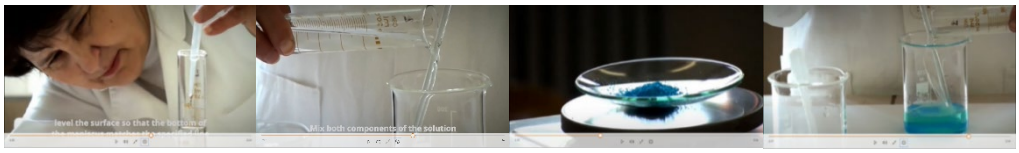
TRAINING MANUAL CHEMTUBE



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ChemTube, training manual with didactical guidelines

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Document overview

IO10 brings together the knowledge and experience gathered throughout the ChemTube project, and lists a training manual with didactical guidelines of how to identify learning settings and situations where tacit knowledge and critical skills can be taken into account.

The following document starts with a brief introduction into different projects in the field that have inspired work within ChemTube. The concepts of tacit knowledge and critical skills will be addressed only briefly, as they have been defined in-depth within IO2 by Jochen Seibold (see: Seibold 2019). Based on these general assumptions the duality of learning in a school or in a company will be considered and different training situations will be presented. This will be connected to explanations how to include tacit knowledge and critical skills within these training situations. Finally, the questions how to assess the learning situations will be discussed and possible solutions will be presented.

1 Introduction

1.1 Projects and sources

1.1.1 CREDCHEM methodology to define units of learning outcomes

The CREDCHEM was an EU Commission driven ECVET pilot project. This first wave of projects was quite central for further developments of ECVET – especially implementations in the chemistry and pharmaceutical sectors as well as in the crafts. The CREDCHEM project developed and tested the credit system for improving mobility within the chemical sector; the following document contains an explanation of the method to identify units based on working tasks and to identify the knowledge, skills, and competence that the VET systems should enable learners to develop to be able to carry out these tasks (CREDCHEM 2012).

1.1.2 Pile Up Process Industry Learning Unit Project

The aim of the Pile Up project was to develop common European units of learning outcomes that can be used to gain insight into, and assess the skills and competences of workers in the chemical industry. This should enable them to "PILE them UP" to reach a higher level of qualification and consequently increase the chances of mobility of the workforce within Europe.

In the process first a common understanding of competence profiles in various European countries was generated, then leading to the construction of new units of learning outcomes and assessment tools (Pile Up 2013).

1.1.3 ChemPharmVET

The ChemPharmVET project was based on previous achievements towards key competences for operators in the chemical industry with the overall objective to develop innovation in vocational education and training.

The project was based on the units of learning outcomes developed in the Pile Up project with the target of developing curricula for the training of operators in the chemical and pharmaceutical industry on EQF level 4.

The ChemPharm VET matrixes have been a critical input for the ChemTube project to identify relevant areas of job-specific knowledge, skills and competence (units of learning outcomes) where tacit knowledge and critical skills can be shown (ChemPharmVET 2017).

1.1.4 Skillstube

Skillstube allows for the user to upload video recordings of their competences in a specific qualification. It also allows for the showcasing of "best practice" videos done by professionals, to teach the learners

how to conduct a specific task. These videos can then be linked to a competence or learning outcome.[1] Skillstube also took into account tacit knowledge and how this can be captured via video recordings – therefore it was an important project that ChemTube builds on.

1.2 Qualification matrices and units of learning outcomes

The basis for the development of training programmes and videos were the units of learning outcomes (ULOs) developed in the ChemPharmVET project. The ULOs were developed by analysing concrete work tasks and national curricula, and reflect the work areas of chemical and pharmaceutical operators as structured in the process industries.

The work areas of chemical and pharmaceutical operators were divided into the following four units:

ULO 1
Perform operational logistics

ULO 2
Conduct processes

ULO 3
Participate in quality control

ULO 4
Participating in maintenance and repairs

The knowledge, skills and competences necessary for the ULO "Participate in quality control" are shown in the table below:

[1] See: https://skillstools.eu/skillstube/ (2021-02-18)

Sächsische Bildungsgesellschaft für Umweltschutz und Chemieberufe Dresden mbH
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Pharmaceutical Process Operator

ULO 3	Title of the unit: Participate in quality control	Date: 03/06/2016 Version: #1
Work tasks:	1. Taking samples 2. Sample analysis 3. Participating in quality control	
Technological context	Taking samples, methods of analysis, quality management,	

Learning Outcomes:

