

Future Mining – Workers’ Skills, Identity and Gender When Meeting Changing Technology

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ABSTRACT

The aim of this paper is to discuss how to form work and organisations in the mines of the future. The Kiruna underground iron ore mine in the far north of Sweden is used as an example on how technical development affects organisational issues like skills, work identity and gender. Over a period of 50 years one can see a transformation of work from manual underground work to automation and remote control from surface level. What characterised the old underground workforce was the close relation between man and the hard rock and with arduous physical work under dangerous conditions. Today, the face miners are located on the seventh level of an office building close to the mine. There is also an emerging, and in many aspects already evident, knowledge transformation – from the old and obsolete physical and tacit knowledge and skills (for example the ability to ‘read the rock’) to something new, which can be described as abstract ‘high-tech’ knowledge and skills. The modern technology has created a new type of work – new in terms of competencies and knowledge as well as workload and organisation. At the same time the mining company are recruiting more women and promoting the former pure male work as attractive workplaces for both women and men. All this has effects on how individuals and company create and recreate skills, identity and gender. To some extent the technological development predestines these changes, but there are some choices to be done when forming good work and organisations for the mines of the future. The traditional mining workplace culture and behaviours and the old type of masculinity, the ‘macho’ style, will be challenged by the new ‘high-tech’ work and new competency demands. The changes risk meeting restoring responses, which can have negative impact on the performance of the organisation, for example making it inflexible and perhaps ‘lagging’ behind the technological development. These questions need to be handled when planning future mining.

INTRODUCTION

The aim of this paper is to discuss how to form work and organisations for the mines of the future. Luossavaara-Kiirunavaara AB’s (LKAB) underground iron ore mine in Kiruna, in the very north of Sweden, is used as an example of how technical development interact with organisational issues like skills, work identity and gender. LKAB’s underground iron ore mine is today one of the most modern underground mines in the world. The company has continuously invested in development of new technology to increase the capacity of their mining. In that way, new conditions for mining work have been established. For a long time the underground mining work was characterised by a close relation between the worker and the rock. It was hard physical and dangerous manual work under difficult conditions. In this environment a certain type of workplace culture developed and, as in many other similar workplaces, this culture was characterised by a form of ‘macho-masculinity’ (Blomberg, 2006). However, the last 50 years has seen a gradual transformation from manual underground work close to the rock to remote control work conducted above ground. Today, the face miners are located on

the seventh level of an office building close to the mine. The workers have left their old blue-collar workmates and moved into a ‘white-collar environment’. They leave their job at the end of the shift just as clean as when they arrived. The contact with the hard rock is mediated by machines controlled by remote control technology. The modern technology has created a new type of mining work, when it comes to skills and knowledge as well as workload and organisation. At the same time the mining company are recruiting more women and promoting the former pure male work as attractive workplaces for both women and men. All this has effects on how individuals and company create and recreate skills, identity and gender. And this in turn affects the organisation’s ability to develop an effective, flexible and yet sustainable production.

Before moving further on in the discussion there is probably a need for a few lines on underground mining, and especially the method LKAB uses in Kiruna; ‘sublevel caving’. This method means that the ore is mined and transported via galleries and shafts, up to surface level for concentration and converting. The process has two main parts; development and caving. Development means that holes are drilled straight forward making horizontal parallel galleries into the orebody. The vertical and sideway distances between the galleries have varied over the years, but the main trend is longer distances and more large-scale technology. The development work consists of five work elements: drilling, charging blasting agents, blasting, loading (the ore) and transport/discharging. Caving means that you mine out the ore between the galleries. However, the drill pattern is different compared to development. In mining you drill up in the roof of the gallery in a fan-shaped pattern. The mining consists of the same five elements as development. After discharging, both in the development and mining processes, the ore (and the waste rock) is crushed and then transported up to ground level for converting and concentration.

Method

The mining workplaces will be studied in four different visits, 1957, 1969, 1985 and 2005, focusing on the direct work in the mining process (development and caving). This means the excluding of, for example, maintenance work and the concentration and converting processes. Methods for the empirical collection were interviews, observations and analysis of historical as well as current documents. The material for the first two visits is reconstructed from historical materials combined with interviews with workers remembering how it was ‘in the old days’. The material for the two last visits is collected on site.

