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Interdisciplinary opportunities and challenges in creating m-learning apps: two case studies

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Mobile digital devices such as smart phones and tablets support mobile learning (m-learning) and this is reinventing pedagogical and curriculum approaches in education. The unprecedented growth in digital technologies, and the educational apps they support, provides a unique opportunity to increase engagement in learning anywhere and at any time. However, the development of m-learning apps requires collaboration between learning and content experts and technology specialists. Such interdisciplinary collaboration presents both opportunities and challenges. This paper describes two case studies related to m-learning app development with the aim of highlighting the range of educational and technical issues that arose in the collaborative process, and the solutions devised by the interdisciplinary team.

Keywords: m-learning, app development, interdisciplinary teams, literacy, academic literacy, higher education, digital learning.

Introduction

Mobile learning (m-learning) is upon us (Murphy, Farley, Lane, Hafeez-Baig & Carter, 2014; Nicholas, Fletcher & Davis, 2012; Paulins, Balina & Arhipova, 2015). The considerable uptake of mobile devices such as smart phones and tablets has provided students with the opportunity to grasp learning in the palm of their hands. Mobile devices mean that students can facilitate their own learning anywhere and at any time (Gikas & Grant, 2013). The most recent *NMC Horizon Report* (Johnson, Adams Becker, Estrada & Freeman, 2015) indicates that a proliferation of open educational resources is likely to occur within a mid-term time frame. This includes the development, widespread dissemination, and uptake of free or inexpensive educational apps. The development of such apps will require timely, intensive and creative collaboration between education experts and technology specialists. The educational fruits of such interdisciplinary collaboration will be immense, yet relatively little has been formally documented regarding the productive processes and potential pitfalls of such collaboration (Druin, Stewart, Proft, Bederson & Hollan, 1997; Herrington, Herrington & Mentei, 2009; Shankar, McAfee, Harris & Behara, 2013).

The purpose of this paper is to detail two case studies related to m-learning app development with the aim of highlighting both the range of educational and technical issues that arose in the collaborative process, and the solutions devised by the interdisciplinary team. One case study involves the 'repackaging' of an existing set of educational videos, targeting undergraduate students, into an app (*Uni Tune In* app), while the other describes the development of a serious game to improve literacy (*Apostrophe Power* app). The paper suggests that more scholarly attention needs to be paid to understanding the interdisciplinary experience of educational app development so that teams can harness the most appropriate expertise and skills to improve both the process and products of m-learning collaboration.

Some characteristics of interdisciplinary learning

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Interdisciplinary learning refers to the bringing together of knowledge and skills from more than one discipline so that these influence each other's perspectives (Ivanitskaya, Clark, Montgomery, & Primeau, 2002). In contrast to the additive nature of knowledge in multidisciplinary learning, interdisciplinary learning is integrative (Spelt, Harm, Tobi, Luning & Mulde, 2009). The integrative dynamic of interdisciplinary learning requires connections to be made between technical and basic knowledge, concepts, theory, methods of inquiry and, on occasion, paradigms (Ivanitskaya et al., 2002). Interdisciplinarity often involves 'solving problems and answering questions that cannot be satisfactorily addressed using single methods or approaches' (Klein, 1990, p.196). Hence, interdisciplinary collaboration involves approaching complex problems by bridging epistemological positions and the cultural attributes of specific disciplines (Woods, 2007). Combined, these aspects of interdisciplinarity can generate significant challenges for research teams.

One of these challenges involves communication and the building of common ground (Repko, 2008). Oberg (2009) suggests that, '(j)oint construction of common ground can be an especially taxing form of interaction' for interdisciplinary teams (p.158). Furthermore, effective learning within an interdisciplinary environment is often associated with attributes such as curiosity, respect, openness, patience, diligence and self-regulation (Spelt et al., 2009). Opportunities for individual and group reflection, over extended periods of time, are also key to identifying successes and acting upon opportunities in interdisciplinary teams (Woods, 2007). Interestingly, despite its often interdisciplinary nature, there is limited understanding of how these aspects of interdisciplinarity 'play out' in collaborations between educators and software engineers particularly in developing m-learning tools, and in agile design (Matthews, Lomas, Armoutis & Maropoulos, 2006). This paper explores such dynamics through two case studies of m-learning app development.

