Experiences and Competencies of Final-Year Technology Student Teachers during Their Work-Integrated Learning

A Longitudinal Study

Rina Grobler and Piet Ankiewicz

Alternative entrance requirements and flexible curriculum options for the four-year BEd degree in technology education were implemented in 2016 attempting to combat the trend of decreasing enrolment numbers. The entrance requirement of Engineering Graphics and Design (EGD) in year 12 was dropped, and Engineering Graphics and Technology Education (EGTE) as major at second-year level combined with Physical Sciences or Geography or Mathematics at third-year level, was introduced. The experiences and performances of students with or without EGD in year 12 were documented over a period of four years. The findings after the first stage of this longitudinal study, which were reported at the PATT36 conference, indicated that having done EGD in year 12 was not essential to pass at university level provided that sufficient support was provided to meet students' needs and challenges. However, the students' experiences and competencies during their final-year work-integrated learning period (WIL) is still unknown. The purpose of this stage of the study was to determine the students' experiences and competencies during WIL. The research questions were: How did the WIL experiences of students with EGD in year 12 compare to those without EGD? How did the teaching competencies of students with EGD in year 12 compare to those without EGD? During the seven-week WIL period at schools, an observation schedule was completed for each student and a focus-group interview was also held. The findings revealed that implementing more flexible curriculum options, utilizing innovative and creative pedagogical practices, and receiving the required support from their mentor teachers during WIL, contributed towards these students becoming competent EGD teachers.

Keywords: Flexible curriculum options, Innovative and creative pedagogical practices, Longitudinal study, Technology teacher education

Introduction

To combat the trend of decreasing enrolment numbers for the four-year BEd degree in technology education as part of the Initial Professional Education of Technology Teachers (IPETT) programme at a South African university, alternative entrance requirements were implemented in 2016. Engineering Graphics and Design (EGD) at senior secondary school level (year 12) as entrance requirement was dropped and Engineering Graphics and Technology Education (EGTE) as major at second-year level could be combined with Physical Sciences or Geography or Mathematics at third-year level. The experiences and performances of students with or without EGD in year 12 were documented over a period of four years. The findings after the first stage of this longitudinal study, which were reported at the PATT36 conference (Grobler, 2018) indicated that having done EGD in year 12 was not essential to pass at tertiary level if sufficient support was provided to meet students' needs and the challenges they faced.

The purpose of this second stage of the study was to explore the students' experiences and competencies during their final-year work-integrated learning period (WIL or school practical). The research questions were the following:

How did the WIL experiences of students with EGD in year 12 compare to those without EGD? and How did the teaching competencies of students with EGD in year 12 compare to those without EGD?

Context of the study

Due to the more flexible curriculum options and alternative entrance requirements, more intensive support was provided to the students who entered the programme without having done EGD in year 12. During their first and second year of study a double period per week was assigned for practical apprenticeship for year 10–12 EGD, which was facilitated by an expert who was appointed as a tutor and provided guidance in a peer-based collaborative learning environment (Jakovljevic & Ankiewicz, 2015). During these tutorials the purpose of the interaction between the expert and the novice students was particularly to develop their procedural knowledge (*knowing how*). During their second year of study an additional expert was appointed as a tutor assistant to provide individual attention during the tutorials and consultation times to assist the students to cope better with the learning content.

The students who participated in this second stage of the study had gained discipline knowledge in their major (EGTE 1, 2, and 3), generic pedagogy (Teaching Studies 1, 2, 3, 4 and Teaching Methodology and Practicum 2), as well as specialised pedagogy (Teaching Methodology and Practicum focusing for Senior Phase {year 8–9} and Further Education and Training Phase {year 10–12}). During their third and fourth year the students also did the school subject knowledge for EGD, in line with the Curriculum Assessment Policy Statement (CAPS) for Senior Phase (DBE, 2011a) and Further Education and Training Phase (DBE, 2011b). During their final year, these students had to do ten weeks of WIL in approved schools, for three consecutive weeks during the first semester and seven consecutive weeks during the second semester. Two of the schools where students were observed were under-resourced public schools in a less privileged, developing environment. The findings regarding this stage of the study are based on the seven-week WIL period.