Knowledge (theoretical + factual) ***Scientific Context Theoretical context***	***Skills (practical + cognitive (= use of knowledge)***	***Competence (Role and level of responsibility and autonomy)***
• define various methods of taking and preparing samples for in process control and final product check	• distinguish processes for taking and preparing samples for in process control und final product check	• assume responsibility for choosing the right sampling method
• recognize the correct process specific method for taking samples	• select and give reasons for the required method for sample taking	• assume responsibility for choosing the right sampling method
• identify possibilities for taking samples suitable for the respective equipment and tested materials	• prepare samples und sampling devices as well as pay attention to specifics of the equipment and safety regulations	• takes responsibility for abiding by safety regulations
• explain methods of sampling	• take samples correctly	• autonomously take samples from the

1.3 Tacit knowledge and critical skills

"Tacit knowledge is highly personal and hard to formalise, making it difficult to communicate or share with others. Subjective insights, intuitions, and hunches fall into this category of knowledge. Furthermore, tacit knowledge is deeply rooted in an individual's action and experience, as well as in the ideals, values, or emotions he or she embraces" (Nonaka/Takeuchi 1995, 8).

"Tacit knowledge represents personal knowledge obtained as a result of direct interaction between individuals and their environment, which in time becomes experience. It contains also intuition, feelings, hunches, talent and many other forms of knowledge which are non-rational" (Bratianu/Oreza 2009, 111).

1.3.1 Different meanings of tacit knowledge

There are at least three different ways to look at the meaning of tacit knowledge:

1. Tacit knowledge often means doing something intelligently in an intuitive manner. Somebody might be able to articulate corresponding rules before or afterwards, there need not be any self-instruction during the course of action.
2. By reflecting on our actions, we can try to make descriptions of knowing what is implicit in them. Knowing-in-action becomes knowledge-in-action; descriptions of knowledge-in-action are always constructions and therefore "we know more than we can tell" (Polanyi 1983, 4): somebody is able to judge or act skilfully without being able to articulate it appropriately.
3. In the strongest sense tacit knowledge means that even a third person is unable to describe intelligent action in terms of rules. This does not mean that skilful acting is intuitive; it may be highly conscious, but it does not follow strict and formalizable rules, it is creative (Neuweg 2004, 133ff.).

1.3.2 Transmitting and acquiring tacit knowledge

The acquisition of practical knowledge requires learning by doing, shifting the emphasis of 'expertise in verbalising' to 'expertise in doing'. This supports the view that "what we need is not so much theories, articles, books and other conceptual matters, but, first and foremost, concrete situations to be perceived, experiences to be had, persons to be met, plans to be exerted, and their consequences to be reflected upon" (Kessel/Kothagen 1996, 21).

Experts always know more than they can tell and even more than anyone could ever formalise, it seems clear that expert knowledge cannot be transmitted by prescription alone. Therefore, tacit knowledge has to be learned implicitly. What is left unspoken can be attained through personal experience and transmitted within master-apprentice-relationships and cultures of expert practice (Neuweg 2004, 140ff.).

The paradox of learning a new competence lies in the fact that "a student cannot at first understand what he needs to learn, can learn it only by educating himself, can educate himself only by beginning to do what he does not yet understand" (Schön 1987, 93).

1.3.3 Critical skills[2]

"Critical skills as a concept, refers to the demand for an element of the practical, foundational or reflexive competence that allows for specialization within roles/professions or occupations and includes specific 'top-up' skills. Particular specialization top-up skills for roles/professions or occupations top-up might have arisen as a result of changing technology or new forms of work organization" (Department of Labour New Zealand 2006)[3] .

Different organisations list critical skills for 2020, such as MobileMonkey's list:

- Sense-Making
- Social Intelligence
- Novel and Adaptive Thinking
- Cross-Cultural Competency
- Computational Thinking
- New Media Literacy
- Trans-Disciplinary
- Design Mindset
- Cognitive Load Management
- Virtual Collaboration

The Cefic project "Skills needed to improve innovation the European chemical industry" in 2011 listed the following three critical skills for chemical engineers: Communication, teamwork and problem-solving.[4]

1.4 Identification of relevant areas for tacit knowledge and critical skills

Within IO3 relevant areas within the pharmaceutical process operator matrix were identified where tacit knowledge and critical skills can be highlighted (see IO3 result).

[2] Information based on report by Jochen Seibold (2019), pp. 38ff.
[3] See: https://www.agriseta.co.za/downloads/agm_presentations/Department_of_Labour_definitions.pdf (2020-06-03).
[4] See: https://circabc.europa.eu/sd/a/8bee7525-90db-48c9-8507-3507e6edab6b/Chem_20111209_wg_ETLLL_pres_Skills%20for%20innovation_%20S%20Wilmet.pdf (2020-06-03).

