Ergonomics Research Techniques

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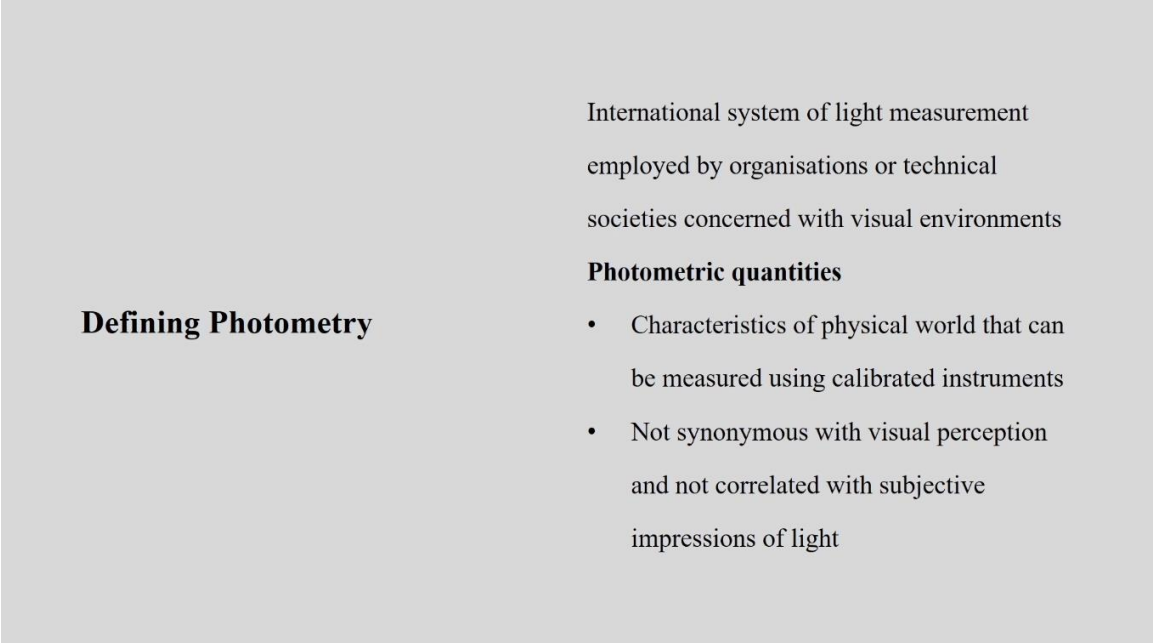
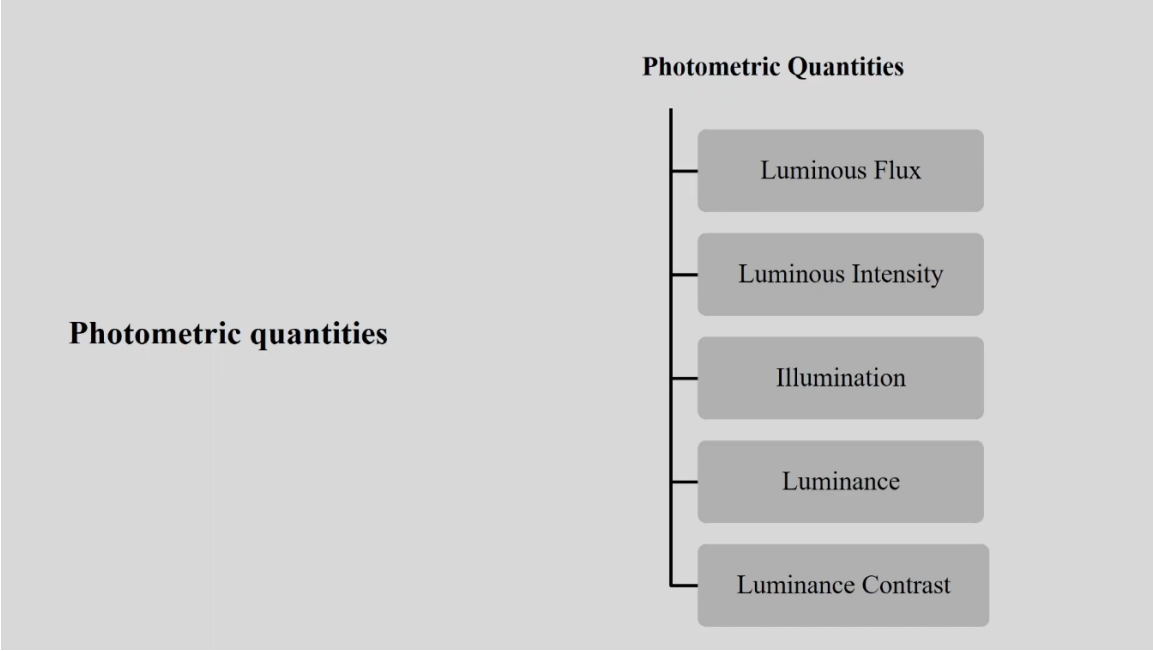
Week 12: Lec 42- Assessment of environmental factors

Measurement of different environmental factors- Part II

Welcome back for today's session. This will be your last session that we are going to discuss about the environment and we will try to conclude this MOOCs course in this particular session. So let us start with light that is very important factor if we talk about working environment. Now you can see that if you are in a place where you need to do any kind of activity, any kind of activity even if it is occupational or non-occupational does not matter. If you need to do some kind of activity for a normal person, you definitely need the illumination, you need the light right. Without light you will not be able to perform anything. So understanding light and the effect of light is very important. So today we will be discussing light. Along with light earlier we talked about thermal environment, we talked about olfactory environment. Today we will talk about also the vibration. Because in many cases we also face lot of issues related to vibration at the workplace. And overall when we are talking about ergonomics, two important thing that is the participatory ergonomics and the macro ergonomics. We will be discussing today and we will be concluding today's class or session with this particular lecture. So when we are talking about light.



Photometry is a terminology that always comes in mind and we need to understand photometry clearly. Like as earlier also I mentioned, we do not have much scope to explain and work in detail as far as these topics are concerned. We will be giving brief of it. So international system of light measurement employed by organization or technical societies are concerned with the visual environment and they only try to do the quantification of the photometry. So characteristics of physical world that can be measured using calibrated instruments that is one of the requirement and it is non-synonymous with the visual perception and not correlated with the subjective impression of light ok. So when we are talking about photometric quantities we normally try to measure these five elements or we try to understand these five factors.



First one is luminous flux, then luminous intensity, illumination, luminance and luminance contrast ok. So we will be explaining one by one.