Literature review and theoretical background

A tutorial is a cognitive and practical apprenticeship (Jakovljevic & Ankiewicz, 2015) with coaching, scaffolding, and prompting in a collaborative learning environment. According to Arzello, Chiappini, Lemut, Marara, and Pellery (1993) cognitive apprenticeship is an interaction between an expert and a novice aimed at enhancing the cognitive and metacognitive skills of students (Jakovlejevic & Ankiewicz, 2015). Tutoring forms part of a university's teaching-learning process and is a basic strategy for improving students' academic success and professional goals (Morillas & Garrido, 2014). It can be regarded as a 'high impact practice' (Motsabi, 2018). It helps to improve the performance of students because tutors assist in making academic knowledge accessible and provide epistemological access (Boughey, 2005). The tutor as the expert, with the help of an assistant tutor, are actively involved in coaching and scaffolding the development of students' engineering graphics and design skills.

Shulman (1986) argued that there is growth in the knowledge of teaching specific to the process of converting subject matter for the purposes of teaching. He described pedagogical content knowledge (PCK) as a special type of knowledge that only teachers have. It involves the process whereby teachers transform special knowledge of their subject discipline into content suitable for effective pedagogical dissemination (Shulman, 1986, 1987). To expand on this notion, Gess-Newsome (2015) defined PCK as personal knowledge that teachers use to design and reflect on instruction within context. She also defined pedagogical content knowledge and skills (PCK&S) as the "act of teaching" (p.36) and this differentiates between what a teacher knows ("knowing that") and what they are able to do ("knowing how"). According to Ruhaan, Taconis and Jochems (2009) the PCK required to facilitate a design task in the context of technology education is different from the PCK required to facilitate a task in the context of science education or mathematics because tasks in technology education tend to have a more open-ended character. Banks, Barlex, Jarvinen, O'Sullivan, Owen-Jackson and Rutland (2004:144) stated that: "Compared with other subjects, such as science and mathematics, perhaps a teacher of technology is less in a position of being a 'fount of wisdom' but rather a guide to help a pupil ...".

Gill (2019) argued that the act of learning through doing is important for developing proficiency in both knowledge and skill. Gill's (2019) research revealed that if pre-service teachers view their subject knowledge as deficient, their ability to adapt subject matter for teaching is compromised. Irving-Bell (2019) found that weak subject knowledge has a significant impact on a pre-service teacher's development. A lack of subject knowledge prevents a pre-service teacher from developing the ability to transform subject matter into pedagogical content in order to make knowledge accessible to a learner.

Banks et al. (2004) produced a graphic framework (Figure 1) that helps to visualise the different aspects of teacher professional knowledge.

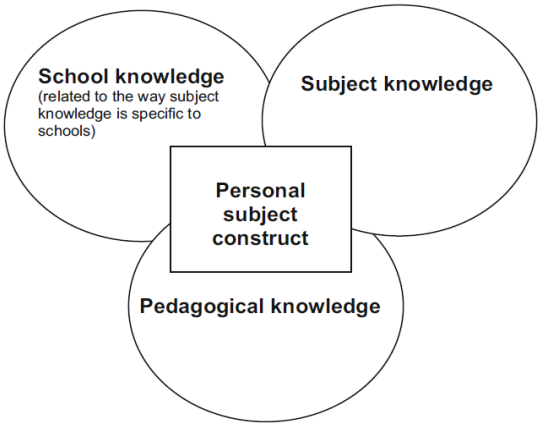

Figure 1. A model for conceptualising teacher professional knowledge (Banks et al., 2004, p. 143)

The model indicates that within Design and Technology a teacher's personal subject construct comprises a combination of school knowledge, subject knowledge, and pedagogical knowledge. According to Martin (2018) subject knowledge forms a key element of the professional knowledge needed by pre-service teachers. The dynamic intersection of subject knowledge, school knowledge and pedagogical knowledge constitutes teacher professional knowledge (Banks et al., 2004; Engelbrecht & Ankiewicz, 2016). In addition, teachers' subject knowledge is enhanced by their own pedagogy in practice and by their contextual expectations, which form part of their school knowledge. Therefore, a teacher often understands a topic better after teaching it to learners.