2 Learning situations in schools and companies

2.1 Work-based learning (WBL)

The term “work-based learning” (WBL) is used often with regard to VET and TVET and its meaning ranges from learning-on-the-job to informal learning or work-related learning. There are however some common aspects that different practices and approaches can agree on, e.g.:

- WBL means learning for work, learning at work and learning through work.
- WBL takes place in schools and colleges as well as in companies.
- Learning targets and outcomes of WBL are knowledge, skills and attitudes. Their purpose is to develop professional, social and personal competences, which are prerequisites for employability, identify formation and social integration.
- Knowledge, skills, and attitudes are developed through a reflected process of participating in work tasks in a dynamically evolving professional setting.
- Guidance from tutors and senior colleagues increases the learning potential of WBL.
- The particular strength of WBL lies in the acquisition of practical skills and competences.
- WBL supports the transfer and application of codified disciplinary knowledge into work situations. Furthermore, it helps to cope with demanding professional situations.
- The character of WBL can be formal (structures and intentionally planned), informal (not highly structured and planned) and incidental (happening unintentionally) (Bahl et al. 2019, 13f.).

There is a range of different models of work-based learning and close-to real simulations. These include:

- Apprenticeships (that formally combine / alternate company-based training with school-based education through different forms of duality between training institutions and workplaces)
- School-based VET with on-the job training periods in companies (internships, work placements, traineeships)
- Work-based learning / work tasters in a school (on-site labs, workshops, printing press, kitchens, restaurants, junior or practice firms, simulations or real business / industry projects).[5]

[5] See: https://www.cedefop.europa.eu/en/toolkits/vet-toolkit-tackling-early-leaving/intervention-approaches/work-based-learning-and-simulations (2021-02-01).

3 Setting up a training plan and how to assess learning situations

Following on to experiences from the previous, and more general project Skillstube, the ChemTube is an extension and targets not just tacit knowledge but also critical skills, where areas were identified in the units of learning outcomes from the ChemPharmVET project. After selecting the appropriate work task, the included tacit knowledge and/or critical skills were identified. Then a script was produced, and a video was recorded.

The videos are collected within Skillsbank, so that Skillsbank's users have an idea of the expected competencies in practicing the profession of chemical and pharmaceutical operator.

The work on the units of learning outcome will not be finalised, due to future changes in the requirements of the chemical and pharmaceutical operator. The identification of relevant areas of tacit knowledge and critical skills cannot be concluded conclusively, since the changes in the job profile are also reflected here.

The duality of learning in schools as well as in companies brings to attention the need of close relationships between schools and companies. With regard to assessing the learning situations in both contexts, there are already well-established quality management systems within schools in place that should make sure that the learning results in knowledge, skills and competence and regular quality circles are being performed. About the companies and the learning/training situations there, it depends which country one focuses on. Countries like Germany and Austria with a long-established apprenticeship-scheme have set up their own tailor-made quality systems, whereas in other countries with less experience companies might view the assessment of their learning/training as a bureaucratic burden or even a waste of time.

Within the ChemTube project the assessment of learning within the Skillsbank-database is supported that brings together not just the qualification matrix of the ChemPharmVET project but also has the possibility to include assessment criteria for units of learning outcomes.

Assessment of learning in schools is usually realised through exams, portfolios, final projects or standardised tests. Usually these are connected to grades that communicate the individual's achievement to learners, teachers or parents. In companies and with regard to WBL formative assessment would be more recommended.

Formative assessment is understood as the continual qualitative feedback between student/apprentice and teacher/master during the course of the learning process (Black, William 2009). The student/apprentice can be guided during the process to improve both the learning process and the results of the summative assessment of the finished work or product (Hattie, Timperley 2007).

Furthermore, the use of rubrics (Attachments No 1) is recommended to communicate both quality expectations and criteria, and to rate students and communicate the assessment to the students (Fjørtoft 2014; Wiggins, McTighe 2006). The use of rubrics is helpful in ensuring fair, transparent, and

democratic assessment (Picón-Jácome 2013), which might enhance student participation, self-efficacy, and student motivation (Frailea et al. 2017).

To ensure that the student is able to document tacit knowledge and practical skills, filming and digital storing of the student's/apprentice's practical work is recommended. Combined with the student's/apprentice's written description the tacit knowledge might be unveiled. The use of e-assessment might be included to ensure a rapid response and continual communication with the student/apprentice to assist in motivation and self-efficacy, in line with theories on formative assessment (Fjørtoft 2020).