Luminous Flux

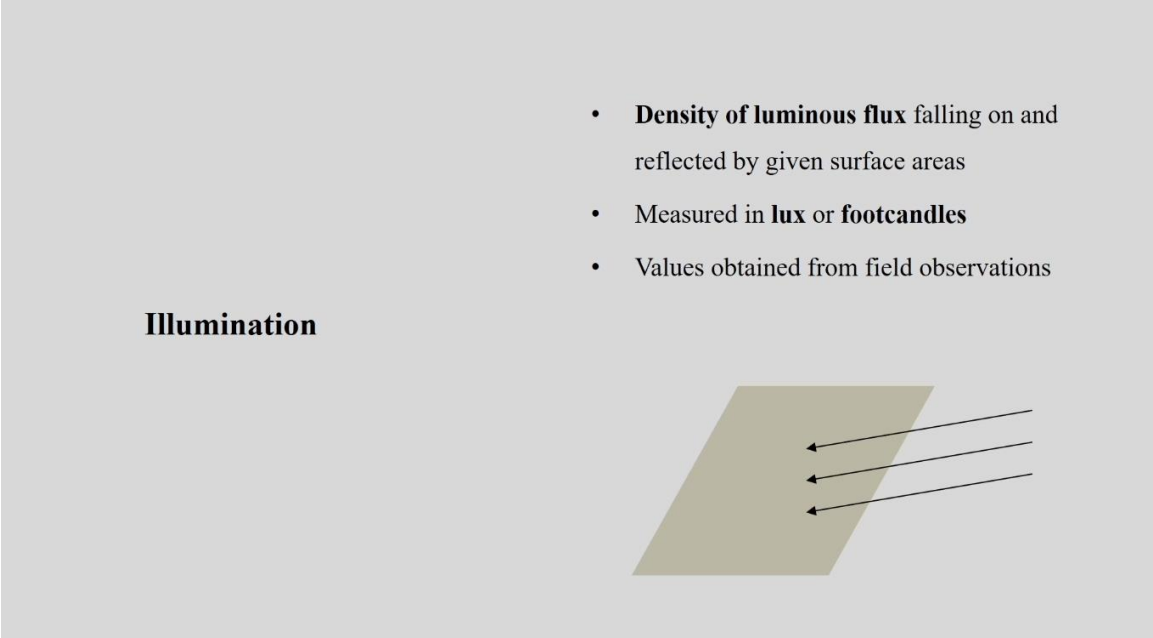
- Defined as **total amount of light emitted** by a light source, measured in **lumens**
- Manufacturers required to print **rated lumens** on product packages
- **Rated lumen value** – average amount of light produced by large product sample, operated at their rated voltage
- Values obtained in photometric laboratories, not measured in the field

What is luminous flux? So defined as the total amount of light which is being emitted by a light source and measured in a lumen. Lumen is the unit ok. So manufacturers required to print rated lumens on a product package because that is mandatory and rated lumen value you know is the average amount of light produced by large product sample operated at their rated voltage. So values which is obtained in photometric laboratories not measured in the field. So this luminous flux which if we are talking about it is always in a particular laboratory testing ok.

Luminous Intensity

- **Different intensity distributions** of two or more light sources emitting same number of lumens
- Measured in **candelas** (lumens per solid angle)
- Values always obtained in laboratory setups

What is luminous intensity? So it is the different intensity distributions of two or more light sources emitting the same number of lumens ok. So same number of lumens so you are calculating more like two or three or four different sources and what are the different intensities of distributions are there. So measured in this unit for the luminous intensity is the candle. So lumens per solid angle that is the candle and values always obtained in the laboratory setup. Here also you need a laboratory setup.



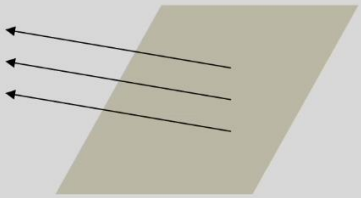
Third one is the illumination. So this is the density of luminous flux falling on and reflected by given surface area. So you have a surface there what is the kind of amount of density of luminous flux is you know coming and getting reflected. So this is measured in flux or foot candles. We have a specific instrument called the called the lux meter through that we may measure this particular variable.

Luminance

- Correlated exhibit of **perceived brightness**
- Measured in **nits** (candelas per square meter) or **foot-lamberts** (1/candelas per square foot)

Illuminance falling on surface ∝ Luminance of surface

- Depends on geometric relationship b/w light source, surface & viewing angle

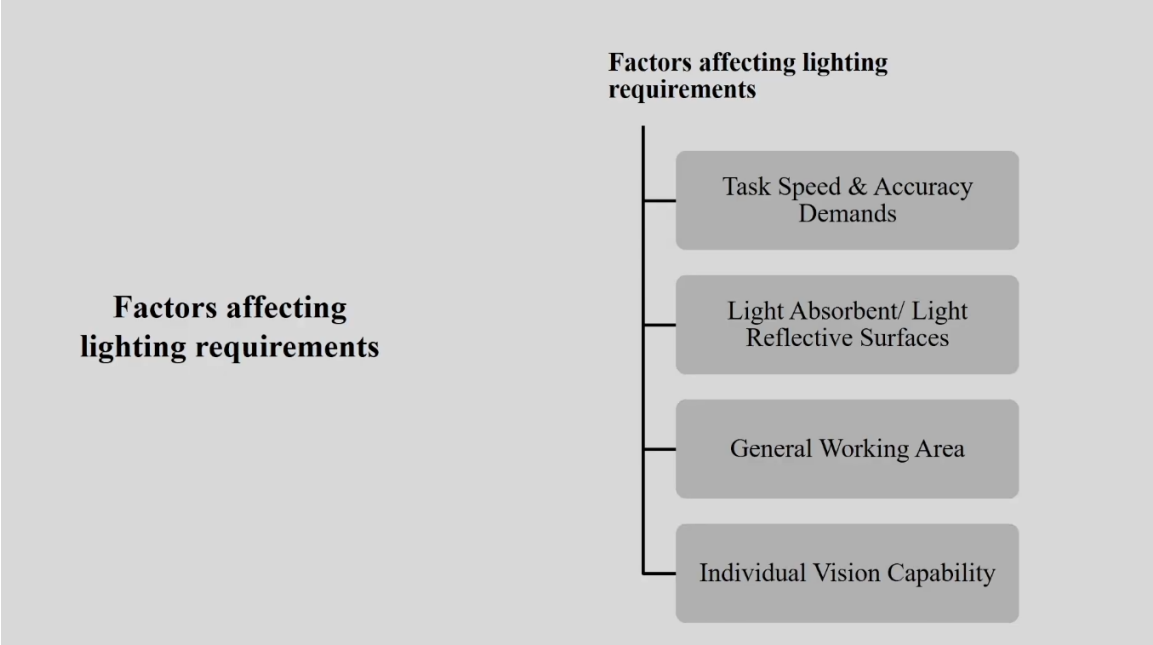


The fourth one is the luminous. This is the correlated exhibit of perceived brightness ok. So measured in units that is the candelas per square meter, candelas per square meter or foot lamberts that is the unit we use ok. So it depends on the geometry. So when we are talking about size, shape specifically shape of a particular object ok so that there it is very important for us to understand the luminous. So what kind of surface it is, what is the curvature of it. So for all these cases this is very important and this is going to affect your visual environment ok.