Research design

During this longitudinal study, a pragmatic paradigm was adopted which made it possible to use multiple methods and different forms of data collection and analyses (Creswell, 2003) over consecutive years. A mixed-method approach was used whereby quantitative and qualitative data were collected (Creswell, 2003; 2005). During this second stage of the study a concurrent strategy was applied whereby different methods of data collection were used during the same time and the information was then integrated in the interpretation of the overall results (Creswell, 2003).

Extreme sampling, a form of purposeful sampling (Creswell, 2005; Flick, 2009) was used whereby all the final-year technology education students completing their WIL period participated in the study. Four of the five students did not have EGD as a school subject in year 12. Each student was placed at a different school for the seven-week WIL period. To assess the students' competencies (professional knowledge and skills) an observation schedule was completed by the researcher during one lesson presentation by each student. This lesson was also assessed by the teaching methodology and practicum lecturer.

The observation schedule included the following aspects: setting the context; working towards a goal; clarity about the learning content; adjusting to learners' prior knowledge; instructional approach, instructional strategies, instructional skills, preparedness for the lesson; explanation of the relevance of

subject matter in society; learner activities; resources utilised; assessment; responses to learners' questions; formative assessment in relation to Bloom's taxonomy; and overall impression of the lesson presentation. The observer's remarks for each aspect of the lesson presentations were captured and a score for each aspect was given according to four categories, namely: expectations not achieved (1), approaching competence (2), competent (3), and exemplary (4). The mean score for each aspect for the four students who did not have EGD in year 12 was then calculated and compared to the score achieved by the student who did have EGD in year 12.

The lesson presentation assessment rubric included the following aspects: written lesson design criteria (aspects included and aligned), and lesson presentation criteria such as introduction of the lesson; the presentation style; PCK; resources; classroom management and professionalism; assessment strategies and conclusion of the lesson. Each student also had to write a brief reflection on the lesson presented. In addition, a one-hour focus-group interview was held with the students who did not have EGD in year 12. A forty-minute individual interview was held with the student who did have EGD as a subject in year 12. These interviews were facilitated by a senior colleague in the field of study and the co-author of this paper. During the focus-group interview and the individual interview the students were requested to share their experiences at the schools during the WIL period.

Observing the students only once could have the following limitations: no continuation to the next lesson could be observed; the students were not observed teaching different content in different contexts; and the development of the students over the seven-week period was not observed. However, by using an observation schedule which was completed by the researcher together with the university's lesson presentation assessment rubric which was completed by the lecturer and taking the students' reflection on the lesson presented into account, the researchers could limit some biased assessment decisions.

Findings

The findings focused on the WIL experiences of the students without EGD in year 12, the single student with EGD in year 12 and the students' teaching competencies.

WIL experiences of students without EGD in year 12

It was mentioned during the focus-group interview that the WIL experiences were good, although they were challenging.

> The WIL experiences were both interesting and challenging ... the people I had to work with was welcoming as well but the HOD was not. The reason for this was that he said he felt that the student teachers were not equipped enough to teach. Male, 1
>
> My experience was a good experience. The school was a very open environment. Male, 2

The support received from the mentor teachers was much appreciated by some of the students.

> The mentor teacher was the best mentor teacher I could ask for. I think that he absolutely understood the way I did things. Every day after teaching he would give me professional feedback. Male, 1

The fact that these students had not done EGD in year 12 became an issue during WIL, especially when they did not get support from their mentor teacher.

> I did not do it I did maths and science. Geography and all the others. So, it is a new thing to me even though I have been doing the practical for the past three years ... but it gets easier with support. So, when you are not getting the support and you have to spend seven weeks with the learners it is really challenging.
>
> Everything I did was trial and error ... me trying things out to see if it works. Female, 1

The students felt that they were not well equipped to teach EGD. One student indicated that at university they were taught to do lesson planning for EGD and Life Sciences (LS) in similar ways but during WIL they realised that teaching LS was quite different from teaching EGD.

> The moment I step into a LS class I just teach, EGD class is different ... I cannot teach EGD the same way I teach LS. They (the lecturers at university) should not put as much effort as they do into lesson plans right now ... 12 lesson plans do not help at all. Male, 2

One specific challenge was the assessment of EGD for example how to do assessment.