Context for the case studies and the interdisciplinary team

The setting for the interdisciplinary collaboration is the University of Newcastle (UON), Australia. UON is a relatively young institution (50 years old) with a strong history of engagement with its local community in regional Australia. This engagement has led to the development of an ethos of equity at UON, particularly with regard to providing access to higher education for 'non-traditional' students or groups of people that are underrepresented in Australian universities. Non-traditional students include those from lower socioeconomic and first-in-family backgrounds, Indigenous people, those with a disability, and mature age students (Schuetze & Slowey, 2002).

The impetus for the development of the m-learning apps discussed in this paper came from an identified need to assist in the academic preparation of undergraduate students and, in particular, students from non-traditional backgrounds. Specifically, research conducted at UON indicated that many undergraduate students were underprepared for the transition into university study and that their academic literacy needed to be improved to ensure academic success (Southgate, 2012; Southgate, Douglas, Scevak, MacQueen, Rubin & Lindell, 2014).

Academic literacy refers to the ability of students to use the English language to make and communicate meaning through speech and writing in academic contexts (Department of Education, Employment and Workplace Relations, 2009). Its core elements are: grammar; sentence structure; comprehension; academic writing; oral communication style; and analytical and critical thinking (Rolls & Wignell, 2009). Research indicates that there is a clear association between academic literacy skill level and success in tertiary studies (Kirkness, 2006; Rolls & Wignell, 2009). The rapid uptake of mobile devices by undergraduate students provided a new opportunity to deliver targeted educational resources to assist students to independently develop study and academic literacy skills.

The team that developed the *Uni Tune In* app comprised an education specialist (Southgate) and a computer scientist (Smith). The team that developed the serious game, *Apostrophe Power*, included an education specialist (Southgate), an educational designer (Stephens) and computer scientists (Smith, Billie and Hickmott).

Case study 1: *Uni Tune In* app

Background and educational issue the app addressed

In 2012-13, Southgate led a team of 25 UON academics and university student support staff on an

interdisciplinary project that aimed to produce resources to improve the transition experience of undergraduate students from non-traditional groups (MacQueen, Southgate, Scevak, Clement, 2012). Principles of transition pedagogy (Kift, Nelson & Clarke, 2010) underpinned the production of text and video resources for students and academic staff. One set of 17 short videos, called *Tune in to Uni*, focused on developing study skills and academic literacy. The intention was for these videos to be integrated into first year courses through the university's online learning platform. Examples of the videos produced include: active listening; reading like a university student; understanding the assessment task; how to fix 'run-on' sentences; and writing in paragraphs. Videos were deliberately short (2-4 minutes), in plain English, and provided worked examples on the topic. To facilitate learning, content in each video topic was 'chunked' (Woolfolk & Margetts, 2010) with information broken down into small components that linked to form a larger principle or skill.

Opportunities

Bringing together academics from various disciplines (education, psychology, linguistics, social work and business) with student support staff (Indigenous engagement, counselling and student learning development) created a 'hot bed' for creative ideas. The group decided to tap into an observed 'YouTube generation' effect by producing brief learning videos. The specific inclusion of literacy experts, educational psychologists and pedagogical specialists in higher education allowed for the translation of complex ideas into fun and accessible academic literacy and study skills videos. The *Tune in to Uni* videos communicated study skills and academic literacy information that was unlikely to date. This made the videos ideal for 'repackaging' into an app format. Students could download the free app containing embedded videos onto their devices and use them as an academic 'starter' guide, anywhere and at any time, without the need for internet access to stream the videos. For the sake of brevity, the app was called *Uni Tune In* (see Figure 1), and was made available free of charge through the iTunes App Store (March, 2015) and Google Play store (May, 2015).
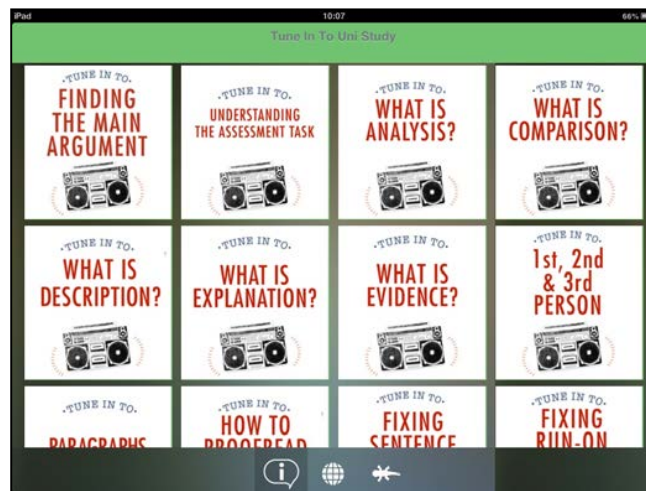