Luminance Contrast

- Measure of **difference in brightness** of two surfaces
- Surface brightness measured by **luminous reflectance** (LC) of the surface
- **Vision-impaired** individuals prefer **high luminance contrast** to **identify tactical surfaces**

Then is last one is the luminous contrast. So it is the measure of the difference in the brightness of two surfaces. That surface brightness measured by the luminous reflectance that is the LC of a particular surface. So vision impaired individuals prefer high luminous contrast to identify the tactile surface ok. So if someone has some kind of imparity in the vision, so for them this contrast is more important ok. If they contrast they identify the object very easily ok. So for those cases, so when we are talking about the designing any element for the visually impaired, maybe not completely visionless, but there are vision, but it is a little different than usual for those cases maybe this type of concepts are very important.



Now when we are talking about light we should understand what are the factors which is affecting the lighting requirements. So task speed because if the illumination level is different, luminous is different, the task speed also changes and the accuracy of the demand. Light absorbent, so what is the amount of light is getting absorbed in the surface. General working area, so working surface area and individual vision capability. This is very important and this is maybe it is difficult for someone to control, but these parameters you can control easily.

Improper/Poor Contrast

- Types of contrast problems – different light levels between areas, and contrast between colours of objects
- Immediate working area should be brighter than surrounding areas, to ensure reduced distraction from task areas
- Too little contrast between character and background makes reading tasks difficult
- Machine parts of same or similar colours are harder to distinguish due to poor contrast

Now when we are talking about all this illumination, we are talking about the visual environment, it is very important for us to understand the contrast which is not correct or incorrect or improper contrast ok. So type of contrast problem that is the different light levels between the areas and the contrast between the colors of the object. So immediate working area should be brighter than surrounding areas to ensure the reduced distraction from task areas. So very little contrast between the character and the background makes the reading task difficult. So you can understand, so suppose there is look at this presentation, your background is white and the letters are in black. So contrast is very high, so it becomes very easy for someone to understand visual, acuity is quite good ok. Now take the same presentation maybe some blue background or violet background or some other you know dark color background and write on the same black color font, you will see that there are so much of difficulties in reading right. So this poor contrast actually is very important for us to understand when we are doing any kind of visual design.

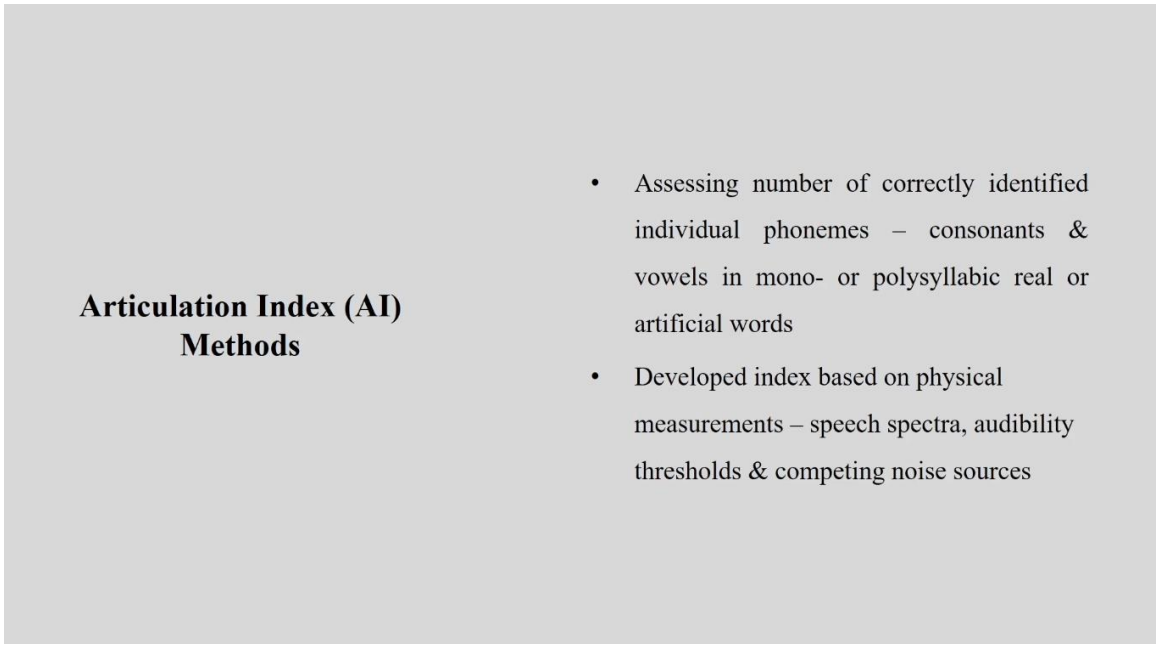
Noise

These all were about the light, now coming to noise. We will not talk about noise more, I will introduce you to the two major concept that is the speech intelligibility and the articulation index.

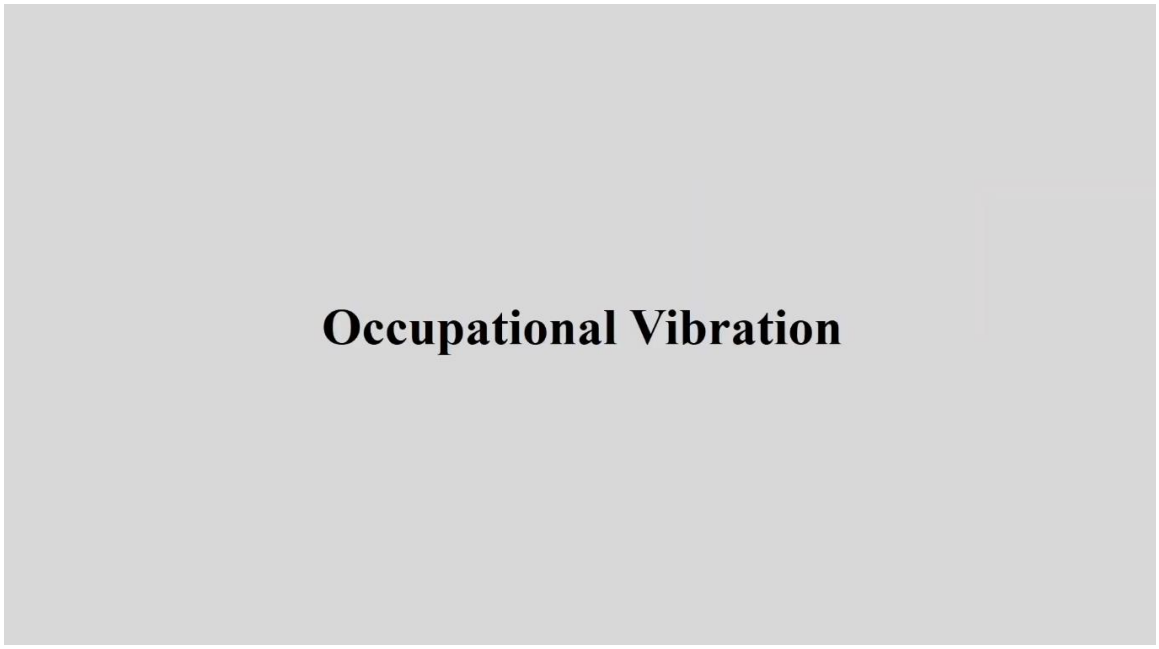
Speech Intelligibility (SI) Methods

- Assessing number of correctly identified words, phrases or sentences under noise conditions
- Most common SI method – Speech Interference Level (SIL)

So what is speech intelligibility method? So this is the assessing number of number of correctly identified words, phrases and sentences under any noise conditions ok. So there will be some background noise, the person how they are assessing any words, phrases and sentences correctly. So most common SI in method is the speech interference level that is called SIL ok.



