People's mathematics in working life: Why is it invisible?

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Abstract

The labour market requirements play a central role in the answer from politicians and educational planners to the question "Why teach mathematics to adults?" Mathematics is interwoven with technology in the workplace - in technique, work organisation and people's competences. Still "No" is the most common answer to the question "Do you use mathematics in your work?" This leads to one relevance paradox. – Mathematics as a visible tool disappears in many workplace routines. However, this kind of invisibility is not the only reason for the negative answer. People simply do not recognize the mathematics in their daily practice – as mathematics. They do not connect the everyday activity and their own competence with mathematics. Most of them only associate mathematics with the school subject. Hence the two main answers to the question "Why do adults study mathematics?" are proving to yourself that you can learn the mathematics that you did not learn in school and being able to help your children with their homework. This leads to a second relevance paradox.

Key words: adult education, justification, lifelong learning, mathematics in work, special needs education.

Lifelong education

In the European countries, the right and the obligation concerning education does not stop with childhood and youth but also includes adult life. The idea of lifelong learning has left its mark and adult education programmes are prioritised in educational and labour market policies. In adult and continuing education there seems to be two parallel and combined processes going on: an institutionalizing process adding schools for adults to the schools for children and adolescents, and a de-institutionalizing process with a focus on adults' learning processes outside schools (Wedege, 2004b). In various policy reports, the so-called "key competencies" and "basic skills" are identified and appropriate educational responses to societal demands for qualifications are postulated. As one of the basic skills, "mathematics", "mathematical literacy" or "numeracy" is among top 5 on the subject list in the educational programmes. Among the reasons for offering lifelong mathematics education, we recognize the economy to be decisive at the political level; technological development in the labour market is the main reason for demanding mathematics education for all. However, in this context, people's everyday competences do not count as mathematics (FitzSimons, 2002). Mathematics is to a large extent invisible in people's everyday life and they do not feel it relevant to study mathematics. One of the reasons is that people experience themselves as competent in their jobs without being aware of how mathematics plays a role in their activity (Wedege, 1999; Wedege & Evans, 2006). Thus, mathematics education is experienced by the learners as a field of tension between felt needs concerning what one wants to learn – or has to learn – and various constraints from society and the labour market (Wedege & Evans, 2006).

In the article, I discuss why people's mathematics in work is invisible and present two relevance paradoxes connected to this phenomenon. The first paradox is related to reasons for teaching mathematics to adults. It is about the objective relevance of mathematics in society versus the subjectively experienced irrelevance. The second paradox is related to adults' reasons for studying mathematics. It is about the discrepancy between societal reasons for offering mathematics education to adults and individual motives for learning mathematics. In this context, the term *adults* refer to people with workplace experiences and short formal educational stories.

Why teach mathematics to adults?

As mentioned mathematics is among top 5 on the subject list in adult educational programmes. According to Niss (1996), there are three overall reasons for providing mathematics education in general:

- Contributing to the technological and socio-economic development of society at large, either as such or in competition with other societies/countries;
- Contributing to society's political, ideological and cultural maintenance and development, again either as such or in competition with other societies/countries;
- Providing individuals with prerequisites which may help them to cope with life in the various spheres in which they live: education, occupation; private life; social life, life as a citizen. (Niss 1996, p. 13)

The first two reasons (technology/economy and culture) are formulated from a societal point of view and the third reason from an individual's point of view. If you look at the rationale of the ideas of lifelong education over a period of time you may find the same kind of reasons: technology, economy, culture and democracy. According to Rubenson (2001), UNESCO introduced lifelong learning as a *utopian-humanistic* guiding principle for restructuring education, in the late 1960s. "Education for all" and democracy were on the agenda. The concept disappeared from the policy debate but reappeared in the late 1980s where the debate was driven by an interest based on an *economistic* worldview emphasising the importance of highly developed human capital, science and technology. From the first to the second generation, lifelong learning had changed from a utopian idea to an economic imperative. However, in the late 1990s, it seemed that a third generation (*economistic-social cohesion)* with active citizenship and employability as two equally important aims for lifelong learning – at least on the rhetorical level – were taking over. Here, the market still has a central role but the responsibilities of the individual and the state are also visible (Rubenson, 2001). The concept of lifelong learning is not formed on a national level but on an international level (UNESCO, OECD and EU). It is a globalised idea being reinterpreted on the national level. In the official Nordic documents concerning lifelong learning we recover the discourses of the second and third generations. Here are examples from Norway and Sweden (from Wedege, 2004b):

