those more tightly integrated into a students' program providing greater opportunities for student learning.

Introduction

Humanitarian engineering education and related areas including global engineering, development engineering and engineering for social justice, have expanded rapidly since the year 2000. Formal undergraduate qualifications in humanitarian engineering are now available in countries including the USA (such as those at Colorado School of Mines¹, Penn State² and Ohio State³), the UK (including Coventry University⁴) and as of 2016, New Zealand (University of Canterbury⁵). Central to many humanitarian engineering education programs are service learning or learning through service (LTS) initiatives. These support opportunities for students to engage with communities, individuals or organisations and provide a service which will have benefits for the partner in addition to student learning outcomes⁶. These also provide benefits for recruitment and retention of students particularly from under-represented groups within engineering⁷.

The expansion of humanitarian engineering education initiatives and service-learning opportunities has been supported by a range of volunteer, not-for-profit and community groups. Significant among these have been numerous independent Engineers Without Borders (EWB) organisations established since 2000, notably EWB Canada (founded in 2000), EWB UK (2001), EWB USA (2002), EWB Australia (2003), EWB New Zealand (2008) and EWB-Asia (2014). In Australia, many of the humanitarian engineering education initiatives and service-learning opportunities are developed and supported by EWB Australia (EWB-A). These include the EWB Challenge, an embedded first year coursework program, and the Undergraduate Research Program, providing service-learning projects for later year individual or group work. These represent the extremes of an undergraduate degree, leaving a significant gap in the program for a student interested in humanitarian engineering. In addition, it was observed that students undertaking a final year project often did not have a relevant background in development or people-centred approaches. Without this, students

often took a strong technical focus in their final year capstone project, often at the expense of other contextual or people-centred factors, as observed in other studies and programs¹.

A link was required to support humanitarian engineering student learning between the extremes of a students' program. This link needed to provide scaffolded and structured activities to provide learning on communication, design and development approaches particularly leading into substantive or immersive service-learning projects. To fill this perceived gap, the EWB Humanitarian Design Summits were developed. These are two-week international experiences combining facilitated workshops, cultural experiences and a community visit. This is available to mid-program students to optionally undertake and are designed to be a lead into later year service-learning projects. A range of approaches have been used by universities to incorporate the experience into students' formal program including work experience, research projects and for-credit courses. This paper will provide an overview of the EWB-A Humanitarian Design Summits and their implementation within an undergraduate engineering program at a single institution in Australia. A summary of EWB-A's humanitarian engineering education programs will first be provided, including the EWB-A Summit. How these are incorporated into an undergraduate program at the Australian National University (ANU) will be described. Results in the form of student engagement on the first three Summits of 2015 will be provided, followed by a discussion of the initial results and impacts, as well as plans for further integration, evaluation and research.

EWB Australia Programs

EWB-A was established as an independent national EWB in 2003. It places around 20 volunteers a year with partner organisations in Australia, South and South-East Asia including Cambodia, India, Nepal and Timor-Leste. International volunteer placements are typically 12-24 months per placement with all costs to the volunteer covered and a living allowance provided. Volunteers are placed with host partner organisations ensuring the opportunity for capacity building and multiple placements if required. EWB-A supports a significant education program focusing on students in Australia. At an undergraduate engineering level, two well established programs are the EWB Challenge and the EWB Undergraduate Research Program, with the EWB Summit being offered for the first time in January 2015.

The EWB Challenge targets first year students and aims to provide an introduction to engineering through a humanitarian engineering project. Each year, one partner organisation is a focus for the Challenge, with a range of topics, challenges and resources identified with the partner. These are provided to universities to incorporate into first year classes as appropriate for their needs and context. In 2015, the EWB Challenge was used by almost 30 universities in Australia reaching around 10,000 first year engineering students, about 60-70% of the total first year undergraduate engineering population in the country. The EWB Challenge has been delivered internationally in the UK, Ireland and NZ, with over 50 universities in total being involved around the world in 2015. With such large numbers of students involved, there is no direct engagement between students and the partner organisation and community members. Resources are provided by EWB-A and if further detail is required an EWB-A volunteer placed with the partner sources the necessary information. At the end of each year, universities nominate up to four student reports which are provided to EWB-A. These are summarised and a portfolio of concepts and ideas provided to the partner organisation for them to select any that appear relevant, interesting or

require further work. Further evaluation of the EWB-A Challenge has been undertaken since it started in 2007⁸.