Figure 1: *Uni Tune In* app screenshot

The iOS version of the app was produced first because it made use of an existing app template and the software expertise of the app developer (Smith). However, as soon as the iOS version was released through the iTunes App Store, requests were received from academics and learning advisors at local and international institutions for an Android version. Thus, the development of the Android version was driven by demand.

Issues

The primary problem with repackaging the videos into an app was shrinking the video content, in MP4 format, to a suitable size. The 17 *Tune in to Uni* videos were an average of 17.3 megabytes each and the total size of the videos was 294.2 megabytes. The videos were resampled for an iPad screen using Handbrake, an open source video transcoder (see www.handbrake.fr). This reduced the average video size to 4.1 megabytes and the videos' total size to 69.8 megabytes. The final iOS app was 94.3 megabytes, including the iPhone and iPad user interface components for multiple screen

resolutions. As the target download environment was via wi-fi connections, this final size was deemed acceptable. However, when the Android version was being developed, it was found that the maximum size on Google Play for a standalone app was 50 megabytes. Thus the videos for the Android version were further reduced in resolution until the final app size was 40 megabytes. Each of these changes required additional specialist rework beyond the app and content development.

One key decision was whether to develop the app for a single platform (e.g. iOS only) or to build apps for multiple platforms (e.g. iOS, Android or Windows). Building for a single platform can simplify development and testing, and allows easy access to native device capabilities (Paulins et al., 2015), e.g. specific user interface elements, built in cameras, GPS sensors and accelerometers. However, this comes at the cost of limiting potential distribution avenues and accessibility to users with the supported platform only. Creating for multiple deployment platforms has resource implications, as multiple apps need to be built and maintained, with overheads in the technologies required e.g. Apple hardware and the Xcode independent development environment (IDE) for iOS and a Java IDE for Android, and developers with an extended skillset. An alternative is to use a more general development environment, such as HTML5, or an IDE that supports wrapping apps for multi-platform deployment, e.g. Xamarin (www.xamarin.com). However, wrapped apps may: (i) limit access to native device features (Paulins et al., 2015); (ii) add complexity, e.g. the use of third-party technologies, to the app development process; and (iii) require additional technology skills from the developers.

For the *Uni Tune In* app, the choice of a single platform was driven by the desire to quickly generate a prototype, and by the nature of the app development team, in this case a single developer (Smith) with significant iOS app development expertise. The move to an Android version, as noted above, was demand-oriented after the iOS version was deployed.

A further issue when developing apps with a small team is the required skillset for content development. In addition to the learning resources, development of the app itself is required, i.e. the underlying coding, and the app user interface such as app graphics, sound elements and interface components. For the *Uni Tune In* app, the learning resources came from the existing videos, and the app coding from the project's software engineer. However, in order to provide a professional look and feel for the user interface, an app template was purchased (from www.appdesignvault.com). This significantly reduced the app development time by removing the need to generate user interface graphics.

The key decision here was to use a general template with its associated time and cost savings instead of employing a graphic designer (or similar) to develop customized interface content. However, customized interface content would be necessary should an app's look and feel be required to meet specialized criteria.

Lessons learned

The interdisciplinary work in creating the content for the *Uni Tune In* videos was complete by the time the idea for app development occurred (see Figure 2). Although the videos appear to be simplified explanations of study skills or aspects of academic literacy, the process of creating the content was intellectually difficult because it brought together disciplinary perspectives and specialist knowledge. It was also time-consuming, taking twelve months to complete. In contrast, the app development was relatively quick, although there were technical issues to work through.