> Lifelong learning and educational opportunities for adults are important principles of Norwegian educational policy. The aim is to provide suitable conditions in order to strengthen the competence of the adult population. Updated and new competence is necessary to improve competitiveness and increase flexibility in a changing working life. New competence can give individuals greater freedom of choice and possibilities to realise their wishes and needs. (Norway)
>
> Lifelong learning is a holistic view of education and recognises learning from a number of different environments. The concept consists of two dimensions. The lifelong dimension indicating that the individual learns throughout a life-span. The lifewide dimension recognises formal, non formal and informal learning. (…) Lifelong learning and lifewide learning is an issue for educational policy, labour market policy and workplace as well as civil society. (Sweden)

As the other Nordic countries, Denmark has a long-standing tradition of adult and lifelong education ranging from liberal adult education activities to qualifying general as well as vocationally oriented adult education. In 2001, a new programme Preparatory Adult Education (PAE) in Mathematics was introduced as an entrance level to formal adult education. During the political debate and the educational planning process of this programme, “active citizenship”, “employability” and “personal needs” were used as equivalent arguments for establishing this programme (Johansen, 2006, p.275).

The aim of PAE in Mathematics is to develop the adults’ numeracy, which – in this context – is understood as the functional mathematical skills and understanding that are needed in principle by all people in society. At the first of two educational levels, it is expected that the participants clarify, improve and supplement their number sense and functional arithmetic skills for everyday practical use and personal organisation. The education is to ensure participants the possibility of developing their mathematical awareness and the ability to deal with, process, evaluate, and produce mathematics-containing information and materials, as well as being able to communicate about these things (see Lindenskov & Wedege, 2001). In her doctoral study, Johansen (2006) followed the political debate and the developmental work in Denmark leading to the programme of Preparatory Adult Education in Mathematics. Her focus was on the arguments given by the politicians and by the researchers developing the programme, who agreed in general that adults without basic skills in mathematics should be offered mathematics education. From Johansen’s analysis we learn that politicians and educational planners – in their discourses – constructed a common picture of the world with:

- a labour market with demands on adults’ [mathematical] knowledge and skills
- an educational system with demands on adults’ [mathematical] knowledge and skills
- an everyday life with demands on adults’ [mathematical] knowledge and skills
- a societal life with demands on adults’ [mathematical] knowledge and skills

(Johansen 2006, p.275 [my insertion])

But “No” is the most common reply from adults when asked: “Do you need mathematics in your work?” The place and function of mathematics in the workplace are largely invisible and unrecognised by people (Wedege, 2004). Hence, the answer to the first question, “Why teach mathematics to adults?”, leads me to the *relevance paradox (1)* which was formulated by Niss (1994): There is a contradiction between the objective relevance of mathematics in society and the subjectively experienced irrelevance. This paradox is caused by the “discrepancy between the objective social significance of mathematics and its subjective invisibility” (p. 371). In general, people find that mathematics is important in society and as a school subject but not for themselves. In other words, someone has to learn mathematics but not me. Possible reasons for this paradox may be found in the difference between mathematics in school and mathematics in the workplace.

Visible and invisible mathematics in technology

In educational research, the overall interest in studying adults’ mathematics *in* the workplace is mathematics education *for* the workplace (see Wedege, 2004). At the same time learning mathematics *for* the workplace is the most common argument for mathematics in adult educational programmes and in lifelong mathematics education, across the different generations mentioned above. “Using mathematical ideas and techniques” is usually pointed to as a key competence in international policy reports concerning the requirements of the technological change in society. The general categories of competences are here described in isolation from the technological contexts of workplaces. Hence, the complexity of mathematics in the workplace is reduced and mathematical knowledge as such, referring to the formal disciplines, for example algebra and geometry, is seen as a key competence; (FitzSimons, 2002; Wedege, 2004a). Consequently, use of mathematical knowledge in workplace situations is seen as a simple question of knowledge transfer (Kanes, 1997). Or in other words that school mathematics can easily be transferred and used by the worker as a tool to the workplace situation.