The EWB Research Program is a project-based service-learning initiative to support capstone courses⁶. EWB-A works with its partners and volunteers to identify projects suitable for final year engineering undergraduate or masters coursework students. These are not the first priorities for the partners, as those are the focus of volunteer placements, but common motivations for partners proposing and supporting projects include:

1. time available, partners are typically focused on implementation and on the ground work with very limited time for research, feasibility studies or design improvements.
2. additional expertise, both in terms of undertaking quality research and depth of specialist engineering knowledge.
3. access to equipment and resources, to enable controlled lab and experimental work to be undertaken making use of specialised equipment that would otherwise unavailable.
4. to think in different ways, by engaging with students and academics who can look at an organisation and its work with fresh eyes or a different perspective.

In 2015, EWB-A scoped and offered around 50 project topics. These are allocated to interested academics to supervise or students to incorporate into their studies, with some adaption for specific academic requirements and expertise being made. Students primarily work with an academic supervisor at their home institution, with support from EWB-A current or returned volunteers as required and possibly partner organisations. While many projects require little direct engagement with the partner organisation, all should incorporate relevant development models, appropriate technology principles, and build on a people-centred approach. At the end of the project the students' academic requirements, typically a thesis or research report, are provided to EWB-A and the partner, along with an appropriate open-access summary. Some projects have also completed articles for the open-access *Journal of Humanitarian Engineering*⁹.

The EWB Summit was designed in 2014 with the first Summit conducted in January 2015. These are two-week international experiences to a single country. Typically 40-50 undergraduate students take part on each Summit, supported by three facilitators, three mentors and up to three academic mentors. The Summits commence with four or five days of workshops and cultural immersions, typically in a major urban centre. Topics covered include community development principles, people-centred design, and cross-cultural communication. These provide preparation for the next phase of the Summit, a four to five day community visit, typically in a rural area. Summit participants are separated into three groups, each with a facilitator and one or two mentors, and visit a different community partner organisation. Within these visits, teams of three to five are formed to explore concepts for ideas, opportunities or challenges the partner has. Student teams are supported by the facilitator and mentors, providing a scaffolded way to experience development and people-centred design. All the student participants meet again to spend another four days working on their concepts and further cultural immersions. Each team then presents their concept, including a prototype and summary documentation, to the community partner.

Although community partners can take on-board any concepts or ideas, there is no aim or expectation that development and implementation work will be carried out as part of the Summit. This is captured in the Summits aims which include *supporting community partners by generating ideas for their project*. Other aims include *practise and promote two-way knowledge sharing and embedding people-centred values and approaches in engineering*,

technology and design education and practice. These aims remove some of the pressures and expectations that can be present in programs and trips that are built around implementation¹⁰ as well as potential ethical questions about unqualified engineering students working on implementation projects in overseas countries¹¹. Further development or implementation can be supported by EWB-A's Development program by qualified professionals (although volunteering their time) in consultation with the partner organisations.

A significant factor in the support, accessibility and growth of the Summits has been financial assistance from the Australian Federal Government. This was first through the previous Governments' *AsiaBound* program (2013-2014), replaced by the current Governments' *New Colombo Plan (NCP)* (from 2014). The NCP is a competitive funding pool with a number of programs, one of which can provide universities with scholarships of up to A\$3,000 to support a short term experience in the Indo-Pacific (Asia-Pacific) region. Universities can apply individually or in consortium's, for blocks of 10 scholarships to be used over 1 or 3 years. These scholarships can only be used by domestic (Australian) students. The total cost of taking part in a Summit includes the program, which covers all facilitation, accommodation, travel, insurance and food, with international airfares then an additional expense. Support from NCP scholarships typically covers about 60-70% of all these costs. Previous experience with EWB-A student work has highlighted covering 100% of the costs can have a negative impact, with the experience then seen as 'free' and students taking part regardless of the actual aims or their interests.