It is worth considering repackaging existing educational resources into apps if they have a reasonable 'shelf life' (like academic literacy knowledge and study skills). The mobile-learning format of apps provides educators with an opportunity 'to enhance their educational toolkit' (Arnab et al., 2014), expand the uptake of educational resources, and allow students real time access to academic literacy knowledge and skills at the point of need.

Uni Tune In is available for free download for iOS devices from the iTunes App Store (https://itunes.apple.com/us/app/uni-tune-in/id971888771) and for Android devices from the Google Play store (https://play.google.com/store/apps/details?id=reptiliaware.com.unitunein)

	J	F	M	A	M	J	J	A	S	O	N	D
2014												
Academic literacy content and video development						■	■	■	■	■	■	
Throwaway prototype app with dummy videos											■	
Uni Tune In series videos provided to developer											■	
2015												
First full version of *Uni Tune In* app	■											
Uni Tune In (iOS) in iTunes App Store			■									
Android *Uni Tune In* development started				■								
Uni Tune In (Android) in Google Play Store					■							

Figure 2: *Uni Tune In* app development timeline (2014-2015)

Case study 2: *Apostrophe Power* app

Background and educational issue the app addressed

A large proportion of the Australian adult population has poor literacy. The Australian Bureau of Statistics (2006) reports that approximately seven million Australians have literacy below the minimum level needed to fully function in life and work. Poor grammatical literacy has been documented in some of the Australian university student population (Hendricks, Andrew & Fowler, 2014; Scouller, Bonanno, Smith & Krass, 2008; Southgate, 2012). Without adequate literacy, undergraduate students are unlikely to succeed academically or want to continue with their studies.

The *Apostrophe Power* app is a serious game (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012) designed to assist students to improve their use of the different functions of apostrophes, including ownership, contractions of words, and irregular uses of apostrophes (or 'misfits' as we have termed these). In *Apostrophe Power*, the learner must drag the apostrophe into the correct position in a sentence under a time constraint – this being before the mouse avatar drops into the water as the island it is standing on slowly sinks (see Figure 3). The goal is to place the apostrophe correctly in ten sentences so that the mouse leaps from island to island until it reaches the cheese at the end of the level. There are three levels of difficulty for each apostrophe function and a combination level that combines the uses of apostrophes to test the learner's skill.

Opportunities

The advent of the serious games movement has created an opportunity for educators and instructional and software designers to collaborate in the creation of learning games that incorporate the characteristics of leisure games such as fun, flexibility, competition (including self-competition) and goal mastery (Charsky, 2010).

People of all ages now play app based games and the *Apostrophe Power* collaboration capitalized on this trend to develop a fun way to learn about the function of a component of language (apostrophes) to improve the literacy of students. An app based serious game is particularly relevant to the area of

literacy improvement as students can learn in a flexible and fun way, in private. This was important because it was reasoned that serious games played in private could help alleviate feelings of shame or embarrassment felt by students who exhibit poor literacy (Nicholas et al., 2012). This makes app based serious games on sensitive topics an ideal tool for promoting learning and equity in schools and universities.

The collaboration in developing *Apostrophe Power* was a creative dialogue that melded the following: (i) equity issues in higher education and the need to produce a *free* literacy resource that would be attractive to a wide range of students, including non-traditional students; (ii) instructional design for literacy acquisition; and (iii) the incorporation of game characteristics such as challenge, level of difficulty, rewards, enjoyment and usability.
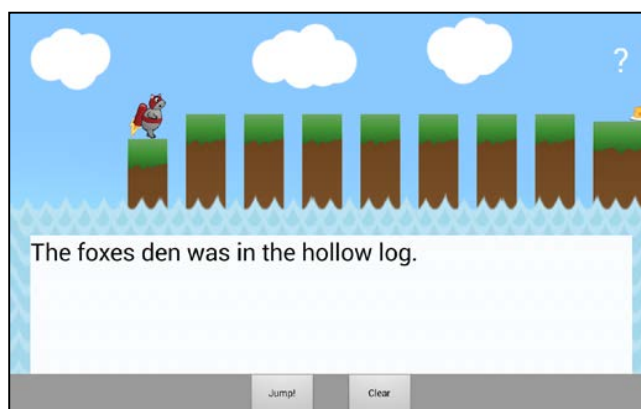