The next one is the articulation index method. It talks about the assessing the number of correctly identified individual phenomena that is the consonants and vowels in mono or polysyllabic real or artificial words ok. So it is developed the it developed the index based on the physical measurement like the speech spectra, audibility threshold and computing the noise resources ok. So this is all about the articulation index method.

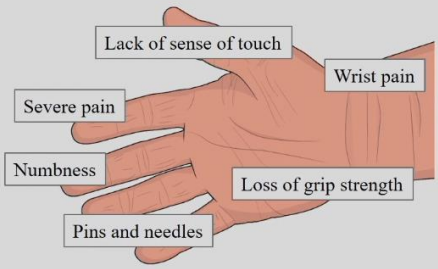


Moving to vibration, two important concept that is the hand-numb vibration and whole body vibration.

Hand-Arm Vibration (HAV)

Transmitted from work processes or equipment to workers' hand and arms, caused by operating hand-held power tools

e.g. pneumatic wrenches, angle grinders, road breakers.



Symptoms commonly associated with HAV

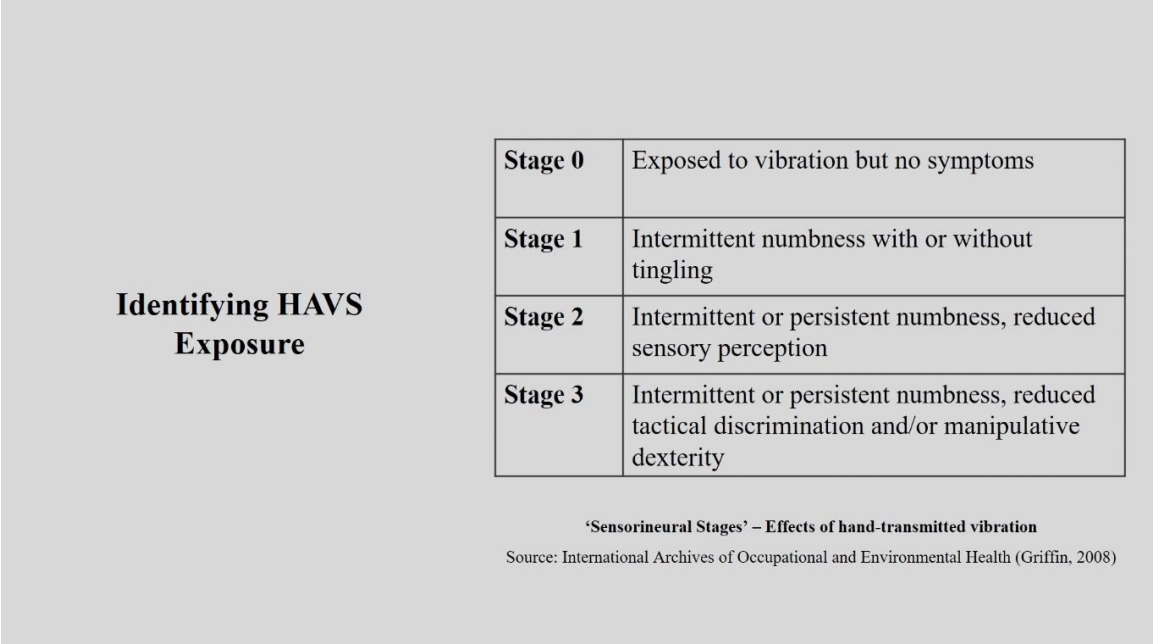
First we will talk about hand-numb vibration. So it is the transmitted from work processes or equipment to workers hands or arms. So only the arm and this hand portion ok caused by the operating hand held any kind of powered tool. So what happens you can see these are the symptoms: wrist pain, loss of grip, pins or needles if you prick you you find that kind of sensation, numbness, severe pain and lack of sense of touch ok. These are the common symptoms of hand-numb vibration.

Hand-Arm Vibration Syndrome (HVAS)

- Exposure linked to irreversible condition of fingers & hands, characterised by tingling and/or numbness in the fingers
- **Blanching** – Appearance of white fingertip in cold conditions, beginning of irreversible finger blanching process
- Extreme conditions w/ loss of blood supply to fingers lead to gangrene, requiring eventual finger amputation
- Workers to cease vibration exposure & seek immediate medical attention at the earliest onset of symptoms

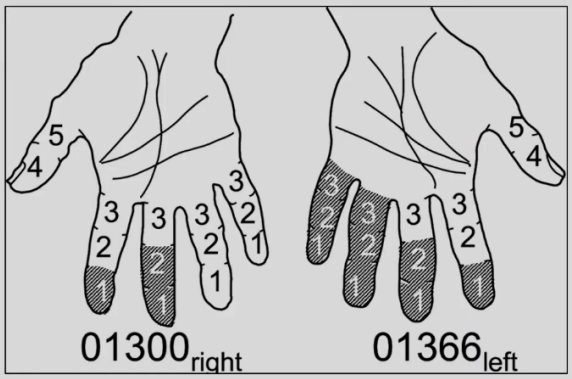
So exposure linked to irreversible condition, this is very important to know ok. It is irreversible condition. It is not that if you try to do some kind of therapy or maybe rest or

something this will go back ok. So this is irreversible conditions of fingers and hands and characterized by the tingling and numbness in the finger. So appearance of the that is also very important blinching ok. So this this top of the fingers sometimes or part of the fingers is like you know you get white fingertip and in cold conditions specifically and beginning the irreversible finger blinching process. So then you you do not actually what happens you do not get any kind of blood supply there or nerve sensations are not being picked up. So extreme conditions with loss of blood supply to fingers lead to you know such kind of situation. So hand-numb vibration is very very dangerous. Those people who are what I can say using lot of drilling machine or vibrating tool or by the hand and arm they are developing this type of syndrome.



How do we identify? These are the stages stage 0, 1, 2 and 3. So 0 is the exposed to the vibration, but you do not see any symptoms. Intermittent numbness with or without tingling that is the stage 1. Stage 2 intermittent and persistent numbness and you have reduced sensory perception and stage 3 which is an really dangerous condition that is the persistent numbness, reduced tactile discrimination and the manipulative dexterity. So this is very very dangerous and you should take care of these things when actually you identify stage 1 itself, you should try to rectify it ok. So this is the hand-numb vibration.