Contrasting with this view of mathematics, research from the beginning of the 1980s until now has shown that mathematics in people’s everyday life in many ways is different from mathematics learned in school. In an early study, Lave, Murtaugh and de la Rocha (1984) concluded that people going to the supermarket are not doing arithmetic but grocery shopping. Workplace studies have shown that mathematical knowledge is integrated with and dependent on other kinds of professional knowledge and experiences in the worker’s competence (see Hoyles et al., 2002; FitzSimons, 2002; Wedege, 2004). For example, Hoyles, Noss and Pozzi (2001) did a study on proportional reasoning in nursing practice, where they found that the formulas used by the nurses for calculating medicine in the workplace context were different from the algorithm taught in the training programme.

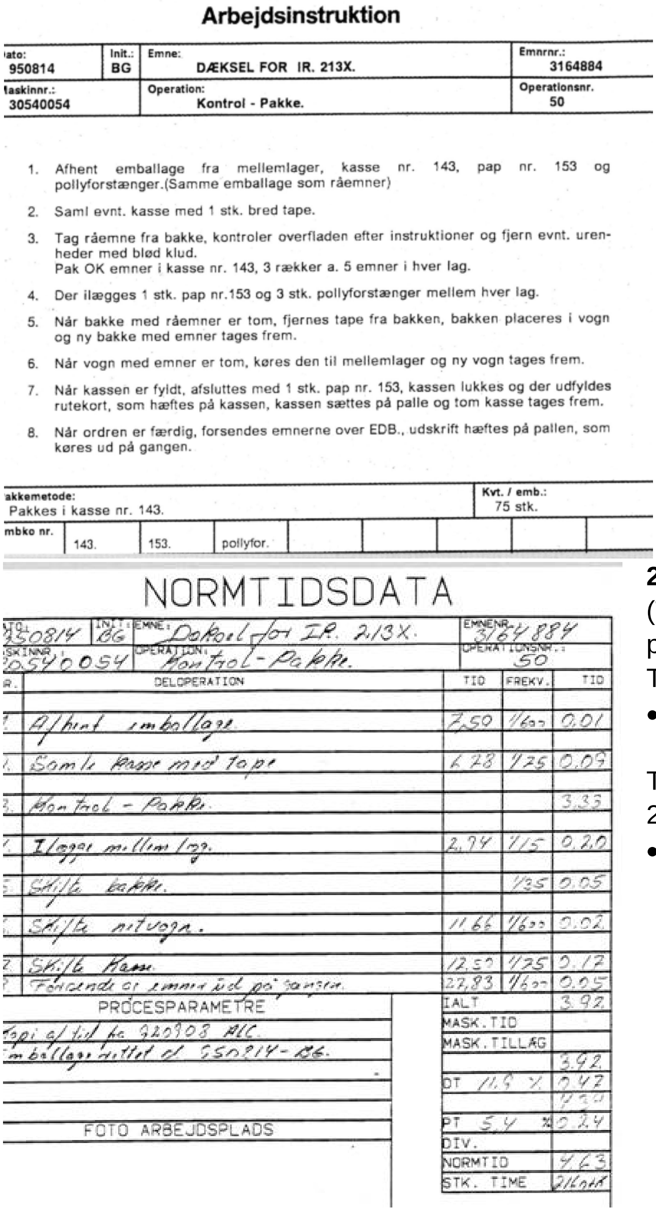
This exemplifies two problems that many researchers agree upon (cf. Bessot & Ridgway, 2000; Sträßer & Zevenbergen, 1996; Wedege, 2004):

- Mathematics is integrated in the workplace activities and often hidden in technology.
- The so-called “transfer” of mathematics between school and workplace – and vice versa – is not a straightforward affair.

The focus of the article is on the first issue. However, the problem complex related to the second issue on differences and relationships between mathematics in school and mathematics in work underlies any debate on the visibility of mathematics, as we shall see.