SOLO (structure of the observed learning outcomes) (Biggs & Collis, 1982; Biggs and Tang, 2007) is a taxonomy for a systematic description of how the student's learning outcomes grow in complexity from surface learning to deep learning. SOLO defines two main changes; quantitative (the amount of details in the student's answers increases) and qualitative (the details are integrated in a structured pattern).

SOLO defines 5 levels between incompetence and competence. The lowest level is called "Prestructural", where the student has either not understood or misunderstood. The next level is "Unistructural", where the student can identify / describe a relevant aspect, which in the third level "Multistructural" is extended to the student having an understanding of several relevant but independent aspects. In the fourth level "Relational", the student manages to integrate several aspects in a structure, seen in relation to each other. The highest level is called "Extended abstract" and is about the student being able to draw conclusions, create, generalize, theorize etc. SOLO uses verbs to describe the different levels, which in turn is helpful in defining learning outcomes, learning activities and assessment. SOLO emphasizes the use of verbs to describe the different levels of understanding in a taxonomy; Remember (identifying, retrieving), Understand (interpreting, exemplifying, classifying, summarizing etc.), Apply (executing, implementing), Analyze (differentiating, organizing, attributing), Evaluate (checking, critiquing) and Create (generating, planning, producing, hypothesizing, designing, constructing).

3.1 Didactic

Learning in the subject shall help develop the learner's / apprentice's competence in processing and production methods. Furthermore, learning in the subject shall contribute to the individual's development of an understanding of the relationship between production, environmental issues, economy and quality. Learning in the subject shall also promote communication skills and the ability to solve problems.

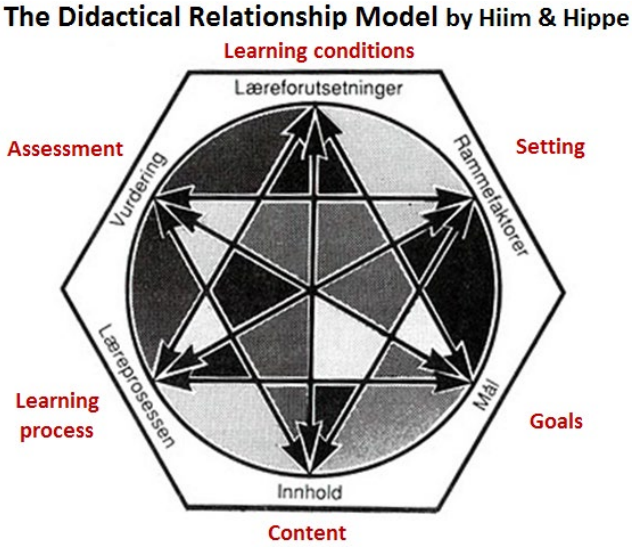
Learning shall arrange for varied training in the ability to assess and analyse processes, control settings and monitoring of process variables. Furthermore, the subject shall help the apprentice learn to work independently and cooperate across professional groups. Learning in the subject shall also promote respect, tolerance and equality. Working according to procedures, standards and requirements

established for environment, health and safety are central themes in learning (Norwegian Directorate for Education and Training 2016).

In order to teach one must have a series of tools. The training must take place within specific boundaries and be known to the candidate. The training institution / company may be able to profit from the use of a didactic planner in this work, who helps facilitate good learning and good education. The candidate will see that using a didactic planner in video and video production will help to create a safe framework and a predictability for the product's quality.

Within teacher/trainer education *Didactic Analysis*, as a means to learn how to plan, act, observe and reflect on didactic practices, has been a core component of the curriculum, and especially one model for didactic analysis has gained widespread use, namely the so called "Didactical Relationship Model" by Norwegian education researchers, Hilde Hiim and Else Hippe. Building on the work of fellow countrymen, Bjørndal and Lieberg (whose original model was more teacher-centred), Hiim and Hippe developed the model to show some important relations between different elements in didactics using a learning theoretical approach.

In the following training plans using this model will be elaborated.



[6]

Examples of using the didactic model. (It is important to see the model as a dynamic understanding).

- Learning conditions.

[6] Source: https://marianneriis.files.wordpress.com/2010/01/hiimhippe.png

The student's learning conditions, are about documenting / discovering what the student already knows, what's new, what interests the student has in his/her education and, whether the student has special challenges or needs any special resources in their education.

- What different learning conditions and potentials exist with the candidate?
- What attitudes and values do the company and candidate have?
- What do they know about the learning content?
- Where to find learning outcomes within the qualification matrix?