> ... we did not really have instructions on how you have to construct an assessment. Male, 1
>
> The challenges that I faced ... I would say right now EGD practice ... the content that we teach here at school is not what we experience in class (at university) ... certain things like marking an EGD paper. We need to be taught how to mark a question paper. Male, 2
>
> When it comes to the technical part, EGD it is difficult ... how do we allocate marks? Male, 1

It became clear that these students felt that they lacked foundational/background knowledge in EGD because they had not done EGD in year 12.

> Marking was a challenge to me ... maybe more because I did not do it in high school ... I had no background knowledge. Male, 2
>
> ... there is a gap ... when they (the learners) ask why they have to do it ... it becomes a challenge for us. Male, 1
>
> ... how to explain different concepts to the learners with regards to EGD ... they (the lecturers) do not give enough content of EGD other than what is in the CAPS document. At some point I actually learnt from the learners. Female, 1

There was consensus among the students that they initially struggled with EGTE at university, since they had to start from scratch while the prescribed content was designed for students who had mastered the background knowledge based on EGD in year 12.

> ... they (the lecturers) should know that without background knowledge ... they (the students) have not done it before ... it would take them a lot of time and you are bound to make mistakes ... and you are not going back to your mistakes because of time .... Male, 2
>
> They treated us all the same as if we all had the basic knowledge of what EGD is and how EGD is ... We had tutorials but even at the pace that we were going ... it was not enough for you who were still learning how to draw .... Female, 1

The biggest issue for these students seemed to be the marking of assessments, as their final remarks included the following:

> ... what I want to learn this year is how do we mark Male, 1
>
> Please put the marking in the content. Male, 2

The next section will focus on the single student who had EGD in year 12.

WIL experiences of student with EGD in year 12

The student appreciated the support from her mentor teacher.

> The HOD was actually my mentor teacher and he was extremely helpful. I received support from him and where and if he could, he helped me improve my lessons in terms of interaction with other educators in the field. He was broadening my understanding of the subject in terms of cross relations to other subjects. In general, I would say it was a very positive and educational experience.

With regard to the support she received to improve her lessons, she elaborated as follows:

> ... if I had something in my lesson plan that I wanted to experiment with he was very supportive by allowing me to go on with teaching strategies that I wanted to incorporate. If the lesson did not go as planned he was not very negative about the experience, he did tell me that it did not go as planned and here are things you could have done to improve that lesson so maybe not think of discarding the entire idea but just perhaps improve on that.

In terms of her professional development, the mentor teacher also expected this student to assist with the marking of the preliminary exam papers of the learners in year 12. When she mentioned to him that she had not marked EGD papers before he guided her through the marking process.

When she was asked to elaborate on her preparedness for WIL she acknowledged that EGTE helped her to improve her knowledge of EGD.

> The course has helped me to drastically improve my understanding of quite a lot of what I struggled with in high school ... that is all due to my lecturers and also the tutors...

She clarified the help she received from the lecturers and the tutor as follows:

> Also, in terms of developing a model for practical, the lecturer's assistance in the workshop was really helpful.
>
> The tutor we had in the first year, he was also equally helpful in terms of ... if I did not understand something it was not a feeling of I may be judged for not understanding. It was a very open very I would say an interactive environment.

Regarding her preparedness for WIL she mentioned:

> In terms of the teaching methodology and the integration of content into school, he (the lecturer) really did help in terms of assessing our lesson plans and also looking at our reflection to see if that was critical enough for us to have a good impact on teaching going further.

Teaching competencies

The data from the observation schedule indicated that the students who did not have EGD in year 12 achieved a mean of 2.4 (61%) for all 14 aspects and the student who had EGD in year 12 achieved 3.1 (79%) out of a maximum of 4. The student who had EGD in year 12 achieved a significant higher score than the group who did not have EGD in year 12 for the following: adjusting to the prior knowledge of the learners, instructional skills, preparedness for the lesson, explaining the relevance of the subject to society, activities for learners, assessing whether the aim and objectives of the lesson content had been achieved, responding to learners' questions, and how well the formative assessment related to Bloom's taxonomy.