When discussing the levels of technology a modified version of Kern and Schumann’s (1974) classical classification system is used³. It is a model that tries to relate technology to human work from the view of the workplace and the work situation. The model consists of six different types of work tasks in growing complexity⁴:

1. *Manual work* with or without hand tools. The category includes both skilled work and simple operations.
2. *Motor manual work*. In motor manual work most activities are performed in a similar way as in manual work. The motorised tool can be seen as a first step towards mechanisation, but the worker still has control of the most important part of the work process.

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 3. For a complete description of the model see Johansson (1986).
 4. Kern and Schumann’s model consist of 15 different types of work, most of them not relevant for mining.

3. *Machine work.* This category includes work tasks where the operator directly steers the progress of the work process. This category includes connecting and controlling functions. Typical work tasks are driving a loader or handling a drill rig.
4. *Operating work.* Work tasks are similar to machine work with the exception that the work object is part of a plant or a stationary machine. Typical work tasks are tapping from shaft, crushing or skip filling.
5. *Remote control.* This is a category typical for mining. In fact remote control has many similarities to both machine and operating works. The difference is that the worker is located far away from the work process, but still controls and steers the process by a TV-camera and a monitor. It is important to notice that the process is not self-regulated. With remote control it is possible to locate the working site to centralised control rooms, first underground and later above ground.
6. *Automated work.* This category corresponds to Kern and Schumann's category control rooms work. The main task includes control, especially preventive control (differing from remote control). Here work is performed in a control room or a similar location.

Theoretical starting points – skills, identity and gender

In this paper skills and knowledge are not seen as things that are simply static and accumulated by individuals; but rather as things that are created and changed in socio-cultural contexts, through individual as well as collective processes. Knowledge is therefore not only a question of individual behaviour; it is also about organisation, power and identity (ie Fenwick, 2005). Also creating work identity involves learning. For example, individuals need to figure out what identities to enact, how to enact them and how others perceive their identity. Individuals' actions and identity formation at work will tend to be affected by the organisational structures and/or the symbols characteristic of the production system in different ways. This can be understood as both socialisation and learning, ie as a part of the process of becoming a full member of an organisation or a community of practice (Salminen-Karlsson, 2003; Wenger, 1998). People's sense of their own knowledge in work, and the skills valued by the group to which they see themselves belonging, forms a critical element of their identity (Fenwick, 2005). Together with the more formal structural aspects at the workplace, ie technology, organisational structure and qualification demands, the identity aspects of work, the symbolic aspects of work, ie stories, myths, ideas and perceptions of what a 'real' worker is like, and relations form four organisational processes (Acker, 2006).

The gender perspective is used as a method to highlight problems and opportunities that otherwise would be difficult to grasp when planning the mines of the future. Even though gender is a fluid and dynamic phenomenon, certain stability exists especially regarding work and organisations (Abrahamsson, 2006; Acker, 2006; Connell, 2002). A lot of the attitudes, norms and cultural symbols at work are connected to gender and 'the gender order'. When the 'gender order' in surrounding society or local work organisations is 'strong' it can have different kind of valuing and structuring effects on individuals as well as organisations. These effects, often unconscious, embedded and believed as natural, may have a problematic restorative and maintaining function on the 'gender order' itself. This is one explanation to the difficulties of breaking down the hard-to-cross borders between men's and women's jobs. As this study deals with male-dominated industrial organisations, the paper also touch the discussions on workplace cultures based on male bonding, homo-socialisation and identification and exclusion of

others (eg women, office staff, management) (Willis, 1977; Kanter, 1977; Collinson, 1992; Roper, 1996). Strong homo-social relations and gender-segregated businesses risk creating confusion of gender (in this case masculinity) and competence. A related factor to be encountered is men's experiences of degradation if they have to do something that might be seen as feminine (Collinson and Hearn, 2005; Abrahamsson, 2000; Connell, 1995). Many of the practical problems, concrete obstacles and reactionary events occurring in connection to ordinary change projects can be explained by the fact that the intended change challenges and stirs up local prevailing 'gender order'.

FOUR VISITS AT THE UNDERGROUND IRON ORE MINE IN KIRUNA

1957

The first 'visit' to the mine is in 1957. Sublevel caving has just been introduced. In the development work the equipment consists of a jackhammer which weighs 40 kg. A compressed air fed support-leg keeps the machine in place as the hammer strikes the rock. The noise is deafening and it requires a lot of physical strength to keep the drill in place. The salary system is based on the team's performance with a deduction for the cost of consumed drilling steel and blasting agent. In order to maintain work pace and minimise salary deductions, it is important that holes are made in such a way as to take advantage of any weaknesses in the rock. The drill holes are charged with dynamite cartridges packed in the hole with the help of a charging rod. An experienced blaster can stretch the blasting agent by partially filling up the hole with wooden sticks and thereby increasing his earnings.

