Integration of formal and informal knowledge networks: A South African mining education case study

Clinton Birch

School of Mining Engineering,
University of Witwatersrand
1 Jan Smuts Avenue, Braamfontein 2000
Johannesburg, South Africa

Grzegorz Majewski, Marija Jakovljevic

Department of Computing
University of South Africa
UNISA P.O.Box 392 UNISA 003 RSA

** Corresponding author*

Structured Abstract

Purpose: In today's world knowledge workers are immersed in a great number of diverse networks. Very often access and exposure to such networks is an indication of how well a given knowledge worker will perform in his or her organization. So far most of the research focused on the formal organizational mechanisms (formal knowledge networks). This is however not enough as noticed by some researchers. There is also a grave need to examine the role played by informal mechanisms. Additionally it is necessary to investigate how the formal and informal knowledge networks operate and interplay between each other.

Design/Methodology/Approach: The research approach is an empirical study. Qualitative approach was used with convenient sampling. Data gathering method was in a form of a questionnaire, with follow up individual interviews. The empirical study was conducted among 70 final year students, who were split into 13 groups with 5/6 members in each group. Students were given an objective to carry out a mine design exercise to the level of a pre-feasibility (PFS) study based on the mineral deposit block model supplied to them.

Originality/Value: The originality and value of this research is as follows - displaying the impact of establishing a formal knowledge network (CoP) on both formal and informal knowledge sharing as well as knowledge integration. Additionally this research reports on the results of an empirical study conducted in South African mining industry and education sector. This can bring another original value as there is in general lack of studies in this area.

Practical implications: This study investigated how the introduction of a Community of Practice (CoP), which is a formal knowledge network, affected the existing informal knowledge networks among the students of the 4th year BSc mining engineering students at one University in South Africa. Moreover it measured the performance of the students that were members of the CoP and those that decided not to ("formally") participate in them. Additionally it provides an insight into the opportunities of integrating knowledge from formal and informal knowledge networks. The results provided will be interesting for CoP practitioners as well as knowledge networks researchers.

Keywords - Knowledge management, knowledge network, Communities of Practice, knowledge sharing, human resources management

1. Introduction

Communities of Practice (CoPs) have existed for a long time and can be found in schools, universities, research institutes (Nistor, Baltes, & Schustek, 2012) and business organisations. However, the specific guidance to form CoPs in higher educational institutions (HEIs) does not exist. CoPs are one of the most recognised knowledge sharing tools, making it a very highly valued tool of knowledge management. Knowledge sharing in turn enhances effectiveness (Gupta and Govindarajan, 2000) because, unlike other organisational assets, knowledge tends to increase when used or shared: "ideas breed new ideas and shared knowledge stays with the giver while it enriches the receiver" (Davenport and Prusak, 1998, pp. 16-17). One of the most important characteristics of CoPs, which appeals to knowledge managers, is their ability to traverse geographical, organisational and cultural barriers. Lave and Wenger (1991) described it as an activity system that brings together individuals with common values, interests, and varied experiences to share among them.

Gannon-Leary and Fontainha (2007) highlight that the technological developments which gave rise to improved communication and participant interactivity, academic staff and learners (students) in higher education have been functioning in virtual Communities of Practice (VCoPs). These online environments allow participants to communicate synchronously or asynchronously (Baran, 2006). According to Bolger (cited by Gormley 2012) VCoPs can facilitate employee development and learning while preserving crucial organisational knowledge. Nistor et al. (2012) notes that although VCoPs' usage improves academic participation and learning success, full participation in VCoPs does not occur that often.

Research on the environments of online CoPs has significantly increased (Baran, 2006). There is a wide range of open research questions, which need to be addressed. One of these questions is how to establish CoPs and keep it alive over a longer period of time. It is a difficult task. Gannon-Leary and Fontainha (2007) support further research on CoPs and virtual learning communities across European Union countries. Similarly Petersen (2007) cited by Gannon-Leary and Fontainha (2007) proposed that the concepts of learning in CoPs need to be further developed.