The data from the lesson presentation rubric as assessed by the lecturer in the specialised pedagogy, indicated that the student who had EGD in year 12 achieved an overall mark of 82% compared to the mean overall mark of 78% for the group of students who did not have EGD in year 12. The student with EGD in year 12 performed better than the students from the group who did not have EGD in year 12 in the following aspects: introduction of the lesson, utilisation of resources, classroom management and professionalism, assessment strategies, conclusion of the lesson, and reflection on the lesson presented.

Concluding discussion

The important role of the mentor teacher in the development of the student as a pre-service teacher during the WIL period cannot be over-emphasised. The interaction between the pre-service teacher as the novice and the mentor teacher as the expert in the classroom can be compared to a tutorial where a cognitive and practical apprenticeship (Jakovljevic & Ankiewicz, 2015) is brought into effect.

Regarding their WIL experiences (research question 1) students with and without EGD in year 12 appreciated the support and guidance which they had received from their mentor teachers. One student mentioned during the focus-group interview that she did not get the support she needed from the mentor teacher.

The focus-group interview revealed that some of the students felt that they were not well equipped to teach EGD. As these students did not have EGD in year 12 they felt that they lacked a proper foundation

in the subject and according to (Gill, 2019) this might compromise their ability to adapt subject matter for the purpose of teaching. However, it became clear that the real challenge was when they had to do assessment and specifically the marking of assignments and tests. The student who had EGD in year 12 mentioned that when she informed her mentor teacher that she had not marked EGD papers before he guided her through the marking process as part of her professional knowledge development. It is recommended that students should get more experience in the marking of assessment papers during the specialised pedagogy courses before they do their WIL experience in their final year.

The student who had done EGD in year 12 acknowledged that the content of EGTE, the lecturers and the tutor helped her to improve her understanding of EGD and to prepare her for WIL. However, the students in the focus group were concerned about the fact that they struggled with EGTE because in their opinion the content had been designed for students who had done EGD in year 12. They felt that they were not well equipped for the challenges they experienced at schools.

Comparing the teaching competencies according to the observation schedules of students without and the student with EGD in year 12 (research question 2), a difference of 18 percentage points was reported. The student with EGD in year 12 scored just beyond 'competent' while the mean scores for the students of the group without EGD in year 12 varied between 'approaching competence' and 'competent'. Their competencies may be further developed with the guidance of a mentor teacher as the expert (Jakovljevic & Ankiewicz, 2015). It is recommended that lecturers should ensure that especially students who did not have EGD in year 12 should be placed in schools where experts in the field would guide and support them to apply and develop the new knowledge gained in their training (Engelbrecht & Ankiewicz, 2016; Martin, 2018).

From the lesson presentation assessment rubrics the teaching competency of the student who had done EGD in year 12 was slightly higher than that of the mean score of those who did not do EGD in year 12 (82% compared to 78%). The performance of the students during these lesson presentations may be regarded as competent as they demonstrated the required professional knowledge and PCK (Banks et al., 2004; Shulman, 1986, 1987;).

Whether or not students had done EGD in year 12 they had similar WIL experiences. They valued the support and guidance by the mentor teachers except for the one student who did not receive this support. The perception of not being well equipped for the WIL period was mainly due to their lack of ability to handle assessments, especially the marking thereof. This could be overcome in a collaborative learning environment (Jakovljevic & Ankiewicz, 2015) as was mentioned by the student who did have EGD in year 12. The teaching competency of the student with EGD in year 12 compared to those without, seemed to be slightly better than the others. This may be because the students without EGD in year 12 felt that they were not well equipped to teach EGD. This may be overcome with the support of a dedicated mentor teacher.

A limitation of this study was that only five final-year students participated in this final stage of the study. Due to the extreme case sampling the researchers had to work with this small number of students which enrolled for the module and were the whole population. Therefore, the findings should be carefully generalised.

The next stage of this longitudinal study will entail following these student teachers' experiences and professional development when they become novice technology teachers in 2020. Will the needs and challenges of students with and those without EGD in year 12 differ during their first year of teaching?

References

Arzarello, F., Chiappini, G. P., Lemut, E., Marara, N., & Pellery, M. (1993). Learning programming as acognitive apprenticeship through conflicts. In E. Lemut, B. Du Boulay, & G. Dettori (Eds.) *Cognitive models and intelligent environments for learning models* (pp. 284–297). Heidelberg: Springer.