The loading occurs with an overhead loader, which has been nicknamed 'the pig' because it squeaks like a pig with every throw. This machine has a bucket, which is pushed into the ore and filled. The bucket is then moved upwards and backwards to dump the ore into a transport cart waiting on the tracks. When the cart is fully loaded, it is pushed to connect with the train of carts and driven to the shaft for emptying.

In caving, the first elementary task is to drill contour-shaped patterns in the tunnel's ceiling with the contours at precise distances from each other. The work is carried out by a driller using a drill rig with two chain-fed drilling machines. Most time is devoted to coupling and handling heavy drilling steel. The work is heavy and the environment is very noisy. Production drilling does not allow workers to demonstrate their skill and experience in the same way as the development work drilling. Here it unnecessary for the driller to see 'how the rock is going to fall'; instead the worker places the drill and drills according to a standardised pattern.

The loading occurs with a scrape loader. Like a lobster with large claws it scrapes out the ore which is then taken on a transporter over the loader and down to the waiting shuttle car. Despite the fact that the loader is electrically powered, the noise level is very high. The workers have been trained on the new machine but the art of loading is very difficult to learn. It is important to know where one will load in order to keep the mixture of waste rock to a minimum – something most of the workers learn with experience. The ore is then transported from the loader to the shaft by two electrically powered shuttle cars. Towards the end of the shift, it is time to charge the next round. Charging is done manually but rock blasting occurs electrically and is initiated centrally when the mine is empty.

As mentioned above, the ore both from the development work and from caving is dumped down the shaft for processing at the main level. From here the ore is transported by train from the shaft to the crushing station where it is crushed and then transported up to the surface with an elevator/skip. A train engineer and a switcher fill up the train's ten carts at the shaft.

The switcher fills the cart via the chute, which is a compressed air-driven hatch, and then the engineer drives the carts forward one at a time. After the chute loading, the train is driven to the crushing station where the switcher carries out the dumping. He stands beside a control panel by which he tightly locks the carts wheels and then empties it with a hydraulic cylinder.

The crushing station consists of two crushing units each with a boulder crusher and a spider crusher. Each crushing unit is manned by a crushing machinist. The crushed ore is stored in pockets under the crusher. The pockets are connected to a pocket measure which automatically fills the skip with as much ore as it can take. Finally, ore begins to move up to the surface.

Process type	Work task	Technical level	
		Preparation	Excavation
material extraction	drilling	2	3
	charging	1	1
	blasting	1	5
transport	loading	3	3
	hauling/dumping	1/3	3
	chute loading		4
	dumping		3
processing	crushing		4
transport	skip loading		4
	skip hoisting		6

FIG 1 - Levels of technology at different work tasks, 1957.

Mining work in 1957 was characterised mainly by hard physical work in an extremely challenging work environment. There was a close relationship between the mining worker and the rock, especially in the development work. If he (because it is always a man) could judge the rock accurately, then he could minimise the drilling and save explosives in order to increase his earnings. In production drilling, key elements of the work tasks had already been standardised, which makes the individual work skills less significant. In the rockslide loading, however, it is essential to be able to ‘read’ the mountain, both in order to optimise earnings and avoid accidents. Generally it was critical for workers to be vigilant in undertaking all work tasks on the mountain so as to avoid being crushed and injured by falling rocks or heavy machinery. The work culture at LKAB circa 1957 was pure male.

1969

The second ‘visit’ takes place in 1969. In the development work, hand-held machines have been replaced by a drill rig that is equipped with drilling machines on each of its arms. The machine is driven from a control room where the driller can sit and conduct the work. Typically workers drill for two rounds per shift compared to one round on the earlier visit. The environmental conditions have been improved in terms of the physical workload; however, the noise problem is still apparent.

Charging has changed with the introduction of explosive in powdered form. The charging is now performed with a hose that is pushed into the drilled hole. All the equipment is kept on one small vehicle that drives between the charging locations. Loading has also changed in that the overhead loaders have been replaced by larger and more effective scrape loaders. Hauling to the shaft has been changed so that shuttle carts have been replaced by diesel trucks. With this innovation a new problem – pollution – has been introduced, especially for the loader who has to stand behind the truck while he works.