Calculating HAVS Exposure Score

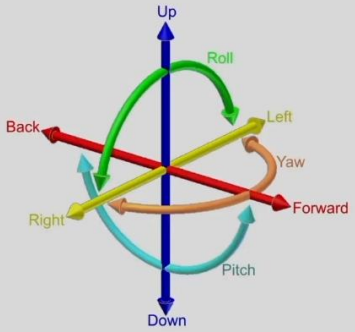


Scoring method for areas of digits affected by blanching, numbness, or tingling

Source: International Archives of Occupational and Environmental Health (Griffin, 2008)

Now how do we calculate the risk? So this is how the numbering is done. I will just explain for one maybe you can do the next. So we have fingers, we have blocks over here right. So 1, 2 and 3. So like that every 4 fingers these 4 fingers these 4 fingers you have numbering 1, 2, 3 and the only thumb we have 4 and 5 ok. So if you have any symptom in any one of this region, you just marked with ok. Here like this they marked. Now counting starts from here. This is finger number 1, 2, 3, 4 and 5 fine. So here you can see 0 means in thumb there is nothing. Then 1, 1 means in 1 region it is 1 there is some symptoms. 3 that means 1 plus 2 this is 3 again here you do not have anything here you do not have anything that is why it is 0, 1, 3, 0, 0 that is how we give the scoring of hand-numb vibration syndrome.

Basic Measurement Parameters

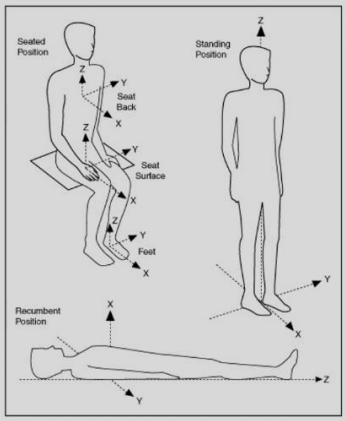


Pictorial representation of Vibration Vectors

- Vibration describes motion as a vector quantity
- Defined by 6 vectors :
  - Three mutually perpendicular linear motions (forward-back, up-down, left-right)
  - Three rotational vectors (pitch, yaw, roll)
- Vibration measurement:
- HAV measured from tool handles where worker grasps the tool
- WBV measured from top of seat cushion where the driver sits

So how the basic measurement parameters are? So vibration describes motions as a vector quantity. So defined by 6 vectors; 3 mutually perpendicular in linear motion that is the forward back, up down and left right and 3 in a rotational vector that is the pitch, yaw and roll ok. So vibration measurements are hand-numb vibration measured from the tool handles where worker grasp the tool. So suppose here is the handle where the person is holding that. So that exact the point where the person is holding it ok and whole body vibration measured we are going to discuss that next that whole body vibration measured from top of this seat cushion because whole body vibration normally comes from a seat pan ok where people are sitting the whole the pan is shaking ok getting vibrated. So cushion where the driver is sitting. Normally it comes for the automobiles that is why it is called as the driver is sitting.

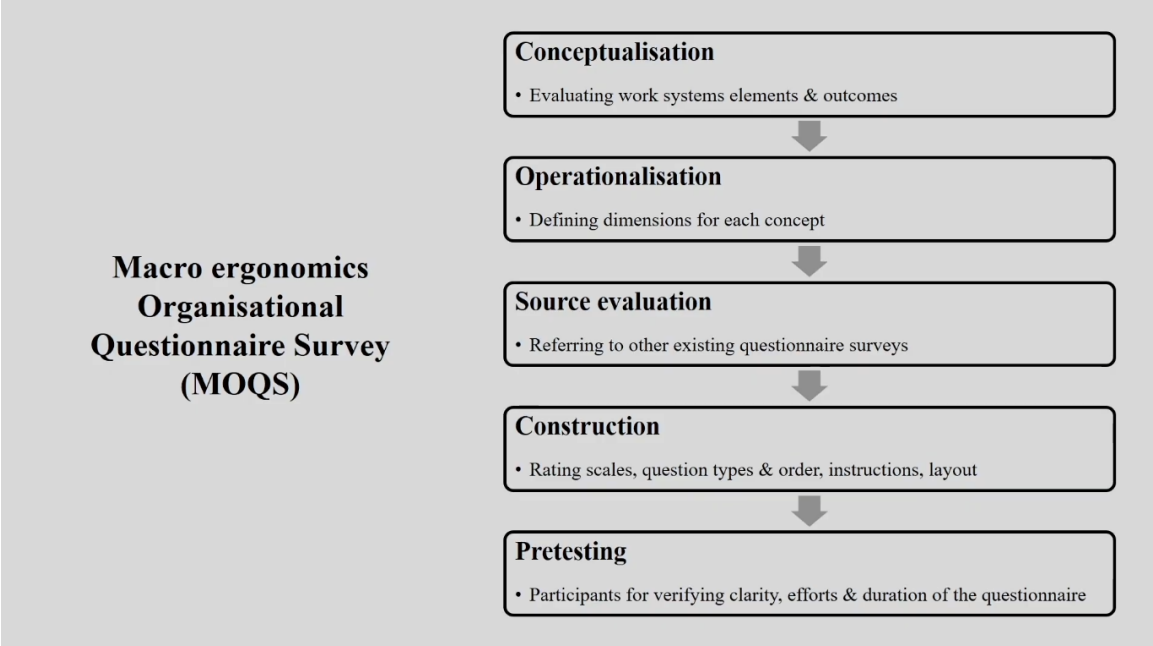
Whole-Body Vibration Measurement Parameters



Measurement axes for WBV

- Use of rubber seating pad/disc equipped w/ triaxial accelerometers
- For steady-state measurements below 1 Hz, devices like piezoresistive or capacitive accelerometers
- Data collection should last for at least 2 to 5 minutes

So coming to whole body vibration it is very important that hand-numb vibration is only from your arm this whole arm and your palm whereas whole body vibration is for your whole body. How does it happen? When you are sitting in on a vibrating seat pan, then only this is happening mostly in the automobile sector where people are you know sitting in a driver seat and they are driving the while driving the seat keeps on vibrating and from that only this type of syndromes happen. So use of rubber seat pad disc equipped with tri axial accelerometer. So x y and z axis. So for steady state measurements below one horizontal devices like piezo resistive or capacitive accelerometer need to be placed and data collection should last for at least 2 to 5 minutes that is important. Now how do we do all those things? Hand-numb vibration and whole body vibration measurement, we have a specific instrument named vibration meter. It is available in the market it is quite costly. So any laboratory has this instrument and using that there are two separate device one is for the whole body that you need to place on your seat pan and you need to do the measurement, another is for your hand-numb ok. So using vibration meter you can measure all these exposure level. Now moving to very important concept which is need to be addressed in many of the research cases that is the macro ergonomics.



So I am not going to discuss lot about it. However I am going to introduce two concepts of it. One is macro ergonomics organizational questionnaire survey. So what this is all about first you do need to do a conceptualization that is the evaluating the work system element and the outcome. Once you conceptualize that whole environment you have to define the dimensions of each concept because you are talking about a particular concept, so you have to define those concept and you have to do the source evaluation that is the referring to other existing questionnaire survey and then you need to construct it and after constructing is done then you have to do a pre testing. In pre testing what you are going to do? Participants for verifying the clarity effort and duration of the questionnaire. That is can be done through this macro organizational questionnaire survey ok. So that is one thing I would like to introduce.