When talking about mathematics being hidden in technology, I mean *technology* in the labour market consisting of three elements and their dynamic interrelations: technique/ machinery, human competences/qualifications, and work organization (Wedege, 2004a, 2006). *Mathematics-containing technology* is technology where mathematics is an integrated but potentially identifiable part; for example in pin and bar codes. With the optic of a mathematics teacher, one might recognize mathematics in the three dimensions of workplace technology: integrated in technique and machinery, embedded in work organization, and incorporated in human qualifications and competences. But one cannot make the deduction from mathematics *in* work to mathematics education *for* work. The translation from mathematics in the workplace into mathematics in school and vice versa is not straightforward. From written material collected in the workplace (work sheets/instructions, description of machinery etc.), it is possible to generate a long series of mathematical tasks, with the workplace as task-context. But without observations of mathematics in the workplace context (how is the work organized – how does a competent worker handle this situation) the use of authentic material might be just a pretext for teaching mathematics. I suggest calling these tasks, which are construed for the sole purpose of practising mathematics, school mathematical tasks.

By a *school mathematical task* I mean a task primarily used to practice skills (use of algorithms and concepts) and to test skills and understandings. Thus, the task is often solved by the individual student. The task is formulated by the teacher, the textbook or the program. The task has one correct solution. (Accuracy in the school and tolerance at the workplace are two different things.) Solving tasks has no practical meaning: the results are not used for anything except, maybe, solving more tasks. Contrary to this, in a *workplace task* the numbers are to be found or constructed with the relevant units of measurement (hours; kg; mm). It is the working tasks and functions in the technological context which controls and structures the process, not the task. Tasks are solved in different ways and different procedures and solutions might be OK. At the workplace solving tasks is a joint matter: you have to collaborate, not compete. Solving tasks has always practical consequences: a product, a working plan, distribution of products, a price etc. (Wedege, 2002b).



Arbejdsinstruktion

Dato: 950814	Init.: BG	Emne: DÆKSEL FOR IR. 213X.	Emnenr.: 3164884
Maskinnr.: 30540054		Operation: Kontrol - Pakke.	Operationsnr. 50

1. Afhent emballage fra mellemlager, kasse nr. 143, pap nr. 153 og pollyforstænger.(Samme emballage som råemner)
2. Saml evnt. kasse med 1 stk. bred tape.
3. Tag råemne fra bakke, kontroler overfladen efter instruktioner og fjern evnt. urenheder med blød klud.
   Pak OK emner i kasse nr. 143, 3 rækker a. 5 emner i hver lag.
4. Der ilægges 1 stk. pap nr.153 og 3 stk. pollyforstænger mellem hver lag.
5. Når bakke med råemner er tom, fjernes tape fra bakken, bakken placeres i vogn og ny bakke med emner tages frem.
6. Når vogn med emner er tom, køres den til mellemlager og ny vogn tages frem.
7. Når kassen er fyldt, afsluttes med 1 stk. pap nr. 153, kassen lukkes og der udfyldes rutekort, som hæftes på kassen, kassen sættes på palle og tom kasse tages frem.
8. Når ordren er færdig, forsendes emnerne over EDB., udskrift hæftes på pallen, som køres ud på gangen.

Pakkemetode: Pakkes i kasse nr. 143.	Kvt. / emb.: 75 stk.

Embko nr.	143.	153.	pollyfor.					

NORMTIDSDATA

Dato: 950814	Init.: BG	Emne: Dæksel for IR. 213X.	Emnenr.: 3164884
Maskinnr.: 30540054		Operation: Kontrol-Pakke.	Operationsnr.: 50

Nr.	Deloperation	Tid	Frekv.	Tid
1.	Afhent emballage.	7,50	1/600	0.01
2.	Saml kasse med tape	6.78	1/75	0.09
3.	Kontrol - Pakke.			3.33
4.	Ilægge mellemlæg.	2.74	1/15	0.20
5.	Skifte bakke.		1/35	0.05
6.	Skifte ny vogn.	11.66	1/600	0.02
7.	Skifte kasse.	12.50	1/75	0.17
8.	Forsende og emner ud på gangen.	27,83	1/600	0.05

Procesparametre		
Kopi af tid fra 920908 ALC.	IALT	3.92
Emballage rettet d. 950814 - BG.	MASK. TID	
	MASK. TILLÆG	
		3.92
	DT 11.9 %	0.47
		4.39
Foto arbejdsplads	PT 5.4 %	0.24
	DIV.	
	NORMTID	4.63
	STK. TIME	216 stk

1. Packing

(The four basic arithmetical operations)

600 covers are to be checked and packed in boxes. There are to be 5 layers in each box. Each layer is to consist of 3 rows of 5.