Humanitarian Engineering Education Incorporation into Coursework

As with all EWB-A education initiatives it is for each university to determine exactly how they are utilised within coursework programs. As one of EWB-A's formal university partners, the Australian National University (ANU) has been an early adopter of all of EWB-A's education initiatives. The EWB Challenge has been used in the first year introduction to engineering course since it was launched in 2007 while the EWB Undergraduate Research Program was piloted at the university in 2008 before being rolled-out across Australia. ANU was successful with 10 scholarships from the only round of the *AsiaBound* program, which were used for the first three Summits in January, June and July 2015. An additional 20 scholarships from the first NCP round will support students for the 2016 Summits and 40 scholarships have been secured from the second NCP round to support students on Summits from 2017 through to mid-2019. In 2014 ANU and EWB-A were successful with a joint competitive education grant to develop a dedicated later year humanitarian engineering course called *Engineering for a Humanitarian Context* (EfaHC) course, which was the first of its type in Australia¹². This was aimed at students in the second half of their four-year degree, and in particular those who had enjoyed the EWB Challenge in their first year and may be interested in undertaking a capstone project in their final year with EWB-A or a similar organisation.

EWB Summit Course Integration

With student funding available for the EWB Summits in 2015, the various ways it could be incorporated into a students' studies were explored. One requirement of the NCP is it must be aligned to a course that students can enrol in. The two expected ways were as work experience or contributing to a research project. However, as the new EfaHC course was to be offered for the first time as an intensive over the winter (June-July) break in 2015 at the same time as an EWB Summit to Cambodia, it was decided to use that offering of the EWB

Summit towards the EfaHC course requirements and learning outcomes. This meant the Summit was available to engineering students at ANU through the options below. A summary of the assessment tasks for the options is provided in Table 1.

1. to contribute to the *work experience* requirement. All students must complete 12 weeks equivalent work experience in order to meet their degree requirements. The Summit can be used to contribute 80 hours of work experience as a number of the facilitators and mentors on each Summit are qualified engineers.
2. directly as part of the final year individual capstone *research project*. All students must complete an individual research project, contributing 25% of their final years' coursework load. The Summit can be used to provide background or context for the project, or in a small number of cases, direct data collection, analysis and testing.
3. through a dedicated *for-credit course*. Students can undertake the Summit to contribute to the EfaHC course. Students complete one and a half days of workshops and three assignments before the Summit, with an additional day workshop and three assignments upon returning from the Summit.

Table 1: Assessment tasks for the curriculum integration options for EWB Summits.

Option	Assessment	Due
Work Experience	<ul style="list-style-type: none"> • Summative 5-page work experience report summarising work completed. 	<ul style="list-style-type: none"> • once all 12 weeks of work experience completed by student.
Research Project	<ul style="list-style-type: none"> • 6-page midterm report • 50-page thesis 	<ul style="list-style-type: none"> • end of first semester of project (½ way) • end of second semester of project (project completion)
For-Credit Course (EfaHC)	<ul style="list-style-type: none"> • 3-page Australian Development Context research report • 1-page Humanitarian Engineering Reflection • 3-page appropriate technology workshop report • 4-page Design Concept Proposal • 3-page Development Perspectives (Stakeholder) report • Humanitarian Engineering Portfolio (artefact consumable in 15mins) 	<ul style="list-style-type: none"> • before Summit • before Summit • before Summit • completed on Summit, submitted upon return • 4-weeks after Summit • 4-weeks after Summit

Outcomes

The EWB Summits commenced at the start of 2015, with three Summits to Cambodia in January, June and July. Based on student interest and demand, and further support from NCP funding, five Summits are planned over the long 2015/16 summer break, three to Cambodia and two to India. Across the first 8 Summits, students from 24 different universities in Australia are taking part. The number of students who have taken part in Summits at the ANU and the different options they have selected to integrate the experience into their studies is shown in Table 2. Advantages and disadvantages of the various options are provided in Table 3, while specific examples of the options are provided below.

Table 2: Number of students at ANU for each course integration option.