Macro ergonomic Analysis of Structure (MAS)

MAS – Structural Dimensions of Work Systems

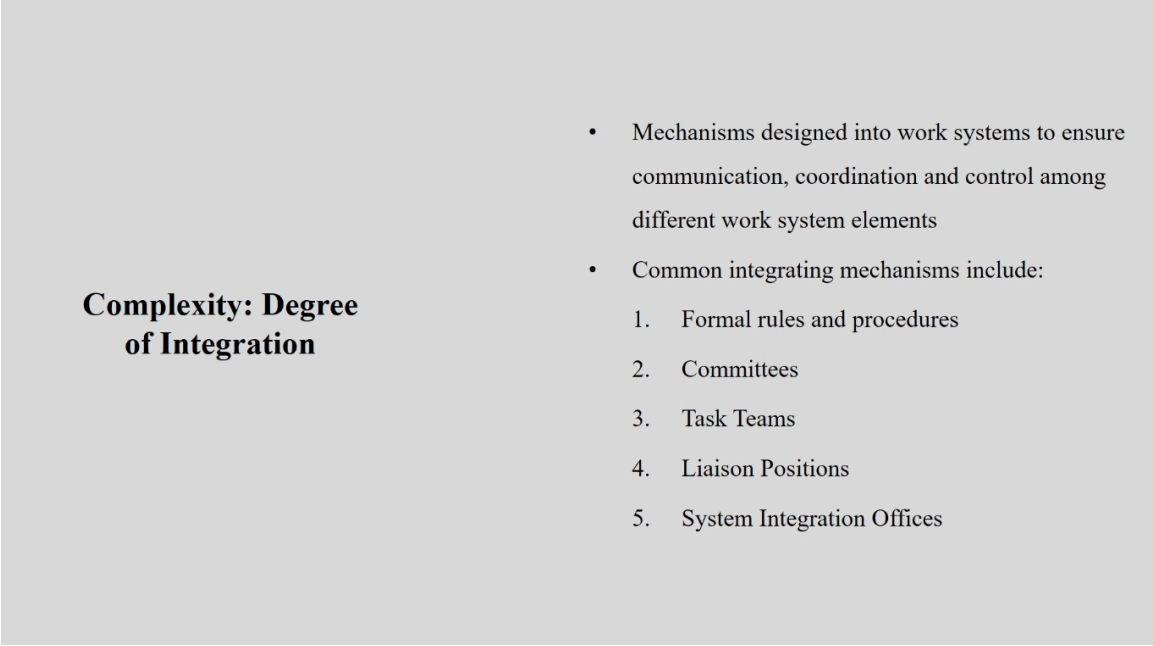
1. **Complexity**
   Degree of differentiation and integration existing within work system structures
2. **Formalisation**
   Number of mechanisms designed into work systems
3. **Centralisation**
   Location of decision-making within work systems

Another one is the macro ergonomics analysis of structure ok, MAS. So structural dimension. So what are those structural dimensions? One is the complexity, another is the formalization and third one is the centralization. So what is complexity? Degree of differentiation and integration existing within a work system structure. Formalization means number of mechanism designed into a particular work system and centralization talks about the location of the decision making within any work system ok. So these are the two small tools that you can use for the macro ergonomics. So if we go detail into the these three variable like complexity formalization and centralization.

Complexity: Degree of Differentiation

1. **Vertical Differentiation**
   - Number of hierarchical levels functioning within work systems
2. **Horizontal Differentiation**
   - Departmentalisation and specialisation degree in work systems
   - Commonality parameters – goals and time orientation
3. **Spatial Differentiation**
   - Span and count of locations for organisational activities
   - Quantification measures – number of geographic locations, average separation distances, employee proportions

Let us explain it little more. So when we are talking about degree of differentiation: vertical, horizontal and spatial. Now what is that vertical? So number of hierarchical levels functioning within a particular work system. So vertically how they are moving, hierarchical structure. So in an organization how the hierarchy of the positions are being maintained. Then is the horizontal that is the departmentalization. Every department has their own hierarchy, but every department works in a parallel situation. So departmentalization or specialization degree in the work system and commonality parameters like goal and time orientation. If we talk about the spatial differentiation so that talks about the span and count of location for any organizational activities and quantification measures that is the number of geographic location, average separation distance, employee proportion and all those things comes under the spatial differentiation. That is the complexity. When we are talking about complexity then under that we need to talk about the degree of integration. First one we talk about the degree of differentiation.



This one is talking about degree of integration. So mechanisms designed into work system to ensure communication coordination and control among different work system elements. So common integrating mechanisms include formal rules and procedures, committees, task teams, lies in position in positions and system integration offices ok. So these all things you need to talk about or discuss or collect information when we are talking about degree of integration.

Then external environment subsystem analysis because when we are talking about the macro ergonomics, we should be very very careful about the subsystem because in a whole bigger system you have we will have lot many subsystems existing. So socioeconomic, educational, political all these environment need to be taken care, when we are talking about the macro ergonomics in a particular organization.

Also cultural environment, legal environment all these things comes under the subsystem analysis or environmental subsystem analysis.

Personnel Subsystem Analysis

- **Degree of professionalism –** Internal formalisation of behaviour through social processes, as an integral aspect of education and training
- **Cultural factors –** Consideration of values, perceptions and attitudes of workforce culture
- **Psychosocial factors –** Assessment model for monitoring cognitive complexity

Now the personnel is very very important, because a person working in a system is definitely going to affect the whole macro ergonomic environment in any kind of organization. So degree of professionalism the person is going to maintain what are the cultural influences or cultural factors are available what are the psychosocial factors are going to affect them. So these are all important issues and everywhere you will get very niche tools which you can use to measure them, assess them and implement them ok. Now once we use macro ergonomics in any kind of situation specifically when you are talking about the organization, environment evaluation and all it is very important when we come to the intervention, when we come to the changes, when we come we talk about the you know doing some kind of implementation of your policies and you know intervention then participatory ergonomics comes into picture. Because when some for whom you are going to implement something, if you take their views in consideration during the whole process, then it is always you know expected the acceptance level will be quite good and quite high ok. Therefore when we are talking about macro ergonomics participatory ergonomics automatically comes into picture.

Participatory ergonomics

- The involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals
- A way to involve an organization's workers, supervisors and other workplace parties in jointly identifying and removing the hazards or risk factors in their workplace, including musculoskeletal disorder risk factors.

So what this topic is all about? So the involvement of people in planning and controlling a significant amount of their own work activities with sufficient knowledge and power very important. Anyone cannot participate. So the participant who are having some kind of knowledge and the power to influence both the process and outcome in order to achieve the desired goal ok. This participatory ergonomics is a way to involve an organization's workers, supervisors and other workplace parties maybe you know managers and all those people in jointly identifying and removing the hazard. Suppose you are going to a particular workplace and you yourself is like you know you identify some kind of hazards, but then the person who is working over there is not ready to accept yes this is a hazard. Then in that particular situation if you give some kind of solution, guideline, intervention to improve the situation, they are not in a position to accept it. Whereas while evaluating the process if you include their views, their participation then it becomes more easy for the person to accept yes this is a hazard and we need to improve upon it ok. So that is where the participatory ergonomics plays a very very crucial role in any kind of such evaluation and such you know implementation ok. So it is very important and effective tool for for any kind of workplace system.