- How many boxes are needed?

2. Basis time

(The four basic arithmetical operations, percentages)

The basis time for this work operation is 4.63. [9]

- How many pieces per hour does this correspond to?

The working time for checking and packing of 248 covers is 1 hour.

- What percentage of basis time is the working time?

Figure 1. Two school mathematical tasks constructed on the basis of a work instruction (Wedege, 2006, p. 32)

Let us look at an example. Numbers and time are important factors in industrial production and any teacher of mathematics is able to generate a series of tasks on the basis of them, for example written instructions (Danish: Arbejdsinstruktion) for the work function of "packing and control of covers", which I collected in a large electronics company. See two examples of school mathematical tasks for practising the four basic arithmetical operations and percentages in figure 1. But the operative who is to perform this work function does not experience the need to carry out these calculations. The work instructions state that each box should include 75 pieces. When the operative fetches packaging material for the 600 pieces, she has to calculate the number of boxes to be used. When new objects appear, she must read, do a little calculation and count, but this quickly becomes routine. The computer carries out all calculations concerning working and basis time.

[9] When the basis time for the work operation (check and pack one cover) is calculated to 4.63 it means that you have to do the operation 1000/4.63 times per hour to keep the standard.

When the teacher constructs this kind of task, he/she might have the impression of translating from the workplace to the mathematics classroom, but is actually doing the opposite: translation from the mathematics classroom to the workplace. In this case, mathematics integrated in technique and work organisation is used as a pretext for practising the four arithmetical operations and percentages.

In the definition above of mathematics-containing technology, I talk about identifying integrated mathematics and it might be asked: identified or recognized by whom? When you ask an adult who doesn’t have an explicit mathematics-containing profession, if he or she uses mathematics in the daily work, the answer is most likely to be “no”. The mathematics integrated in technology is invisible. In a study of competent workers’ mathematics containing activities, at a large electronics factory, I observed a semi-skilled worker with many years of experience in production. She is now working in the quality control. When I interviewed her after the observation, asking questions about the mathematics that I located in her work, she said: “ … that’s just the logic of battery hens” (Wedege 2002a, 2006).

The meaning of *invisible mathematics* is “subjectively invisible mathematics” (people do not recognise the mathematics that they do as mathematics) which is contrary to “objectively invisible mathematics” (the mathematics is hidden in technology) (see Wedege, 2002a). The latter is, for example, the way Richard Noss uses the term “invisible mathematics” when he discusses how technology has transformed work (Noss, 1998). Traditional survey and interview studies do not reveal mathematics at work because mathematics is hidden from the perception of the worker by artefacts (material tools, workplace procedures or organisational features) (Strässer, 2003) or hidden from the consciousness of the adults due to their self perception and/or conception of mathematics – unrecognised mathematics (Wedege, 1999, 2002a). This is also why the approach and the research question are crucial, in the workplace studies. In my research, the basis has been a *subjective approach* starting with people's subjective needs for investigating competent workers’ mathematics (Wedege, 2004, 2006) and not an *objective – or general – approach* starting either with societal and labour market demands or with the academic discipline (transformed into "school mathematics") for asking what mathematics is needed to become competent workers (OECD, 1995, 2005).

Locating the problem

But why is it a problem when adults with short formal educational stories find mathematics irrelevant in their working life; and what is the problem about? In the context of special needs education, an operational definition of low achievement in mathematics is given by Magne (2006, p. 23). According to him *special educational needs in mathematics* (SEM) means low achievement in mathematics. A SEM student has got marks in mathematics below the pass standard according to the valid marking system. Following this definition the students at programmes like Preparatory Adult Education (PAE) in Mathematics per se have special educational needs in mathematics. They have been weighed and found too light in the school assessment and, later after school, in international surveys like the International Adult Literacy Survey (OECD, 1995) and the Adult Literacy and Life Skills Survey (OECD, 2005).