For caving, the drill rig has been developed. Each rig still has two drilling machines and the drill arms are hydraulically

controlled. The driller, however, still has to extend and clean out drill steel by hand, a job that has become more frequent due to the increased production pace. Charging is handled in the same way as in the development work. The task which has changed the most is loading, where the old scrape loaders and truck transporters have been replaced with diesel-powered wheel loaders that work according to the principle: load-carry-dump.

The main transport level is now 450 m underground. The trains here are larger and have more carts. Production planning is controlled via a computer system that automatically determines the destination and reserves the line. A train engineer is still required. Chute loading from the shaft to the cart is managed by a chute loader who controls the chute hydraulically. There are no tippers, instead the carts are emptied automatically into the crusher.

Crushing has been modernised and all the crushers have been equipped with dust vacuums. The work is automated so that each crusher can operate two crusher machines. Filling the skip and hoisting are also automated.

Process type	Work task	Technical level	
		Development work	Excavation
material extraction	drilling	3	3
	charging	1/2	1/2
	blasting	5	5
transport	loading		
	hauling/dumping	3	3
	chute loading		3/4
	dumping		
processing	crushing		
transport	skip loading		6
	skip hoisting		

FIG 2 - Levels of technology at different work tasks, 1969.

Mining work in 1969 is still physically very heavy even though the working environment has been improved, especially in terms of the manual loading. For the caver, however, the increased effectiveness of the drill rig means that he now has to handle substantially more heavy drill rods during the same amount of time. A huge environmental problem has been introduced by the introduction of diesel-driven trucks and loaders. The danger now is not directly from the rock but rather from the tools and equipment that generate harmful diesel fumes. However, the danger of the rock remains. The need for the development work driller’s expert skills, which was obvious in 1957, has diminished because the elementary work tasks have been standardised. Nevertheless, the traditional mining qualifications, skills and attitudes are still important. And the organisation is still all male.

1985

When visiting the mine for third time 1985 a lot of things have happened. In the development phase there is a new hydraulic drill rig. The driller sits in an air-conditioned carriage with a clear view. The carriage is isolated from vibrations and noise but the driller still wears earmuffs. Charging has not been altered in any obvious way. Loading and removal is still conducted with wheel loaders, which are now larger and stronger. The caving stage has been transformed by a new drill rig. Drilling is now done totally automatically. The driller sets the booms and starts the drills. This means that all the heavy drill steel handling is eliminated. Even loading and removal has changed. The

diesel-run wheel loaders have been replaced by electrically powered loaders. This has resulted in significant environmental improvements with the disappearance of diesel fumes and lower noise levels.

On the main level, which is now located 750 m below the surface, the train is operated without a driver. It is notable that the chute loaders who were previously located beside the shaft have been replaced by a TV camera. The chute loading and advance feeding of the carts is operated from a centralised control room with seven work stations where chute loaders sit in front of TV screens and control the entire process. When one train is fully loaded, the loader switches cameras and continues with another.

Process type	Work task	Technical Level	
		Development work	Excavation
material extraction	drilling	3	3
	charging	1/2	1/2
	blasting	5	5
transport	loading	3	3
	hauling/dumping		
	chute loading	5	
	dumping	6	
processing	crushing		
transport	skip loading		
	skip hoisting		

FIG 3 - Levels of technology at different work tasks, 1985.

Mining work at LKAB in 1985 clearly has a different character – one can catch a glimpse of modern mine work as know today. The mine worker has been transferred from the mountain face to an air-conditioned control room. This does not necessarily mean that the work environment is good, but it is decidedly better. Working routines have been all the more standardised and significant parts of the operation on the main level have been automated. A new element that has been introduced is remote chute loading. In this case the chute loader has been moved from the shaft to a centralised control room underground where he can manage the process utilising modern communications technology.

In 1985 one for the first time can meet women underground mining workers, even if there were just a few of them (two to three per cent of the mining workers were women). The prohibition on women working underground (originating in 1900) remained in force until 1978. The mechanisation and the improved work environment was now said to make it possible for women to do the 'male' work tasks they had previously been excluded from – and the mining companies were also keen to employ women. But the development was not without opposition. Many younger men were especially critical of the idea of women working in the mine. Even the trade union was ideologically opposed. There seemed to be a limit to gender equality. According to this view, women, especially wives, were *not* supposed to work in the mine. However this conflict never became a major problem because the economic recession in Sweden in the late 1970s and 1980s forced the mining companies to start dismissing workers – and most of the small number of newly recruited women were amongst the first to be retrenched.