This research project's goal is to investigate how Communities of Practice (CoP) may be used in higher education amongst students to share knowledge. The empirical part of this research took place at the School of Mining Engineering at University of the Witwatersrand. An initial survey questionnaire was distributed amongst various groups within the School of Mining Engineering in January/February 2013 to gauge how students share knowledge and if they are aware of the concept of Communities of Practice. These survey questionnaires were distributed amongst students from the First Year, Fourth Year, Post Graduate and Certificate classes. Researchers observed that the introduction of a CoP (formal knowledge network) greatly increased knowledge sharing among students. Students shared knowledge using both CoP as well as informal knowledge networks that were already established. One of these networks used a mobile app for the purposes of knowledge sharing. Therefore the main research problems of this piece of research focus on the introduction of CoP in the HE institution and the synergy between formal knowledge networks and informal knowledge networks. Most of the research (e.g. Nonaka & Takeuchi, 1995) focused so far on investigating the formal organizational mechanisms (formal knowledge networks) in order to gain insight into how the knowledge is generated, dissipated and absorbed. Some researchers (e.g. Awazu, 2004) noticed that this is not enough and that there is also a grave need to evaluate the role of informal mechanisms (Desouza, 2003a). Additionally it is necessary to examine how the formal and informal knowledge networks operate and interplay between each other.

2. Description of the Research Project

The School of Mining Engineering, where the study was conducted, is recognised as one of the top mining engineering schools and departments throughout the world. Mining engineers play a key role in the planning, exploitation and excavation of mineral resources. The 4 year BSc mining engineering program is the schools flagship program and includes individual and group project work. The final project is a mine design project completed during the final months of the students' undergraduate year (University of Witwatersrand, 2013). The next section will introduce the mining design project and describe the case study.

For the purposes of the study 70 final year students were split into 13 groups with 5/6 members in each group. According to the brief given to the students at the commencement of the project, they had to carry out a mine design exercise to the level of a pre-feasibility (PFS) study based on the mineral deposit block model supplied to them. They were to utilise the knowledge gained over their previous coursework as well as experience gained during vacation work to complete the project. They had to then make a substantiated recommendation regarding the viability of mining the mineral deposit. The financial aspects of the project was thus critical as well as the technical aspects. For 2013, the final mine design project was Lily Gold Mine, close to Barberton in the eastern part of South Africa.

The 4th year Final Mine Design students who were working on the Financial Valuation Chapter of the Mine Design were invited to participate in a Community of Practice (CoP). A CoP is a group formed voluntarily with its purpose to benefit the members by exchanging thoughts and ideas. Thus the 13 groups into which the students were placed for the mine design could not be considered a CoP as they were forced to work together. The association across these 13 groups for the students working on the Financial Valuation Chapter could be considered a CoP because it was their choice to join the group or not. According to the data there were 13 students invited, 9 chose to join the CoP and the other 4 chose to work outside the CoP.

For 2013, the final mine design project was Lily Gold Mine, close to Barberton in the eastern part of South Africa (see Figures 1 and 2).

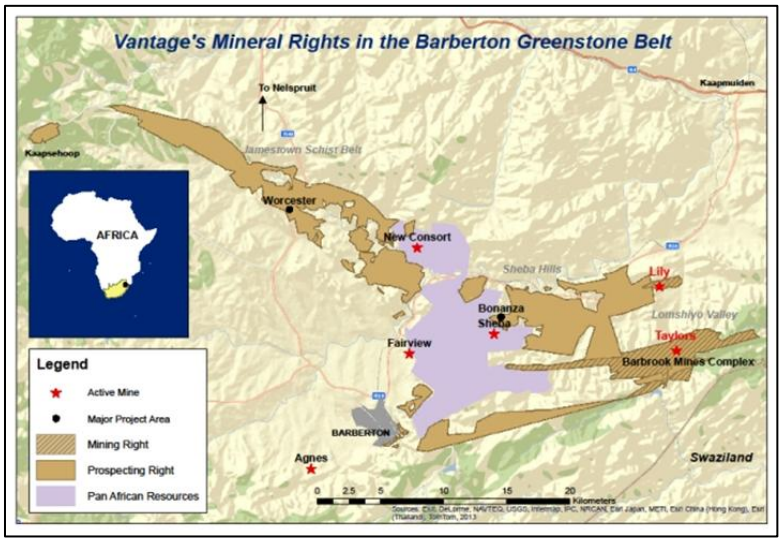

Figure 1. Location of Lily Gold Mine (Vantage Goldfields, 2013)