In Denmark, the politicians and the educational researchers agreed on the reasons for teaching mathematics to adults when referring to demands of the labour market, in the educational system, in the individual’s everyday life and societal life. But they did not agree on the definition of the target group of Preparatory Adult Education. In their discourses, politicians and educational planners constructed conflicting pictures of the adults, according to Johansen (2006). The politicians constructed a picture of adults not being able to take part of societal life, a group excluded from society or in danger of being excluded. Furthermore, the target group is described as people who are unaware of their missing skills. The educational planners constructed a picture of adults being competent and handling the mathematics-containing situations in their daily and working life. But people in the target group are not aware of their own skills and they do not see what they can do as mathematics (Johansen, 2006).

In the two discourses, we find different ways of locating the problem: the politicians place the problem in the adult learner talking about the adults having problems with mathematics, and the educational planners locate the problem in mathematics education talking about mathematics education having problems with the adults.

Why do adults study mathematics?

When adults pursue education or training intending to become a baker or a truck driver, for example, not to learn mathematics, and they are often astonished when they meet mathematics in the vocational schools (Sträßer & Zevenbergen, 1996; Wedege, 1999). But how about adults who voluntarily attend numeracy or mathematics classes? Do they want to learn mathematics in order to acquire "prerequisites which may help them to cope with life in the various spheres in which they live: education, occupation; private life; social life, life as a citizen" (cf. Niss 1994 quoted above)? In the English project *Making numeracy teaching meaningful to adult learners*, a central research questions was about students' motives for attending – and continuing in – adult numeracy classes. The researchers conducted 81 qualitative interviews with students from numeracy classes in four schools to answer the question, and it was concluded that students' reasons for joining, and continuing to attend, numeracy classes are varied and complex (Swain et al., 2005). However, few of these reasons are related to perceived needs within their current employment, or to students feeling that they have a skills deficit in their everyday life – for example not being able to deal with financial problems. In the summary of the key findings from the research project, it is stated that:

> The main triggers are: to prove that they can succeed in a subject where they have previously experienced failure; to help their children; for understanding, engagement and enjoyment; and to get a qualification for further study (Swain et al., 2005, p. 86).

In a survey with 828 respondents among students at Preparatory Adult Education in Mathematics, in 2004, one of the questions concerned the reason for beginning to study (DMA/Research, 2004). Below are the two items with the highest scores among students who found the item relevant:

- To become more self-confident: 89%
- To help my children with their homework: 83%

In both surveys, a main reason for adults who study mathematics/numeracy on a voluntary basis is that they want to prove for themselves that they can manage mathematics, which they failed to do in school, and to help their children with the homework. In these statements, I see the possibility of a closed and vicious circle from school mathematics to school mathematics and I find this to be a challenge for mathematics education as such and for adult mathematics in particular.

The answer to the second question, "Why do adults study mathematics?", leads me to *relevance paradox (2)* which is specific to lifelong mathematics education: There is a contradiction between the adult students' motives for learning mathematics and the societal reasons for providing mathematics to adults. The paradox is caused by the discrepancy between the argued relevance of mathematics (utility in the labour market and in everyday life) and the subjectively experienced relevance (to prove that I have the ability to succeed in a subject which is a signifier of intelligence and to help my children at home). The main reasons for these people to engage with mathematics as adults are not to be found in their working lives or societal lives but in school mathematics. They had special educational needs in mathematics in lower secondary school mathematics and now they want to prove for themselves that they can succeed in the school subject, and to help their children to cope with school mathematics.

These adults have a conception of mathematics restricted to school mathematics. As students they have experienced that the purpose of learning mathematics was to solve school mathematical tasks. In their adult lives, school mathematics is again the reason for studying mathematics and not a felt need in everyday life. There is a vicious circle from school mathematics to school mathematics.

Conclusion

Despite democracy and citizenship being an overall reason, the justification of mathematics in adult education – general education as well as vocational training programmes – is primarily found in the labour market requirements and in the needs of the individual to handle mathematical situations in her/his daily work. But the adults who had special educational needs in mathematics in school do not find mathematics relevant in their working lives where they experience themselves as competent workers without it. Failure in school and a restricted conception of mathematics as algorithms and formulas might lead to people not recognising the mathematics that they do as mathematics and as a consequence result in the belief "Mathematics – that's what I cannot do" (Coben, 2000; Wedege, 1999, 2002a). In other words when adults who struggled in school mathematics handle a mathematical situation in work they see their competence as common sense and not as mathematical knowledge. Mathematics is hidden in technology but this is not the only reason for mathematics being invisible in work.

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