- Settings

Settings include everything from equipment, availability in the process or laboratory, time available, and so on.

It is important to plan all exercises based on the framework factors that are available. What equipment is available, chemicals, what time frame does the student have to do the task in the factory/laboratory? Is it possible to complete the entire task when operating in the workplace or must the exercise be performed during the next maintenance period?

- What are the opportunities and limitations of the learning situation?
- What are the collaboration opportunities?
- How does the time frame look like?
- What resources / materials etc. are needed?
- What practical terms are there?

- Goals

The main goals of training in companies are listed in the matrix for chemical and pharmaceutical process operators. To reach the goals, it is necessary to break down the goals into sub-goals.

- What is the purpose of teaching?
- What are the learning objectives?
- How are the learning goals being set together with the candidate?

Examples in this document are related to the matrix learning outcomes 2.1.1.2 Equipment, where one of the sub-goals is disassembling a valve to learn about function, operation, maintenance, naming, attitudes and not least HSE focus (see appendix No 1, Example of using ULO 2: with reference to video DE01-EVO; Dismantling valve).

- Content

It is natural here to ask oneself what knowledge, competence and skills the student should have acquired after completing the education. The content of the training should be related to the overall competence goal during the training period.

- What should the students learn?
- What training content should be selected?
- What are the criteria for selecting content / learning?
  - Scientific / multidisciplinary selection approach
  - In relation to goals, curricula, etc.
  - Prerequisites and interests (pupils / teachers)

Not all companies are able to adapt the content of the training that covers all training goals in the matrix, and that is not the intention. Most companies are able to achieve the goals in whole or in part. The goal for the company should be to be able to relate the training to the matrix so that there is a universal documentation of the training. This means that experiences from a training situation from one company, can be easily transferred to another workplace.

- Learning process

Most companies have long traditions and a well-developed plan for internal training/ work-based learning. Traditionally, the employees or apprentices will participate in daily production and maintenance. But people are different and have just as many ways to acquire competence. A good idea would be for the company to plan training activities together with the student. The following questions can help during the planning phase:

- What should the candidate be able to do?
- What should the supervisor do?
- What learning methods and principles should be used? And why?
- What different organizational and working methods/videos should be used?

What thoughts do the company instructor and the student have, in what way should they achieve their goals? Here are many ways to facilitate learning. The intention of the ChemTube project was to show how one can make films to document a learner's competence, but can also be used for learning itself. For students who are practically oriented, making a video of their competence will create a good learning situation.

- Assessments

Assessment is about relating the planning of the training and asking questions about skills and competences to be assessed, based on the content of the training and the most appropriate methods.

- Which skills and competences should be considered and why?
- How and when should the assessment of the candidates be done?
- Who will assess the candidates?

Conversations between the company's training manager and the student during or after the exercise are a great way to create security in the training and give feedback. Form-based assessment or video of the exercise / task is a tool facilitating that the student / company has clear goals, characteristics and criteria for goal achievement.

The principles defined and mentioned above will be taken into account when training programmes and work-based learning have to be integrated in a school or a workplace.

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5. Attachments

Attachments No 1. Example of using ULO 2: with reference to video DE01-EVO; Dismantling valve

ChempharmVET-U1-Label of Learning Outcome		Training Module Code	Competence	
			Knowledge	Skills
2.1.1.2 Equipment			Takes responsibility for the correct installation of the equipment used by the team	
			Names equipment that is needed to conduct the process	Clarifie equipment parts and describes their function correctly

	Checklist with feedback			
Goal achievement		Low	Medium	High
		Needs a lot of support along the way. Partially able to perform, but must work with the understanding of why we have procedure for the task		Performs the task very well, uses the procedure and works in a structured way. Is able to reflect on own efforts and execution.
Assessment point	☒			
He / she has been planning the job about HSE, staffing, equipment	☐			
He/ she prepares the task with the team and follows the procedure for the operation.	☐			
He/ she is able to handle tools and equipment in a considerate manner	☐			
He / She works systematically, accurately and has good cleaning	☐			
He/ She describes and explains the working principles	☐			
He / she is able to inspect and assess the condition of the equipment	☐			
He/ she takes responsibility for the correct installation of	☐			

the equipment used by the team					
He/ she is able to clarify equipment parts and describes their function correctly	☐				
He/ she names equipment that is needed to conduct the process	☐				
He/ she explains the operation mode of the respective equipment	☐				
He/ she is able to perform function testing and Leakage testing	☐				
Reporting and clearance	☐				
He / she can evaluate his / her work	☐				
He / she is able to conclude and report	☐				
Completion of the exercise and clearing	☐				