Figure 2. Entrance to the Lily Gold Mine (Photo by author, 2013).

2.1 Description of the Lily Gold Mine

The Lily Mine began as an open pit operation in 2000. The open pit closed down in 2008 and had produced more than 100,000 ounces of gold. The ore body extends for at least 2,000 m along strike and has been drilled to a depth of approximately 700m (Figure 3). The Mineral Resources are currently estimated to be 2.017 million ounces (22.23 Mt

@ 2.82 g.t) and the Ore Reserves are 0.49 million ounces (4.76 Mt @ 3.18 g/t) (Vantage Goldfields, 2013). The mine has continued as an underground operation and the students were able to visit the current mine and observe the mining method employed (Figures 4 and 5).

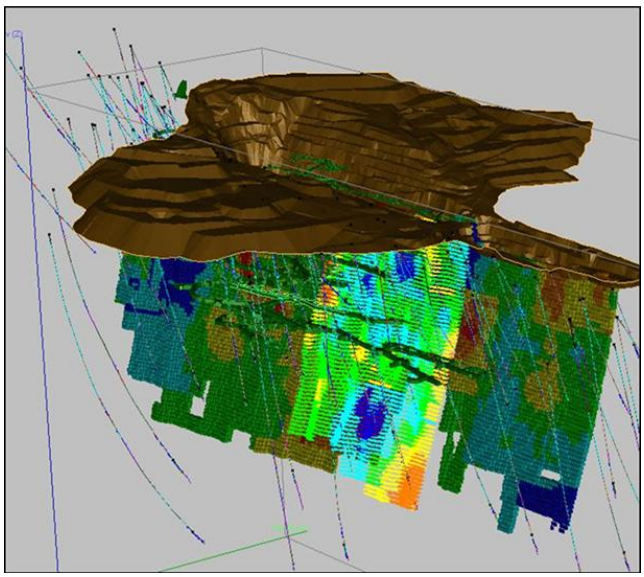

Figure 3. Lily Gold Mine Geological Model (Mawson, 2013)

Figure 4 and 5. Students on underground visit at Lily Gold Mine (Photos by author, 2013).

2.2 Mine Design Report

The students were instructed to start their designs at the stage where the mine started their underground operation and that the plant has a maximum capacity for 37 000 tons per month. The students were given the geological model as generated prior to the mine developing the underground portion based on the sampling in the pit as well as the surface diamond drill prospect holes.

For the purposes of their coursework students had to determine the construction/establishment times and costs as well as operating costs for the life-of-mine. They had to determine appropriate levels and methods of beneficiation and apply the correct royalty and income tax rates. They then had to do a full cost-benefit assessment of the project, including a discounted cash-flow analysis (DCF) and calculate the internal rate of return (IRR). Based on these, they had to make appropriate recommendations.

The total marks for the Mine Design Final Project was 350 marks. 300 marks were allocated for the report and 50 for the presentation of the mine design. All the academic staff within the School of Mining Engineering are part of the marking process and responsible for their own areas of expertise. There were 22 specific areas that were marked.

Part of the marking, which was subject to this piece of research, was allocated 20 marks of the total. This mark allocation was split into the following sub-categories:

- Problem Statement and Background Information (2 Marks)
- Cost of Capital, Capital Cost, Working Cost and Revenue (4 Marks)
- Optimisation (4 Marks)
- Conclusions and Recommendations (10 Marks)

One of the evaluation methods of the students' progress was cross checking the figures presented against those presented in other chapters notable Chapter 6 - Technical evaluation (grade-tonnage curves; resource & reserve statements) and Chapter 10 - Production scheduling to ensure that the figures in the geological block model as well as the mine plan were consistent with the cash flow schedule presented.