Summit (date country)	Course Integration Method		
	Work Experience	Research Project	EfaHC Course
January 2015 Cambodia	3		
June 2015 Cambodia	1	1	8
December 2015 Cambodia	1		
December 2015 India			1
January 2016 Cambodia	1		2
February 2016 Cambodia	2	2	2
February 2016 India			1
Total	8	3	14

Table 3: Advantages and disadvantages of the three options for EWB Summit inclusion.

Option	Advantages	Disadvantages
Work Experience	<ul style="list-style-type: none"> No course fees for students as a 0 credit unit value. Contributes 80 hours of work experience when can be difficult finding work experience with qualified engineers. 	<ul style="list-style-type: none"> No structured reflection or input from teaching staff or direct assessment items. Students 'paying' for work experience through cost of Summit.
Research Project	<ul style="list-style-type: none"> Provides field work component. No additional course fees for students. 	<ul style="list-style-type: none"> Limited to only a small number of days at one point during project. Only used as part of the research project, no structured reflection on the students' experience or their specific role.
For-Credit Course	<ul style="list-style-type: none"> Structured reflection and linking to assessment items supported by workshops before and after Summit trip. Can access additional government loans for their first overseas education experience. 	<ul style="list-style-type: none"> Students need to pay standard course fees for undertaking course in addition to cost of Summit.

Work Experience Student: Two of the students on the first Summit to Cambodia in January 2015 used the experience to contribute 80 hours towards their work experience requirement. Once they have completed the required 12 weeks, they will submit a description of their learning as part of a work experience report. Upon returning, one the students provided the following quote:

On the trip I learned how a systems engineering approach is needed to solve complex problems, and to apply the systems principles I had learned in class in a practical and unfamiliar environment. The workshops taught me not only about basic humanitarian engineering principles, but also about the Cambodian culture. Participating in the trip has let me meet a wide range of people, both peers and professionals, who I would not have the chance to meet usually. I hope to continue applying what I learned on the trip throughout my studies and professional career.

Both these students went on to enrol and complete the EfaHC course in June/July 2015, one achieving the highest mark in the class. Both are now currently volunteering with the local chapter of EWB-A. For these students, completing the EfaHC course after the Summit allowed them to use the Summit as a base for some of their assessment items and allowed them to reflect on the experience in a much more formal and structured manner than only through the work experience report:

After going on the EWB Humanitarian Design Summit in Cambodia I wanted to learn more about humanitarian engineering. EfaHC gave me the chance to build on what I had learnt in the summit, and was just as engaging and hands-on as the summit.

Research Student: Two students will be undertaking the Cambodia Summit in February 2016 as a direct link to their final year individual capstone research project. One of the projects is with a Cambodian organisation working on accessibility and inclusion for people with disabilities, and involves developing initial designs for a wheel-chair accessible tuk-tuk (motor-cycle powered transport). The project has been scoped by the organisation and an EWB-A in-country volunteer. For this project, attending a Summit was set as a requirement. The student will be able to visit the partner, see their current operations and transport available, and discuss their goals and aspirations for the project. The student will be accompanied by the EWB-A in-country volunteer to ensure appropriate communication and expectations. The student in this case is already an active member of EWB-A, and the project is allowing them to pursue further studies in an area of interest to them.

Course-Credit Student: All eight students who attended the June 2015 Cambodia Summit as part of the EfaHC course were able to utilise the experience for their assessment including the final portfolio assignment. The opportunity to reflect on their experience within the context of the assessment tasks was significant. A number of prototypes made while on the Summit were re-made for submission, and allowed the students to submit a ‘tested’ engineering concept for review along with feedback from potential users (the community partner). Specific comments received from these students included:

The combination of the Summit and in-class (pre and post-summit) allowed a great insight into Humanitarian Engineering and also a real-life experience of the context we were placed in.

Doing the course alongside the Human Design Summit allowed me to more deeply and critically engage with the summit, and ultimately made the experience more enriching

As a participant of the recent design summit to Cambodia, I incredibly valued the opportunity to partake in the course ‘Engineering for a Humanitarian Context.’ Not only was I able to understand the theoretical concepts of designing for vulnerable, disadvantaged and marginalised individuals and communities, but I was then also given the tools to sensitively and appropriately expand my vision as to the role of a humanitarian engineer.