Banks, F., Barlex, D., Jarvinen, E., O'Sullivan, G., Owen-Jackson, G., & Rutland, M. (2004). DEPTH-Developing professional thinking for technology teachers: An international study. *International Journal of Technology and Design Education,* 14(2), 141–157.

Boughey, C. (2005). Lessons learned from the Academic Development Movement in South African Higher Education and their relevance for Student Support Initiatives in the FET College Sector. Unpublished report commissioned by the Human Science Research Council, Pretoria.

Creswell, J.W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Thousand Oaks, California: Sage.

Creswell, J.W. (2005). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (2nd ed.). New Jersey: Prentice Hall.

Department of Basic Education (DBE). (2011a). *Curriculum and Assessment Policy Statement (CAPS): Technology, Senior Phase Grades 7–9.* Pretoria: Department of Basic Education.

Department of Basic Education (DBE). (2011b). *Curriculum and Assessment Policy Statement (CAPS): Engineering Graphics and Design, Further Education and Training Phase, Grades 10–12.* Pretoria: Department of Basic Education.

Engelbrecht, W., & Ankiewicz, P. (2016). Criteria for continuing professional development of technology teachers' professional knowledge: A theoretical perspective. *International Journal of Technology and Design Education,* 26, 259–284.

Flick, U. (2009). *An introduction to qualitative research* (4th ed). London: Sage.

Gess-Newsome, J. (2015). A model of teacher professional knowledge and skill including PCK. In P. Friedrichsen, J. Loughran, & A. Berry (Eds.) *Re-examining pedagogical content knowledge in science education* (pp. 28–41). London: Routledge.

Gill, D. (2019). The truth is in the boat: A case study of pedagogical content knowledge and technical skill development in pre-service technology education teachers. In S. Pulé & M.J. de Vries (Eds.) *Developing a knowledge economy through technology and engineering education.* Proceedings of the PATT37 Conference (pp. 167–176). Malta.

Grobler, R. (2018). Innovating and initial professional education of technology teachers (IPETT) Programme. In N. Seery, J. Buckley, D. Canty, & J. Phelan (Eds.) *Research and Practice in Technology Education: Perspectives on Human Capacity and Development.* Proceedings of the PATT36 Conference (pp. 156–166). Athlone, Ireland. https://www.skolfi.se/wp-content/uploads/2018/04/PATT36-Proceedings.pdf

Irving-Bell, D. (2019). Pre-service teachers' perceptions of pedagogical approaches to STEM education; design and technology. In S. Pulé & M.J. de Vries (Eds.) *Developing a knowledge economy through technology and engineering education.* Proceedings of the PATT37 Conference (pp. 221–232). Malta.

Jakovljevic, M., & Ankiewicz, P.J. (2015). Project-based pedagogy for the facilitation of webpage design. *International Journal of Technology and Design Education.* DOI 10.1007/s10798-015-9312-5.

Martin, M. (2018). Pre-service teachers' subject knowledge in secondary design and technology: Findings from an empirical study. In N. Seery, J. Buckley, D. Canty, & J. Phelan (Eds.) *Research and Practice in Technology Education: Perspectives on Human Capacity and Development.* Proceedings of the PATT36 Conference (pp. 388–393). Athlone, Ireland. https://www.skolfi.se/wp-content/uploads/2018/04/PATT36-Proceedings.pdf

Morillas, N.R., & Garrido, M.N. (2014). The role of tutoring in higher education: improving the student's academic success and professional goals. *Revista Internacional de Organizaciones,* 12, 89–100. Retrieved 29 November 2019 from http://www.revista-rio.org

Motsabi, S. (2018). A framework for the academic persistence of first-year first-generation African students in higher education. PhD. (Education) [Unpublished]: University of Johannesburg. Retrieved 19 December 2019 from https://ujcontent.uj.ac.za/vital/access/manager/Index?site_name=Research%20Output

Rohaan, E.J., Taconis, R., & Jochems, W.M.G. (2011). Measuring teachers' pedagogical content knowledge in primary technology education. *Research in Science and Technology Education,* 27(3), 327–338. Retrieved 12 March 2019 from https://doi.org/10.1080/02635140903162652

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher,* 15, 4–14.

Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review,* 57, 1–22.

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