The concept of Optimisation received special focus and resulted in a large range of interpretations of the mining plan to obtain the highest financial return. In marking the projects, an order of magnitude difference was noted between the group with the lowest Net Present Value and the highest Net Present Value, primarily due to differences in Capital Costs, Mining Volume and Scheduling.

3. Community of Practice Project

According to Etienne Wenger, Communities of Practice (CoP) are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly (Wagner, 2010). The Final Year Mining engineering students all share similar professional backgrounds and experience and all have completed the courses related to Financial Valuation. The groups which the students were assigned to; were not considered a CoP for this study as the students within the groups were each working on different chapters and thus not exchanging ideas specific to the chapter in question. They had to work together with the intention of completing the entire Mine Design by the due date and to the required standard.

3.1 Project Groups

The 4th year Final Mine Design students who were working on the assignment were invited to participate in a Community of Practice (CoP). A letter was sent to each of the students by the lecturer outlining what a CoP was and what benefit they could derive by participating in a CoP. The students who chose to participate were invited to a meeting on the 4th October 2013 where the group was formed and a discussion was held about the aims of the CoP.

Students from 9 of the 13 groups chose to form a CoP. The other 4 students chose to work independently. The students chose to meet formally on a weekly basis to exchange ideas and information as well as establish an informal group on WhatsApp Messenger (a mobile application) to discuss specific ideas. WhatsApp Messenger is a cross-platform mobile messaging app. It allows groups to be established where a single message is sent to all group members. It is more cost effective than sending sms messages. WhatsApp Messenger is available for iPhone, BlackBerry, Android, Windows Phone and Nokia and being cross-platform, the phones can message each other. WhatsApp has recently been purchased by Facebook. (WhatsApp, 2014). All the members of the CoP had cell phones capable of utilising WhatsApp Messenger. At this point it is possible to consider WhatsApp Messenger as a technology-based enabler of an informal knowledge network. The choice of this platform was not influenced by the researchers. Quite opposite it was suggested by the students and it was their choice. Students also committed to complete a

questionnaire at the end of the project for the author to help determine their experiences from working in the CoP.

The students who joined the CoP met every Friday for the period that they were working on the Mine Design project. These meeting were facilitated by the researcher who led the discussion and guided the exchange of ideas between the members. Although the attendance was not compulsory there was virtually 100% attendance by the members.

A group was established on 5th October 2013 and ran until the project was completed in November 2013. Messages included setting up the times and place for the formal meetings, ideas around what should be discussed at these meetings as well as specific questions that students wished to discuss.

4. Findings

4.1 Results of the marking of the assignment

One of the most obvious ways to investigate the effect of knowledge sharing in both formal and informal networks was in a form of the academic results. The marks for the groups for the assignment were used as a measure of the effectiveness of the CoP process. The marking was done not knowing if the student had participated in the CoP or not. Table 1 presents the results of the marking.

Table 1. Marking of the students' assignment

Group	CoP	Mark /20	In CoP	Out CoP
1	x	13	13	
2	x	15	15	
3	x	14	14	
4		11		11
5		16		16
6	x	16	16	
7	x	10	10	
8	x	11	11	
9		14		14
10	x	18	18	
11	x	12	12	
12		17		17
13	x	17	17	
Average		**14.2**	**14.0**	**14.5**
SD		**2.5**	**2.6**	**2.3**

At the first sight it could be surprising to notice that the results for the students who were part of the CoP differed only slightly from those outside of CoP (Average of 14.0 with standard deviation of 2.6 as compared to average of 14.5 with standard deviation of 2.3). The total average for the marks was 14.2 with a standard deviation of 2.5. Researchers investigated the issue further. Next section will provide information regarding survey questionnaires.