By combining the [EfaHC] course with the Engineers without Borders Humanitarian Design Summit in Cambodia, I was able to apply the courses content to a real life situation and develop my community consultation and engagement skills whilst having the opportunity to travel and engage with like-minded students.

Multiple Engagements: During 2015, one student highlighted the potential benefits of multiple engagements with EWB-A initiatives to construct an informal specialisation in humanitarian engineering. The student completed the EWB Challenge in their first year, so had been exposed to humanitarian engineering, and then during 2015 undertook two Summits, the EfaHC course and a final year research project. On the initial Summit in January 2015 the student spoke with a number of community organisations during their community visit around solar energy, which was the students' discipline major. This led to a final year research project being scoped between the university, EWB-A and the community partner to explore the feasibility of household solar PV systems to supplement or replace the use of car batteries for lighting and phone re-charging. The student then attended the June 2015 Summit as part of the EfaHC course and as a student mentor for EWB-A. During this time, they sourced two small scale solar house systems based on their initial research and discussions with in-country suppliers. On the community visits for the Summit the student ran a number of workshops on solar PV and supported the installation of the two systems, one at the local school the other at a house (see Figure 1). The student was supported by a number of participants from the Summit during this time. The student then supported the community organisation through the initial monitoring of the systems, both of which are still in use 6 months after installation.



Figure 1: Students (in grey) conducting workshops on solar power at the local school (left) and the household system being installed by community members (right).

Based on their experiences, the student then applied for an EWB-A volunteer role in Cambodia specifically created to support the Summits and the potential further development of any concepts developed from them. The student was successful with this application, and within a month of completing their studies in November 2015 commenced a 20 month placement in Cambodia with EWB-A, being judged as the most appropriate candidate through the open competitive recruitment process.

The work is being continued by another student for their final year capstone project, after they attended the same June 2015 Summit, where they helped with the workshops and installation. This provides the opportunity for longer-term programs rather than just individual one-off projects.

As highlighted, an aim of the Summits is to support community partners by generating ideas for their aspirations and goals, which are available to community partners to use and further develop. From the first three summits to Cambodia in 2015 approximately 35 designs have developed, prototyped and presented from community visits. Of these, it has been observed that five concepts are known to have been further developed or implemented by the community partners. One example is shown in Figure 2. This prototype was developed with a partner working to re-establish mangrove plantations. This work involves collecting mangrove seeds and planting them in a bag filled with mud in order to germinate before being planted out. This is currently done by hand and is time-consuming. The concept developed by the student team on their community visit used waste water bottles and available pvc pipe to provide a way of filling the bags by placing the bag under the bottle to serve as a funnel (on the left of Figure 2). As can be seen on the right-hand side, although the specific prototype developed was not being used, the concept has been adopted and modified by the partner. This is now actively used and has reduced by half the time to fill each bag.



Figure 2: Mud bag filler, with the prototype concept developed by students on the left and the design as implemented by the partner on the right, with the prototype in the background.

Discussion

The rise in the number of well-organised engineering-related community groups over the last two decades has led to an increase in the opportunities for service-learning and extra-curricular activities for engineering students. While some opportunities have been relatively easy to align with formal coursework requirements, such as capstone design or research projects⁷, others have been more challenging to incorporate due to existing coursework requirements and constraints such as semester schedules, timetabling and existing demands on students¹. Integrating curricula learning through service programs and related extra-curricular activities has been recently piloted through the EPICS and EWB-USA student chapters¹³.

The EWB Summit can be considered both extra- and intra-curricular. It can be undertaken by a student to contribute to work experience because they are interested in humanitarian engineering or development work, or it can be the focus of a dedicated for-credit course. From the initial mostly informal feedback received and observations made, students incorporating the Summit for course-credit are gaining the most significant learning

outcomes. The student comments from the June 2015 Summit and the students from the January 2015 Summit who then undertook the EfaHC course all highlighted the opportunity to connect theory and concepts with practice and direct community engagement as significant. The return workshop and assessment items enables a structured de-brief and empowers students to discuss any concerns or questions they still have. Integration through the course provides an appropriate structure better aligned with the aims of the Summit, which match requirements of other similar courses¹. It also provides an opportunity to expand students' thinking by introducing further concepts such as human rights and engineering and social justice¹⁴.