2005

Due to the opening of a new main level (at 1045 m underground) in 1997, new, major investments were made in the form of remote control and automated technologies. In 2004 a combined

production centre for the whole mine came into operation, placed above ground on the seventh floor of the large office building on site. The new production centre is the dominant feature of the fourth visit, in 2005.

However, in the development phase, relatively little has changed. The drill rig is run manually underground by an operator according to a pattern shown on a computer display screen. It can be programmed to run automatically but it is usually better if the operator does it himself. He is bound to the rig because he has to leave the driver's carriage to change the drill cores at certain intervals and sometimes has to clean the holes with a pick axe. After one hour of drilling he moves the aggregate to the next location. Charging is conducted as before by chargers with a specially equipped vehicle for the purpose. Loading occurs as before with electrically driven loaders.

The differences are more obvious during caving. Drilling has been automated and is remotely operated from a control room underground. There are three operators controlling six drill rigs. These are monitored by television and driven completely automatically, but the operator can take over and steer by means of joysticks if something goes wrong. It takes approximately 24 hours to drill a contour, after which the operator goes out and moves the drill rig a few metres to the next contour. During the night the drills operate automatically and immediately shut down if an error or irregularity is detected. The drill is then attended to by the incoming morning shift.

The majority of loading occurs as before. A new element is the presence of female loaders. An even more recent development is that some loading machines are remote-controlled and the driver has been moved to the seventh floor of an office building above ground. The driver has thereby become an operator. The loaders run automatically from the face to the ore shaft where they dump the ore and return to the face. When the loader machines are back at the face, the operator takes control to fill the bucket using joysticks. The operator can manoeuvre two loaders simultaneously. Loading takes place around the clock only stopping during actual blasting.

On the main level there is no big difference in the process although even these operators have been moved up to the seventh floor. Chute loading is conducted in more or less the same way although the equipment is smaller and more modern. The large joysticks have been replaced with small fingertip-operated sticks. One chute loader is able to operate all the chutes single-handedly but most often there are two chute loaders operating. The operation of the transport train has also been moved above ground and is conducted by one man.

However, when the ore gets jammed in the shaft the chute loader cannot, as was previously the case, go out to the chute to blast. As a result a new process stage has been introduced – rock breaking. This entails placing a metal grid across the ore shaft so that larger rocks and boulders can be trapped. A remotely operated hammer is now used to smash the trapped rocks. An operator, again located on the seventh floor of the office building above ground, operates six such hammers using joysticks and TV monitors.

As one can see the degree of automation has increased and more work tasks have become remotely-controlled. In the near future it appears that the only work actually undertaken underground will be maintenance work. As a result, work in the mine has increasingly come to resemble that of a process industry. On the seventh floor mining work is now undertaken in a clean and pleasant work environment with a beautiful panoramic view of the city. From this remote location the excavation process is controlled and supervised by teams of operators. The previously distinct job categories of loaders, chute loaders and rock-breakers now exist within the same work location. Even though the remote-controlled technology implied a direct transition from solitary work in a machine carriage to joint operating teams in the control room, no changes were made to the formal organisation, job positions and work allocation.

Process type	Work task	Technical level	
		Development work	Excavation
material extraction	drilling	3	6
	charging	2	2
	blasting	5	5
transport	loading	3	5
	hauling/dumping		
	chute loading		5
	dumping		
processing	crushing		
transport	skip loading		6
	skip hoisting		

FIG 4 - Levels of technology at different work tasks, 2005.

Workers were still called ‘loaders’, ‘rock breakers’, ‘chute loaders’ and ‘train directors’ and they were still divided between several control rooms. However these arrangements are now under revision and operators have started to alternate between a variety of work tasks on the seventh floor. In the future it is likely that a more generic occupational classification will come to replace the traditional jobs: that of the ‘mine operator’.

Yet another new element is the presence of women as workers underground, and also at the seventh floor. But the number of women mine workers has remained at four per cent. The fact that the girls and young women quite simply do not see the mine as potential employer for them is probably nothing strange considering the history of the mine. The memory of the active and outspoken resistance to women in the mine is just a generation ago, and some of the negative attitudes still are prevalent. Consequently there is a very small number of women among the mining workers and most of the women miners work with sampling (or other laboratory connected work tasks) and in the dressing (concentration) plants. There are fewer women working underground, closer to the mine face, where it is both higher status and higher wages. From this perspective, modern mining work still seems to be an overwhelmingly male affair even if the number of female mining worker slowly is rising.

