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Concept Attainment Teaching Methodology (CATM) – An Effective Approach for Training Workers on Chemicals Health Hazards

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Abstract Workers handling chemicals need to understand the risk to health involved in their work, and this requires training. In this study effectivity of concept attainment teaching methodology (CATM) as training strategy for cleaning workers was assessed. CATM was used to train workers on chemicals information and health hazards. Pictures, illustrations, and hazards/precautionary statements presentations were used in reception-based strategy, while printed pictures and information cards on chemicals health hazards were used in selection-based strategy. The experimental group was given a pre-training test which was repeated on completion of the training (post-test1). The test was repeated after a month to determine level of knowledge retention. Cleaner (n=307) from hospitals, a municipality and from a privately-run company took part. Certified cleaners and supervisors, the control group, were also tested. The tests scores were compared to assess for learning attainment and knowledge retention. Compared mean scores showed improved scores after training. ANOVA of the group means showed the differences were statistically significant. The objectives of the training were met, and with good knowledge retention as indicated by the improved scores in the post-tests. This indicates the efficacy of the method in training cleaning workers.

Keywords Concept Attainment, Cleaning Workers, Workers' Training, Vocational Training, Workplace Training

1. Introduction

1.1. Background

Recent studies show that cleaning workers have an increased risk of developing occupational health conditions due to exposure to cleaning chemicals [1-4]. In a European Academy of Allergy and Clinical Immunology task force consensus statement [5], it is proclaimed that there is an increased prevalence of work-related asthma in the cleaning sector, a consequence of exposure to cleaning chemicals. Similarly, cleaning chemicals are the major cause of occupational skin diseases among cleaning workers [6]. In promoting workplace safety paradigms and in so doing reduce workers' exposure to chemicals, knowledge of chemicals health hazards is vital. Work environment legislation requires employers to train their employees, and provide them with necessary information and equipment to enable them protect themselves from exposure to chemicals. The employers rely on information provided in the safety data sheets (SDS) of the products they use when conducting such safety trainings, as well as in risk assessment of the chemicals. However, many SDS for cleaning products are of little utility [7]. A report on cleaning workers' health from the European Agency for Safety and Health at Work (EASHW) revealed that few cleaning workers take vocational training [8]. Thus, the poor quality SDS and workers' reluctance to take up vocational training signify low competence on chemicals hazards in the cleaning sector. In Norway, cleaning workers' training takes place mostly internally in the cleaning companies with experienced workers training other workers concurrently with job performance [9]. Such training programs lack prerequisite for workers' self-actualization, and do not contribute to increasing workers' knowledge and competence on handling of chemicals as chemicals health hazard is in most cases not a training priority [9]. Priority and the focus of these trainings is on job performance and customer relations as these are essential elements for the continuity of the company [9]. Moreover, it is reported that in Norway, about 75% of the estimated 41 000 cleaning workers have primary education or less [10], and that about 90% of the workers are of minority background [11]. The situation of cleaning workers in other countries is most likely similar that of Norway.

With these challenges in the cleaning sectors, cleaning

workers can benefit from workplace training programs conveniently structured to help them realize good understanding of chemical health hazards. It is essential that the content of a safety performance program render the trainees' ability to transfer the learned skills to actual work [12]. Hence, the training has to be effective, and as most workers are reported to be time-constrained during working hours [11], the training should be short, focused, and such that it does not impose new constraints on the workers. It is evident that cleaning workers understand the importance of such safety training, but apparently, many consider workplace training a time consuming inconvenience. One important aspect is that, planning and execution of a training program necessitates consideration of the cognitive needs of the trainees [13], and this is instrumental in designing a suitable program for the target group. Clemmensen et al [14] reported positive results in prevention of hand eczema for cleaning workers following a low-cost on-site one-hour educational intervention. The results of Clemmensen's study are an indication that effective workplace learning can be attained with short, but focused training programs. Choosing a good training method would thus be paramount in achieving the objectives of the training program.

Concept attainment teaching methodology (CATM) was evaluated, and was adopted for the purpose of this study. The choice of CATM was based on reports from research works reiterating and validating good outcomes with high knowledge retention in different fields [15-20]. Further, Faraday et al [21] and Joyce et al [22] advanced the opinion that the method is suitable for vocational education. The method has been demonstrated to be an effective tool across a range of ages and development levels [23-25] as well as with older adults [26].