Figure 3: *Apostrophe Power* app screenshot

Issues

One of the major challenges in creating the *Apostrophe Power* app was the time it took to develop the scope and sequence of the exercises in relation to aspects of gamification. For example, there were decisions to be made about grouping or separating the functions of apostrophes into game categories such as contractions, ownership (single and plural possession), and one common example of misuse (its and it's) that we categorized as misfits. A fourth category containing exercises which combined the various functions of apostrophes was also developed. Within each category we designed three levels of difficulty (easy, medium, hard) and developed a bank of 20 exercises for each level, for the learner to cycle through as they attempted to achieve 10 correct answers. The exercise development was a lengthy process of rewriting and reworking to take into consideration a number of factors. For example, for the ownership category, especially plural possessives, the exercises were crafted to ensure that context was provided, otherwise there could have been more than one correct answer, e.g. "the boys lunches" could mean either one boy who had lots of lunches, or more than one boy, each of whom had one or more lunch. Ensuring context that provided clarity within a 100 character limit (including spaces) was challenging. Repetition of key phrases and concepts needed to be minimized or eliminated. This was an issue not only within each category but across the game as a whole, so that users would not gain the impression that the exercises were boring and repetitive, which could have led to learner disengagement. We were also careful to eliminate or avoid mentioning certain jobs or fields of study, popular culture or Australian cultural references and colloquialisms, and to present exercises in plain English. This ensured that the concepts could be understood by students for whom English is an additional language, and as part of a more common frame of reference. The combination category, in particular, took the most time to develop due to its complicated exercises.

Gamifying these exercises involved an almost constant process of dialogue and iteration between education specialists and computer scientists, with considerations of cognitive load and the exercise length, complexity and structure paramount. Much consideration was given to the issue of cognitive load or short term memory and its influence on learning (Woolfolk & Margetts, 2010). Consideration of cognitive load was important in judging the optimal time required to undertake the exercises to build positive excitement rather than negative anxiety in play. Getting the timing right for each level was

also vital. Achieving the correct balance of excitement and time for processing information and undertaking the exercises ensured that users would experience ongoing improvement in their skills, which is a key factor in positive engagement (Whitton, 2011). Similarly, the issue of the length of the training module and placement of hints in the game, both key 'scaffolds' (Woolfolk & Margetts, 2010) to assist students towards mastery, took considerable time to resolve and involved experimentation and iterative refinement.

Sometimes it was decided not to gamify an aspect of apostrophe usage because it required a different approach in the game. For example, it was recognised that one of the main problems that students had with contractions was not necessarily which words formed a contraction, but where the apostrophe should be positioned to indicate the contraction. So, positioning the apostrophe correctly became the focus of these exercises. In addition, the on-screen functionality required to either form a contraction, or expand an existing contraction, as well as place or remove the apostrophe, was significantly different to the 'drag and drop' functionality used in every other game category. Rather than risk frustrating or disengaging users with such a large shift in functionality, it was decided to continue to feature the drag/drop function and to only ask users to correctly place the apostrophe within an existing contraction.

One interesting point of tension within the team was the issue of 'gold-plating'. The education specialists were concerned with both producing content and developing an engaging, aesthetically pleasing user interface. The computer scientists were more reluctant to talk about the latter, preferring to explore it towards the end of the project. This tension was apparent throughout the project as the education specialists expressed their continual desire to imagine the look and feel of the game from the perspective of the learner.

Another team challenge was the relative lack of a shared expert knowledge base and specialist language to talk through and resolve issues. Each team member needed to acquire some of the specialist language of the others, and this was more of a tacit rather than an intentional practice. Translating ideas and concepts and their implications between disciplinary fields was important and part of an ongoing experience in building 'common ground'. A simple but illustrative example of the difficulties in building common ground came with the use of the term 'place-holder'. This term was used by the computer scientists to refer to parts of the game that were earmarked for development but was not understood by the education specialist. In fact, it was misunderstood as a lack of progress in developing key elements of the game. The inclusion of an educational designer in the team did assist with some of this translational communication but it was (and continues to be) a steep learning curve for all involved. Scholarly investigations into the dynamics of interdisciplinary collaboration in education apps and serious game design are required as a matter of urgency so that pitfalls can be avoided.