Although only one example has been completed so far, the combination of the Summit for course credit with a following research project, especially when linked to EWB-A volunteer placements, has achieved outcomes far beyond any expectations. From the one completed example, household level solar PV systems have been introduced to a rural part of Cambodia and the student involved has been able to transition directly into a volunteer humanitarian engineering placement. With multiple scholarships already secured through to mid-2019, there is the opportunity to build longer projects and programs. For instance, it can be almost guaranteed that there will be students attending EWB Summits in Cambodia at least once every 6 months for the next 3½ years. This enables a long-term plan to be developed around community aspirations and provides regular face-to-face contact with partners to discuss opportunities and project work. This allows all those involved to start to move beyond just considering projects that can fit into a semester as well as supporting good 'NGO partnering' as work can be established in similar way to longer-term programs¹.

EWB-A's role in organising and delivering the Summits provides a critical mass of students across universities rather than individual universities needing to organise and prepare trips. Summits build on ongoing EWB-A community partnerships rather than universities needing to develop and manage those. This approach makes the implementation of a for-credit course to support the Summit at multiple universities simpler. The bulk of the 'course' is provided by EWB-A through the Summits, while universities are responsible for any pre- and post-workshops and assessment tasks. Participants also report the value of engaging with students from other universities and disciplines, to explore interdisciplinary practice. A higher than average female participation in the Summits has been observed, similar to other initiatives and studies¹³. Of the 125 engineering students to participate in the first three EWB Design Summits in 2015 (at the time of writing), 62 (49%) have been women. This is consistent with the percentage seen across all EWB-A initiatives and activities which is typically around 45%. Of the 14 students to undertake or plan to undertake the Summit for course credit at the ANU six are women, giving 43% involvement compared to the base percentage of women in engineering which is around 20%.

As highlighted, the aim of the Summits is not to develop and implement new technology or engineering. However, from the 35 concepts or prototypes developed by students on the first three summits, five are known to have been incorporated or improved and are being used by partner organisations, which represents one new concept for development per Summit.

Conclusion and Further Work

The EWB Humanitarian Design Summits are providing opportunities for students to engage in a scaffolded community based humanitarian engineering experience. Approaches and learnings are being shared across Australian universities to contribute to the development of

the Australian humanitarian engineering sector. Support from Federal Government funding through the NCP makes this more sustainable and enables integration of extra- and intra-curricular activities in a more structured manner. In the second and most recent round of the NCP program announced in 2015, twelve Australian universities received a total of 245 short-term scholarships to support students take part in EWB Summits in 2016 with Summits planned for Cambodia, India and Nepal. The work here, particularly integrating the Summits into a for-credit course, is of interest to these universities. This also contributes significantly to the development of a humanitarian engineering pathway for Australian engineering students, as originally intended, by providing engagement between the broad based EWB Challenge in first year and final year capstone projects.

In terms of the curriculum integration, students need to have the opportunity to incorporate Summits in some way while balancing the flexibility of opportunities (for example fitting into busy programs and work experience and internships) with achieving appropriate student outcomes. However, it is emerging that integrating the Summit through a dedicated for-credit course with the potential of undertaking a related research project provides the most significant student, and potentially community partner, outcomes.

Within the broader context of the EWB Summits, other elements of further evaluation are currently underway or planned. All student participants are being surveyed before, immediately after and again 6 months later on their views on engineering and social responsibility, with the first analysis due later in 2016. Additional investigation is planned on the involvement of the community partners involved. This has been incorporated into the EWB-A placement that commenced in November 2015 (by the student who undertook two Summits), to allow for data collection and short- and medium-term impacts. The role of the Summits as part of a broader humanitarian engineering program or pathway is part of the PhD studies of the lead author at the ANU.

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