Nevertheless, LKAB has stated that it is very keen to significantly increase female employment in the future. They want to take advantage of the potential offered by a more equal gender structure. By broadening the target group when recruiting and make use of the whole competence reservoir they wish to obtain flexibility and a better processes for communication and learning within the organisation, ie a climate and culture that support a modern organisation. This is visible in LKAB’s four gender equality strategies:

1. recruit and retain women as technical experts and managers (for example a trainee program with 50 per cent women),
2. upper secondary school program with 50 per cent girls,
3. targeting the surrounding society as well as their internal organisation with the image of modern mine work as ‘high-tech’ production in a good working environment that both women and men can carry out, and
4. internal organisational and workplace culture changes when it comes to gender attitudes.

Even if much of this is company rhetoric, this will eventually have an effect on the nature of mine workers’ work identity and the company has, probably thanks to these strategies, during the latest years continuously raised the total number of women employed in the company. Between the years 2000 and 2002 there were less than seven per cent women, in 2005 the figure had risen to ten per cent and in 2007 the company had reached

more than 12 per cent women totally. This doubling within a few years comes from the high number of women among the new recruitments on managerial and technical specialists positions. On these type positions, there are today more than 20 per cent women and this positive tendency seems to continue.

DISCUSSION

The application of Kern and Schumann’s (1974) classical classification system presented earlier has been summarised in four diagrams (Figures 1 - 4). It can be seen that the level of technology in the mine has increased significantly over the entire period. The key development has been a shift towards greater automation and remote control of more and more of the production process. One can also see that throughout the period, the level of technology tends to be highest toward the end of the process chain. In order to understand this it is important to remember that the iron ore changes form along the production process. The iron ore starts as fixed mountain rock. It is then exploded into smaller pieces that are then crushed for transportation and tipping into an ore shaft, in order to be finally crushed before being transported to the surface for further refining. As the material progresses through the production process it is transformed into increasingly manageable form. As a result, the later processes are easier to automate and control remotely. Nevertheless, the technological developments at LKAB demonstrate that even drilling is a process that is possible to automate, especially in production drilling.

As a result of the increasing level of technology, the role of the worker in the technical system has changed and the relationship between the worker and the mountain has changed. While there has always been a machine between the worker and the rock, over time that machine has tended to become bigger and more technologically sophisticated. Work processes have become automated and remotely controlled. This has created new types of work where improvements in the physical work environment are obvious. Down in the mine the bulk of heavy lifting work has been eliminated and the hazards associated with noise and dangerous gases have been diminished. For some of the mine workers’ actual contact with the rock is minimal. In the most extreme cases, the operator makes only occasional visits to the machine that he or she remotely controls. The operator can return home after work as clean as he or she arrived.

Skills

These changes also include changes in qualifications, knowledge and skills. Using Kern and Schumann’s concepts one can see a clear transformation from the traditional craftsmanlike qualifications reflected in a degree of autonomy, the use of manual skills and sensitivity to material (‘rock-sense’) to the more technical qualifications based on abstract knowledge necessary to operate the new advanced technologies that have become central to the production process. Workers are also subject to new demands for teamwork, responsibility, autonomy, and a comprehensive understanding of production flow. This can be seen as a movement to more process-independent qualifications.

Another way of understanding changing qualifications draws on the concept of tacit knowledge introduced by Polanyi (1967). What was once the mining workers’ tacit knowledge has now been formalised and codified into automated routines and computer programs. In this one can see contradictory movements of ‘upskilling’ (rapidly changing skill demands, more theoretical and comprehensive tasks) and ‘deskilling’ (fragmentation of individual craft knowledge and whole tasks). One effect of remote control is that the work tasks seem much simpler when they have been moved out of their context. The work tasks probably are as simple or as complex as before, but since they do not need to be undertaken in a difficult work environment,

the aura of 'job secrets', tacit knowledge or craftsmanlike qualifications disappears. The mining workers can therefore feel a longing for the old times (Andersson and Abrahamsson, 2007). One miner stated:

The environment in the mine is unique and the mine itself is somewhat mysterious, it's important to keep it that way!