A number of technical challenges also existed including the app development approach and the development of app content. Similar to the *Uni Tune In* app, a native app approach was taken in this project. It was felt that a wrapped approach might unduly constrain the project while scoping design issues with initial prototypes. For example, touch-based interaction and the logging of app analytics (Smith, Blackmore & Nesbitt, 2015) were considered desirable features and a native approach would more readily facilitate these features.

The project team selected the Android platform for initial development work as this platform supports extremely easy distribution of app prototypes. In comparison to iOS app builds that can be difficult to share directly, the early versions of the Android app could be uploaded to a shared online folder (e.g. www.dropbox.com) and team members could then install and test versions of the app directly on their own devices. This allowed for a very fast review cycle of working prototypes and helped reduce interdisciplinary communication barriers between the software engineers and the education specialists. After the Android version of the app was completed, a specialist developer was then employed to develop an equivalent iOS version.

To aid the development of the app itself, specialist developers with Java experience were employed by the project to support the initial Android app. Given the graphical nature of computer games, which is shared with many serious games, there was a need to also generate or obtain suitable graphical components for the app. For the *Apostrophe Power* app, a combination of in-house graphics and affordable online graphics (from www.gameartguppy.com) were used. The project's software

engineers developed the in-house graphics. This had the advantage of a fast review cycle for new graphical elements and local customization of graphics for the app, but the disadvantage of diverting resources from app coding and testing. Thus the purchase of some online graphics was a compromise to balance project resources.

The *Apostrophe Power* app will be available for free download for iOS devices from the iTunes App Store and for Android devices from the Google Play Store in December 2015.

Lessons learned

Gamifying learning for literacy, even for the seemingly straightforward functions of an apostrophe, proved to be thought-provoking and time consuming (see Figure 4). It involved sometimes daily communication about content development between the education specialists, and between education specialists and computer scientists. Melding the learning elements with the gaming elements was challenging, with experimentation and multiple iterations required. Balancing the learning with the gamification led, in one instance, to the decision not to include an important function of the apostrophe in the game (forming contractions). In some cases there were misunderstandings concerning discipline specific terminology and there was a constant tension between the desire to understand from a pedagogical point of view what the learner would see and feel and the issue of gold plating as an end stage process.

	J	F	M	A	M	J	J	A	S	O	N	D
2014												
Develop apostrophe content/exercises								■	■	■	■	■
Develop Android app v1								■	■	■		
Refine app v2 and apostrophe content											■	■
2015												
Refine app v2 and apostrophe content (cont.)	■											
Develop evaluation (v3) and release (v4) versions	■	■	■									
Android apps complete				■								
iOS app developed		■	■	■	■	■						
Apostrophe Power user study (using v3)							■	■	■			
Android and iOS versions on respective app stores										■		

Figure 4: *Apostrophe Power* app development timeline (2014-2015)

Some general observations

The collective experience of the team in developing two educational apps has highlighted a range of issues that both enable and constrain collaboration and the production of high quality m-learning tools. Constraints often relate to technical aspects of the project, time, and the need to be patient, intellectually open and willing to learn with colleagues from other disciplines. Perhaps the greatest overall challenge facing the interdisciplinary team was 'selling the idea' to funding bodies who appeared to lack insight into the myriad educational possibilities that m-learning tools and serious games can offer. A key area for further exploration is the area of 'hybrid' projects, those that are interdisciplinary in scope and comprise both applied research *and* product development in the field of higher education, and how hybrid projects can better capture the imagination of traditional funding

bodies. Moreover, attracting enough funding for rigorous evaluation of usability and impact on learning is a further challenge. Another area for exploration is the enhancement of the limited skills that academics have in knowing how to effectively market and promote m-learning tools both within the national higher education sector and globally.

Conclusion

Interdisciplinary collaboration offers exciting opportunities to repackage existing learning resources into apps and the ability to tap into popular trends in leisure gaming to engage students in independent learning. Interdisciplinary collaboration is not always easy, particularly when adopting a more agile design approach, but it can generate deep expertise and creative synergies. These can be harnessed to develop m-learning tools that respond to complex social problems, including the need to provide all students with the opportunity to develop good academic skills and literacy.

Acknowledgments

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