4.2 Findings from the survey questionnaires

Five of the nine students who chose to be part of the CoP completed the survey questionnaire. This questionnaire was handed out to the students after their final project presentations. Some of the respondents were group facilitators. Section A (questions 1-4) of the survey questionnaire was collecting information on the students' age, gender, year of study and race, while section B was collecting questions related to CoP functioning (with question 10 aimed at the facilitators) Full questionnaire is provided in Appendix I. Table 2 provides the summary of the respondents' answers.

Table 2. Respondents' answers.

Q No.	Respondent 1	Respondent 2	Respondent 3	Respondent4	Respondent 5
1	Male	Male	Male	Male	Male
2	22 years	22 years	24 years	22 years	23 years
3	Fourth Year	Fourth Year	Fourth Year	Fourth Year	Fourth Year
4	Black race	Black	Black	Black	Black
5	"Neutral" to all questions	5.2 "Neutral", 5.6 "Strongly Agree", rest "Agree"	5.2 "Neutral", 5.5 "Strongly Agree", rest "Agree"	5.1, 5.3 and 5.6 "Strongly Agree", 5.2 "Disagree", 5.4 and 5.5 "Agree"	5.1 "Agree", 5.2 "Neutral", rest "Strongly Agree"
6	"Neutral" to all questions	"Neutral" to all questions	6.3 "Neutral", rest "Agree"	6.1 and 6.4 "Agree"; 6.2, 6.5 and 6.6 "Strongly Agree"; 6.3 "Strongly Disagree"	6.3 "Disagree", 6.5 and 6.6 "Strongly Agree", rest ""Agree"
7	First 4 questions "Agree" and rest "Neutral"	7.4 "Neutral", rest "Agree"	7.6 "Neutral", rest "Agree"	7.1 "Neutral", 7.2 and 7.3 "Agree", rest "Strongly Agree"	7.2 and 7.6 "Agree", rest "Neutral"
8	About 7 hours in total spent on CoP	5 hours	roughly 5 hours	12 hours	Overall 24 hours
9	9.1, 9.3 and 9.4 "Neutral", rest "Agree"	9.1 and 9.6 "Agree", rest "Neutral"	9.3 "Neutral", 9.5 and 9.6 "Strongly Agree", rest "Agree"	9.3 "Agree", rest "Strongly Agree"	9.1, 9.2 and 9.3 "Strongly Agree", rest "Agree"
10	No response	No response	10.1, 10.2 and 10.5 "Agree"; 10.3, 10.4 and 10.6 "Neutral", 10.13-10.16 "Disagree", rest no answer	10.1, 10.4, 10.9 - 10.11 "Agree"; 10.2, 10.3, 10.12-10.14 "Neutral"; 10.5 and 10.6 "Disagree", 10.7 "Strongly Disagree", 10.8 "Strongly Agree"; rest no answer	10.2, 10.10, 10.11 and 10.15 "Strongly Agree"; 10.7, 10.8, 10.13, 10.14 and 10. 16 "Neutral", rest "Agree"

It is possible to observe that most of the respondents gave similar answers for each section. Regarding section five - one student was neutral on all the points of this section but the other four students generally agreed or strongly agreed with all of these points. One student disagreed with the aspect of following their own activities regardless of the prescribed ones.

In the case of section 6 most students agreed or strongly agreed with all of these aspects, except one student who was neutral for all of these. Two students disagreed (one strongly) about the intention to change their role during the CoP phases. Section 7 was one of the sections where all the students were neutral, agreed or strongly agreed to all of these questions.

Section 8 of the survey questionnaire was asking the students how many hours they spent working within the CoP group. Two students answered 5 hours, one 7 hours, one 12 hours and one 24 hours. There appears to be different interpretations of what time spent was referring to with some students interpreting it as the time they spent within the group scenario (roughly 5 hours) and the total time spent working on the assignment i.e. the report (12-24 hours). Regarding section 9 all the students answered this section with neutral, agree or strongly agree responses. Section 10 of the survey questionnaire was supposed to be completed by the facilitator of the CoP.