Participation Approaches in PE

Parallel Suggestion Involvement (Consultative Participation)	Job Involvement (Substantive Participation)	High Involvement

(Brown, 1994, 2000, 2002)

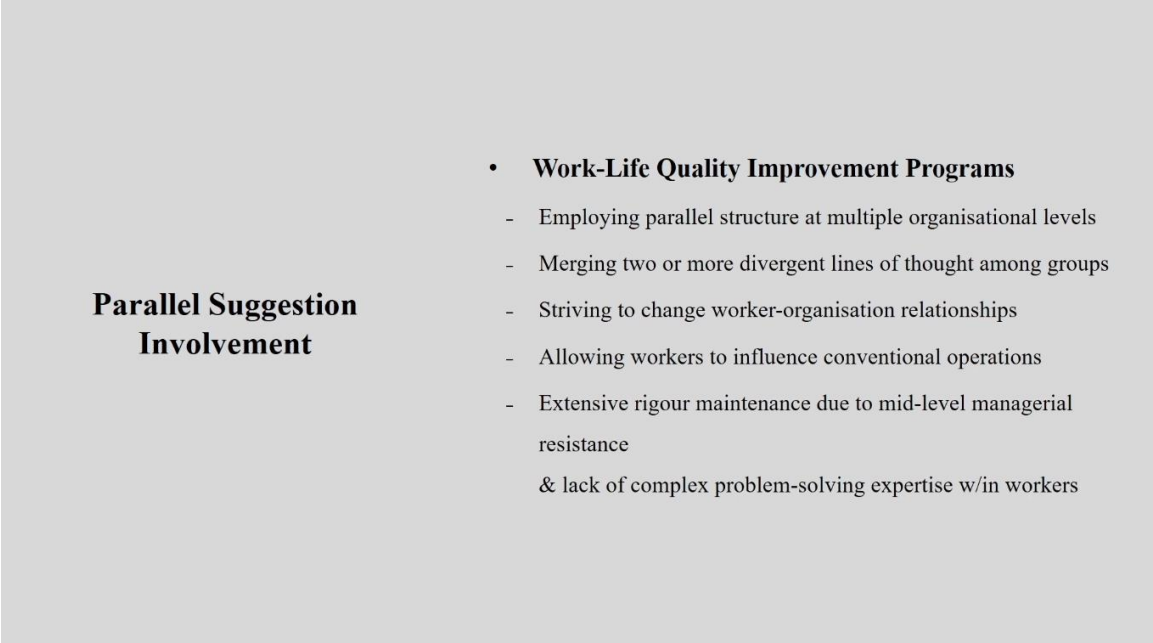
Now participation approaches in participatory ergonomics are these three models you can use that is the parallel suggestion involvement, that is the you know you do consultation with them, job involvement and the high involvement ok that way you can do.

Parallel Suggestion Involvement

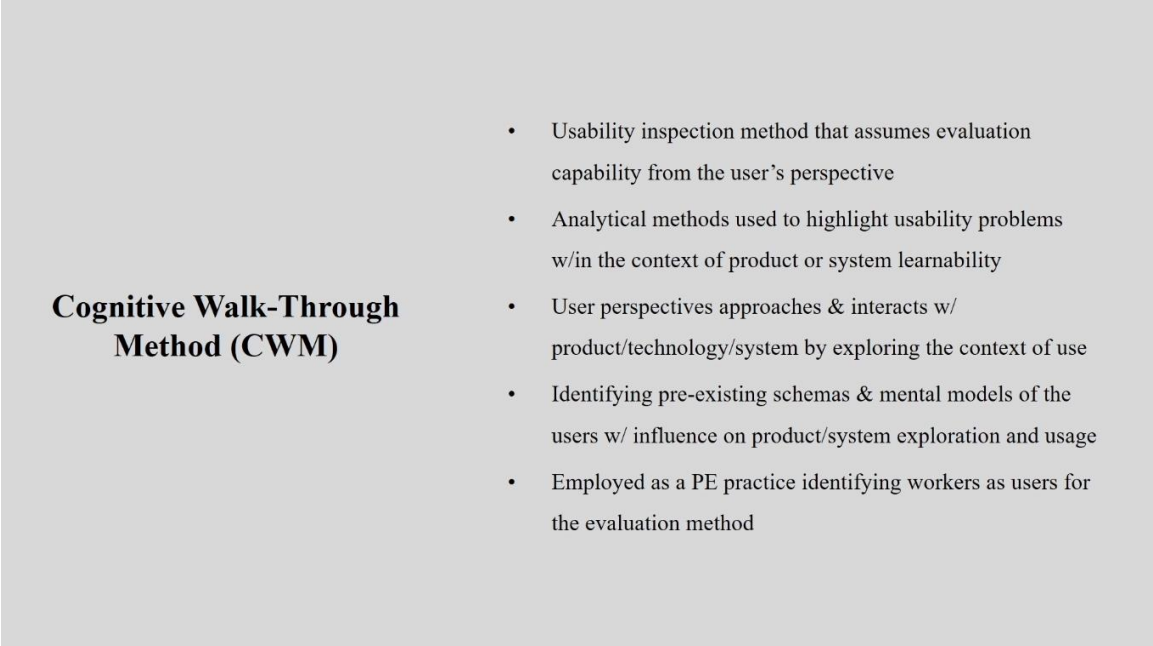
- Driven by the philosophy of consultative participation
- Workers urged towards problem-solving & idea generation, influencing routine operations w/in the organisation
- Quality Circles/ Worker Problem-Solving Groups – Absence of formal authority, direct rewards & power of implementation

So parallel suggestions involvement says that it is driven by the philosophy of the consultive participants because if you are consulting with them regularly definitely they are convinced ok. So workers urged towards the problem solving and idea generation influencing routine operation with or in the organization and quality circles or workers