1.2. About CATM

CATM is an information-processing teaching model that enables learners to construct knowledge and understand given information. Bruner et al [27] explained concept attainment (CA) as an inductive thinking process by which learners decipher attributes of a concept by comparing and contrasting data presented as exemplars with that presented as non-exemplars i.e. not representing the attributes of the concept. Applying the model entails developing and understanding of concepts by looking into identifying attributes of the concept intended (labelled "YES"), and non-attributes (labelled "NO"). Additional attributes that further elaborate on the intended concept, are provided to substantiate the YES attributes. Through inductive learning, discerning crucial features and constructing theoretical statements from the given attributes, the learners form the intended concepts [28]. CATM promotes active learning by engaging the learners to use their experiences and logic, make their own analysis, and comparing and contrasting ideas, instead of a one-way presentation by the trainer [28]. This learning strategy gives an in-depth understanding as it works in the way human beings instinctively learn, i.e. by naturally organizing things into categories based on common attributes [29]. Further, the method enhances one's abilities to acquire, control and to remember the information learnt [30]. McDonald [31] reported from Tenneyson and Cocchiarella [32] that learners' analysis of exemplars prior to discussion of the characteristics or definition of concepts helped them develop clearer conceptual understandings that would sustain over longer periods.

CATM is applied in either a selection or a reception paradigm. In the selection-based paradigm, the learners are provided with unlabelled information from which they freely gather the information they deem to be explanatory and useful for a specific concept that they perceive to be the intended concept [33]. This method allows the learners to control the sequence of the example and choosing the examples they would like to enquire about [34]. On the other hand, in the reception-based paradigm, the data is presented in form of discriminate units and the learners are informed that there is one common concept in the positive (YES) examples that the learners have to decipher [34]. Earlier studies supported the generalization that the reception method is more effective on difficult conceptual tasks, while the selection method is more effective for the less difficult ones [35].

The process of CA method, involves the following phases [34, 36]:

a) Presentation of information related and not related to the concept in question, and the learners formulate a hypothesis of what the concept is.
b) Testing the hypothesis by categorizing additional unlabelled data and by providing other examples that fit with the attributes of the concept.
c) Analysis of the thinking that led to the conclusion of what the intended concept was.

These steps apply for both the selection and reception methods.

1.3. Objective

This study was an endeavour to design an effective training strategy to use as a tool for training workers with low-level formal education on chemicals health hazards. This paper presents the outcome of implementation of the CATM, and provides a discourse on effectivity of the method as a training tool for cleaning workers. The paper also includes a comparison between cleaning workers trained using CA method and those with vocational certificates or other types of enterprises' internal training programs.

2. Materials and Method

CATM was used to train groups of cleaning workers on chemical information and chemicals health hazards. The author of this paper conducted all the training sessions. Prior to the start of the trainings, the method was tested on a group of 10 office workers in order to assess its usability and applicability. This group had neither professional experience nor occupational relation to cleaning chemicals. This test

group was able to comprehend a number of intended concepts, validating the usability of the method. Feedback from this group was used to make adjustments and improvements on the content and structure of the training materials.

The participant of the study, the experimental group (EG), included cleaning workers employed in one of the municipalities of Oslo, Norway (n=24); a privately run cleaning enterprise mostly tasked with cleaning kindergartens (n=6), and cleaning workers from university and national hospitals in Oslo and its vicinity (n=277). All the participants included in EG had longer than 18 months' work experience in the cleaning sector, and had had workplace training, but did not attain vocational certificate (VC). One attains VC for cleaning work in Norway after a two-year specialized training, and a minimum 5 years work experience. A control group (CG) consisting of 31 cleaners with attained VC, and workplace supervisors with/without VC, was also established. The CG that served as point of reference, was expectedly more knowledgeable about chemical health hazards due to their qualifications.

Several training sessions were held each starting with the trainees taking a 10-questions test (Pre-test). This tested was aimed at establishing a baseline for the trainees' knowledge on chemicals and related health hazards. A presumption here was that the workers, based on their previous training, were familiar with some basics of chemicals information. Table 1 shows the questions of the test, and their expected answers.