Three students chose to fill in this section although researchers are unsure of the three which one was the facilitator, or if they considered the author to be the facilitator. There was no definite facilitator defined for this project and thus the responses to these questions are very varied. This is an indication that this section of the questionnaire and methodology needs to be worked upon.

To sum up most of the responses were in favour of introducing CoP as a tool for knowledge exchange and as a help with the assignment.

4.3 Knowledge sharing between formal (CoP) and informal knowledge networks

At the end researchers investigated how formal (CoP) and informal knowledge networks affected students' performance. Based on the students' respondents it is possible to state that the students outside the CoP were communicating constantly with the students within the CoP. It is based on the fact that many of the ideas discussed within the formal CoP sessions were noted in the assignments delivered by the students that were not participants of CoP.

It could be observed that students were constantly exchanging ideas and forming a formal CoP may provide them with a convenient venue to discuss their ideas and problems. Apart from that very often students may opt to form information knowledge networks (or already are part of such networks) as they may feel more comfortable with them.

5. Conclusions

As it was presented in the previous section it is possible to state that there are numerous benefits of introducing CoPs into academia. They are a catalyst for knowledge sharing, exchange of ideas and problem solving. Those students who were in the CoP group and chose to fill out the questionnaire were generally positive about the CoP process and felt it was beneficial to them successfully completing the assignment. Of course there is a grave need to conduct this (or similar) research with different schools, departments and institutions in order to achieve reliability of the results.

Another conclusion that can be drawn from this research is that students very often use informal knowledge networks for similar purposes to e.g. CoPs. Introduction of CoP should take into account this fact that nowadays students use numerous technological services (e.g. WhatsApp, Skype, Facebook or Twitter) to facilitate knowledge sharing. Formal knowledge networks (supervised by the lecture or member of academia) should not compete with those, but rather utilize synergy. This can be achieved by for example encouraging students to share and discuss what was the debated during CoP meeting with those that did not participate. This could be beneficial for all parties involved.

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Appendix I

5.1	The activities were appropriate for my learning tasks
5.2	I followed my own activities regardless of prescribed ones
5.3	Activities stimulated brainstorming sessions
5.4	I understood my CoP activities
5.5	Activities helped in discussing developments of the tasks or project
5.6	Activities were meaningful across CoP phases
6.1	Roles were suitable for allocated time frame
6.2	Responsibilities were clear for my chosen role
6.3	I intended to change my role during CoP phases
6.4	My role contributed to positive group outputs
6.5	Roles were appropriate for our learning tasks
6.6	My role inspired others in problem solving actions
7.1	Volume of work was manageable
7.2	Knowledge covered was appropriate
7.3	Overall standard of accomplishment was acceptable
7.4	Level of difficulty was endurable
7.5	Detail requirements were fulfilled
7.6	Required outcomes were achieved
9.1	I received enough instructions from my team coordinator
9.2	Other CoP members appreciated my ideas and participation
9.3	I was proficient in technology to participate in this CoP
9.4	I contributed constructively in CoP discussions
9.5	I enjoyed sharing my knowledge with others
9.6	The social media helped us to effectively share knowledge and experiences
10.1.	I communicated the primary CoP purpose and specific needs to the CoP group members
10.2.	The short term goals were set in my CoP group
10.3.	The CoP charter was developed in my CoP group
10.4.	Norms for behavior were established
10.5.	I provided orientation to members
10.6.	I evaluated member and group activities
10.7.	I determined the member profile
10.8.	I facilitated a brainstorming session for CoP benefits, name and branding
10.9.	I discussed tasks and activities within the CoP
10.10.	I maintained regular contacts with the CoP group members
10.11.	I provided support for member roles and responsibilities
10.12.	I established clear and measureable objectives for each activity
10.13.	I arranged mentoring/coaching
10.14.	I clarified rewards and recognition
10.15.	There was evidence of performance management in my CoP group
10.16.	I submitted CoP reports regularly to the project leader