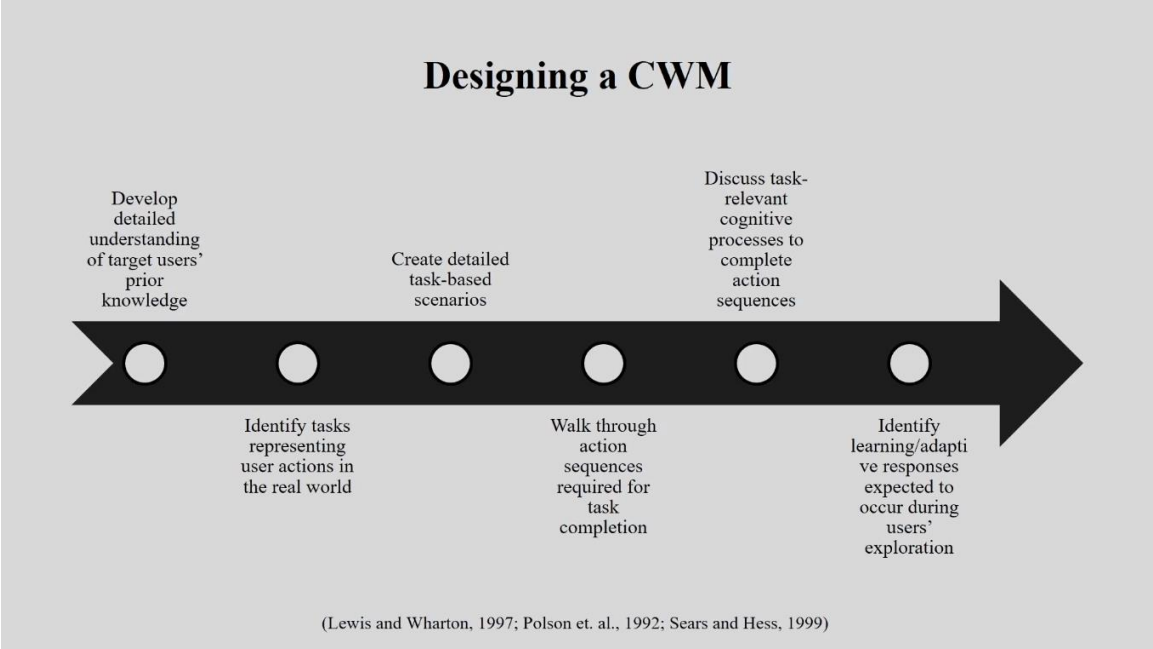
problem solving groups maybe you know in some cases it happens that there are some people who are actually very influencing among the workers and they they take a role in you know problem solving cases. If you can get them into the whole scenario, it will be very much beneficial for the application or you know data collection or any kind of implementation.



So work life quality improvement program that also is a parallel you can do. What actually you do over there? So you are going to employ parallel structure at multiple organizational level, you know merging two or more divergent lines of thought among the groups striving to change worker organization relationship because it is very very critical and you know important sometime. Suppose your supervisor and the person who is working under a supervisor the relation they have. So if you can combine both their emotions, both their you know peer interactions together in the approach, then it will be very much beneficial. So allowing the workers to influence the conventional operation, extensive regular you know extensive rigor maintenance due to mind level marginal resistance and also the lack of complex problem solving expertise within the worker ok. These things actually help in the parallel suggestion and it help in the participatory approach. What are the other methods which is important maybe we could not discuss them in the actual you know whole course, but still I would like I feel that these are something important and I would like to know that I look to mention that you should know about them if required you can study them in detail.



So very important one is the cognitive work through. So this is the usability inspection method. This is a particularly usability inspection method that assumes the evaluation capability from the user's perspective. So it is an analytical method used to highlight the usability problems within the context of a product or a particular system learnability, user perspective approaches and interacts within the product technology system by exploring the context of the use and also the identifying the pre-existing schemes and mental models of the user within which is going to influence on product system exploration and the uses. Also it is employed to as a participatory ergonomics practice identifying the workers as users of the evaluation method. So this is very very effective tool you can take it for such cases ok. So cognitive work through I am just introducing the subject I am not going to discuss it discuss the tool in detail or the like the kind of practice we maintained earlier like you know explaining the data collection and all those things.



However I would like to mention here how do we design the cognitive work through model. So what we try to do at the very initial stage, we develop the detailed understanding of the target users which is having a prior knowledge ok. The second is the identifying the task representing the user actions in a real world, then we create the detailed task based scenario because we are talking about a particular work procedure. So then work through action sequence required for a task completion. So if you have task- task 1, task 2, task 3, task 4; how do you work through them ok. Then we discuss about the task relevant cognitive process to complete the action sequence and finally we identify the learning and adaptive responses expected to occur during the users exploration ok. And this is being studied discussed in various literature. So this is very very useful and very much solid or I can say effective tool if you are talking about the participatory approach, participatory ergonomics, macro ergonomics and cognitive ergonomics in concern ok.

CWM as a Macro ergonomic Assessment Tool

- Despite being a common product design approach, CWM can be applied for evaluation & improvement of work systems.
- Researchers conduct inspection on group levels w/in the organisation to identify conflicts or organisational usability issues.
- Usability assessment of conceptual work system designs for identifying success potential of new work systems or integration extent of existing work systems.
- Effective isolation of problems & conflicts before implantation of organisational changes.
- Detailed identification of key variances that undermine system performance due to incompatibilities w/in new work systems.

So CWM that is the cognitive work through measurement method or method as a macro ergonomics assessment tool as I mentioned earlier what exactly it does. So despite being a common product design approach because this is very general. Suppose you are you developed a particular design. Now you want to test how that is going to used by the person. So you just do a cognitive work through, you will know where they are finding any difficulties to use it or how easily they can use it how they are understanding the references. So that is where the cognitive work through method is very very useful. So researchers conduct inspection on group level within the organization to identify the conflicts and organizational usability issues. And these usability issue assessment of conceptual work system designs for identifying the success potential of any kind of new work system or integration content extent of existing work system. Now suppose you have four models ready. Now if you want to understand which is very much beneficial, you can take cognitive work through method for all four and then you compare them ok. So once you have the data in hand, you can really understand the where the glitches are and how do you remove them. So then you can do more improvised product, more refined product for a particular thing. It is not about product, it talks about the whole system as well. Ok so this is very very easy method and useful method.

Issue	Advantage	Disadvantage
Expert Involvement	Expertise supports usability problem identification	Problems differ from actual user reports
Problem Identification	Significant and realistic problems can be identified	Cannot be used by itself, must be combined with other methods
Tools	Preliminary documents can prove useful	Difficult to acquire documents during early development stages – conceptual design
Cost	Relatively lower resources demands	Time demands can be high, depending upon specificity
Effectiveness	Effectives at capturing usability problems	Low consistency across evaluators and in comparison to other usability testing methods

Advantages and Disadvantages of CWM

Now as I do for most of the courses most of the tools that know explaining the advantages and disadvantages. So if we talk about the advantages of the cognitive work through method so measurement, this is the these are the advantages and these are the disadvantages. So in terms of expert involvement you see expertise supports usability problem identification. So it is very easy however that problem differ from actual user. Because you are talking about only experts right. So there may be you may get some kind of disadvantages. Same if you are talking about the costing, it is it is relatively lower resource demand whereas the if you are talking about time, time demand is quite high. Ok so therefore you need to really understand all the pros and cons of these cognitive work through measurement technique based on your requirement you can really choose that you should take this as a tool or you should not take this as a tool for your case. Ok so this is all about a cognitive work through and we just reached at the end of this particular MOOCs course that is the ergonomics research techniques. So whatever techniques we use in when you are talking about the ergonomics research we try to compile maximum possible methods, tools and techniques and we reached at the end of the program here. Ok so as I mentioned in the very beginning, mainly we divide the whole thing into physical and cognitive, also we have some component in environment, however mostly physical and cognitive. Ok so based on your requirement you can choose any one of them I do not say that these are only tools. Maybe there are many other tools available, but these are the tools which are normally and commonly used in ergonomics research. Ok that is all for today and that is all for this program. So let us meet at the exam and I wish all the best for all of you for the exam which is coming up. Thank you. you