Another said:

As a miner you learn how to handle and appreciate the secrets of the mine, and you find pride in your work because it is special.

There is also a form of 'reskilling' in the changes occurring in mining work. While the new types of work tasks are based more on theoretical or technical qualifications, this does not mean that there is no need for manual skills and tacit knowledge. It is a new type of skills, not based on physical strength but on concentration and tactile ability. These new forms of knowledge and skill are in some aspects more abstract and theoretical than the traditional ones, but in other aspects they are still physical and tacit, only in another way.

Identity

Whether it is a question of upskilling, deskilling or reskilling, the transformation of knowledge has effects on workplace culture and identities. Together with the new technology, the better work environment, and the new type of work tasks, the changes in qualifications challenge old behaviours and attitudes. This process is neither simple and nor without resistance. The resilience of the traditional workplace culture was demonstrated when the operation of the front loaders was moved from underground to seventh floor of the office building. The workers still saw themselves as underground miners, and reinforced this by changing their clothes after every shift in spite of the fact that they were just as clean as when they commenced their shift. While the practice ceased after a year or so it is apparent that the operators still wanted to be seen as miners. The introduction of remote control, and especially the move up to seventh floor, has, to some extent, been met with a division of workers into 'us' and 'them'. The underground miners, especially those doing manual work tasks, see themselves as 'real miners' compared with the remote control workers that are seen as weaker and somewhat effeminate.

It appears that the symbols of mining work are still the traditional ones. In such cases one need to understand individual work practices and interactions as symbolic rather than a reflection of the new technological changes and the company's official aims for the new technology and forms of work organisation (Somerville and Abrahamsson, 2003). This is an example of the fact that changes in one process can be in contradiction to (or be out of sync with) changes in another process. Worker identity and workplace culture can serve a 'restorative function'. The sometimes strong desire to retain the old workplace culture, even if it is outdated, can make it difficult to change the more formal or structural aspects of the organisation. This can also have impact on the performance of the organisation, for example making it inflexible and perhaps 'lagging' behind the technological development. Earlier research shows that there can be tendencies of a hesitant attitude towards technological development (Andersson and Abrahamsson, 2007). One example of this is that the miners sometimes brag about their own contribution to the increased production and the company's great profit, but at the same time the new technology is seen as a threat to the 'uniqueness' of mining work by the workers. Although these attitudes are becoming less predominated, they are still part of the mine worker's identity, workplace culture and workplace learning, even though unconsciously and 'natural' to the mine workers themselves.

Gender

Even if the numbers of women are growing it is a quite recent phenomenon. As described earlier, some reasons to the few women can be found in the local surrounding culture and its labour market and educational traditions. But some of the reasons to the low number of women can also be found within the mining workplace cultures themselves. Mining work has, like many other male dominated workplaces, historically developed strong symbolic links to a special form of 'masculinity' (laddishness, a kind of 'macho-style') and at mining workplaces, blue-collar men have often felt that it is important to distance themselves from women at the workplace and, in particular, from work or behaviour that in some way might be related to femininity or unmanliness (Eveline, 1989, 2001; Somerville and Abrahamsson, 2003; Connell, 1995; Wicks, 2002). The earlier, very open and direct opposition to women's work in the mine can be explained in part by the threats posed by women workers to the traditional images of mining and the traditional identity of miners (Blomberg, 2006). The fact that women and men could now do the same mining work probably still challenge male mine workers' identities and the traditional mining culture seem ill-prepared for that challenge.

Some examples of this are when the underground mine workers, especially those doing manual work tasks, half-jokingly give the remote control workers nicknames such as '*the velour workers*' or just stating '*now it is enough women here*'. Some typically 'restorative' responses, such as men's refusal to do 'women's work', and the desire for 'macho-masculinisation', can be seen as the men (*and* women) guarding the existing local gender order – and local masculinity in particular. Ideas of gender, femininities and masculinities, are often conservative and can create problems and defensive responses during organisational change (Abrahamsson, 2000; Hollway, 1996).

In the mining workplaces one encounters 'mining hero stories' and some 'macho men' around whom the local hegemonic masculinity is built (cp Connell, 1995). And one can also find that behind the overly explicit discourse of macho-masculinity, there is a wide spectrum of individual expressions of identity. The majority of mining workers does not, of course, live up to or behave fully in accordance with the ideals and norms of 'macho-masculinity'. Many men choose to take a subordinated position compared with the hegemonic masculinity, but in doing so, often glorifying, protecting and promoting the hegemonic masculinity-type. In any event, all tend to share the same image of what constitutes a 'real miner' – he is a tough guy and he works underground at the face and with manual or at least practical work tasks. These symbolic and discursive connections between mining work and masculinity, often the specific 'macho-form' of masculinity, probably make the worker identity 'lag' stronger and longer. One illustrative example of this is that even if they were proud of the high-tech production, some miners were at the same time disappointed with the new image of the company as a high-tech mineral business and upset over the consequences for the future of mining work (Andersson and Abrahamsson, 2007). One miner stated:

You get pissed off when all you see in the media are photos of girls in front of computer screens. In my workplace underground, we still use the same heavy tools as in the 1950s, but no one is visiting!

It is also important to note that the 'gender problem' is not only a question of men being afraid of being seen as womanish. Regardless of 'the women issue' the changes in the mining industry during the last 50 years associated with new technology and new qualifications demands have threatened the local hegemonic masculinity rooted in the old type of mining work.

However, one can also see indications of change: something is happening with the construction of gender and contemporary masculinisation processes are taking new forms. There are new types of masculinities (and femininities) that increasingly share the space with the old and potentially fading ‘macho-masculinity’ – not only in workplace cultures, but also in the local surrounding society.

CONCLUDING REFLECTIONS

This paper contains a discussion on how individuals create and recreate skills, identity and gender when meeting new technology and a changing work organisation. From a longer historical perspective there have been quite thorough changes for the miners as a professional group. Deep knowledge about the rock is still essential for the underground miners and their skills are related to the ability to read the rock. For the new type of miners, on the seventh floor, it is more a question of abstract knowledge, an ability to read and understand pictures and symbols and relate them to different measurement test results. Another aspect is social belonging and identity. The workers have to leave their old blue-collar context and move into a white-collar environment. The old type of ‘macho’ behaviour is therefore challenged and the workers have to find new ways of forming identity.

In Swedish mining companies, as well in the working life in general, work organisation, workplace culture and learning are seen as important factors to a company’s ability to develop an effective, flexible and yet sustainable production system. There is also a rising awareness that gender is one aspect of this, even if the companies experience difficulties in their practical measures. Because of the gender segregated and somewhat patriarchal and gender unequal culture that often surround mines it can be difficult to recruit women to the mining industry. When for example starting up at a new mine site, it might be tempting to go the easy way, to follow local traditions and trade routines, and just recruit men, because it probably will be mostly men applying for the jobs. But with such a strategy, there is a risk that the new mine falls into the same trap as old mining companies are trying to get out of. But ‘gender’ is not only a question of recruiting women to a male dominated industry. A gender unequal organisation (where a gender homogeneous organisation is one type and a gender segregated is another) can produce inflexibility and hinder communication, learning, innovations and change processes.

But one problem is that mostly when gender issues are dealt with the discussions stay on quantitative level and also tend to be explained by external causes. To get a really good instrument for decision making, production and organisational development and work environment analysis, a company also need internal and qualitative analyses based on gender theory. Such methods would probably be more useful to shed light on practical gender-based inequalities within the work organisation. The mines of the future need to not only promote the mine as an attractive employer for both women and men, but also actually make the mine a good workplace for both women and men.

Finally, to sum up some conclusions in the view of future mining we can predict that:

- in large-scale mines the trend with automation will continue depending on how well one manages to transform the hard rock into a manageable form,
- parts of the production process that yet can’t be automatised will to a high degree be steered by remote control from above ground,
- in this process a number of ‘blue collar works’ will be transformed into ‘white collar works’ with better working environment and a new set of qualification demands more based on abstract knowledge,

- another trend is a more equal gender balance in the mining companies when more women are recruited as mining workers or engineers, and
- yet another trend is the mining companies’ organisational development inspired by modern management concepts like lean production, total productive maintenance total quality management, knowledge management, etc.

All this has effects on how individuals and company create and recreate skills, identity and gender. To some extent the technological development predestines these changes, but there are some choices to be done when forming good work and good organisations for the mines of the future. The traditional mining workplace culture and behaviours and the old type of masculinity, the ‘macho’ style, will for example be challenged by the new ‘high-tech’ work and new competency demands. Therefore the changes risk meeting restoring responses which can have negative impact on the performance of the organisation. These questions need to be handled when planning the future mining work organisations.

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