The duration of the test was maximum 30 minutes. The training sessions lasted between two and two-and-half hours and covered all the topics presented in the questions above, applying both reception and selection-based strategy. All the training sessions were conducted in a similar way. Training materials were prepared both in English and in Norwegian; the languages were used interchangeably during the training according to the needs of the participants. Overhead PowerPoint presentations with pictures and different illustrations (e.g. labelled chemicals containers for "Yes", and unlabelled container for "No") were used for the reception-strategy. For selection-strategy, printed pictures (pictures of people exposed/not exposed to chemicals, clean nature, picture of "romantic" settings, etc.) and information cards (with physical, health and environmental hazard statements, precautionary and other statements) were used for the selection strategy. The trainees worked individually, and in groups of 3-5 for the reception and the selection strategy respectively. Once the intended concept was attained, and the analysis of the outcome concluded, the trainees were guided through a discourse relating the concept learnt to their work. On completion of the training, the test taken in the beginning was repeated. The purpose of this first post-training test (Post-test1) was to determine if the objectives of the training were attained. The test was then repeated a month after the conclusion of the training (Post-test2). This second test repetition was intended to check on the level of knowledge retention of the participants. Figure 1 shows the program phases in a schematic presentation.

Table 1. Test question and their expected answer used to gauge cleaning workers' knowledge on chemicals and health hazards.

	Questions	Expected responses
1	Name 4 health hazards/injuries that can be caused by chemicals	*E.g.: Skin/airways/eye irritation; Burns; Poisoning; Harmful to health; Eye damage; Asthma; Allergies, Cancer, Mutagenic effects; Infertility… etc.*
2	Which type of hazard does this pictogram represent?	*Health hazard e.g. skin/eye irritation*
3	H-Statements describe chemical hazards. Give two examples of H-statements.	*E.g.: Causes skin irritation; Causes severe skin burns and eye damage; Harmful if inhaled; Harmful if swallowed; May cause allergic skin reaction…, etc.*
4	P-Statements describe safety measures. Give two examples of P-statements.	*E.g.: Store in cool place; Keep in original container; Avoid contact with water; Avoid spraying on open flame; Use protective gloves… etc*
5	When can chemicals cause injury to humans?	*When one is exposed, and the chemical is taken up into the body.*
6	What name is given to health hazard effects that happen immediately or after a short time?	*Acute effects.*
7	What name is given to health hazard effects that happen after a long time?	*Chronic effects.*
8	Name two types of allergies that can be caused by chemicals	*Skin and airways allergies.*
9	Give two methods one can use to protect one's self from chemicals.	*Using personal protective equipment, and technical installations.*
10	Where can one find information on hazards of chemicals one uses?	*On the labels, and in safety data sheets*

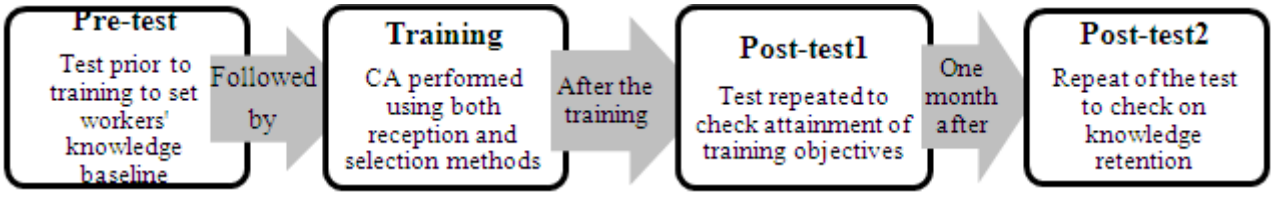

Figure 1. Schematic presentation of the phases of the of training program conducted

The trainings were conducted over two periods with five months in-between. In the first period, both the Pre-test and the Post-test1 were conducted in written form where the participants were required to give short answers to the questions. Because of the challenges the participants had in writing in Norwegian/English that became apparent after the first period, the repeat Post-test2 in was given in multiple-choice questions (MCQ) format except for the one enterprise tasked with cleaning kindergartens, which took the Post-test2 in written format. Subsequent groups in the second period did all the tests in the MCQ format. The CG took the same test as the EG.

The scores of the tests were recorded and descriptive statistics calculated using SPSS v2 (IBM Chicago, IL). A one-way ANOVA was used to test for differences among the pre- and the post-tests. Further, a conceptualized performance ratio (P-ratio) showing how well one test was performed in relation to another, was used to compare the scores of the pre- and post-training tests of the EC as well as between the EC and the CG.

3. Results

The EG in the two training periods consisted of cleaning workers from national and university hospitals in Oslo region (n=277), employees of one Oslo municipality (24) and a privately run cleaning company (6) took part in this study. The CG (n=31) consisted of cleaning workers with vocational certificates (VC) and workplace supervisors.

During the training, each session with the exception of the privately run company, had 12-20 participants. The age-groups of the participants were 18-30 years (6%), 31-45 years (49%), and over 45 years (45%). A large majority of the participants (82%) had work experience of more than six years. The remaining had 1-3 (8%) and 4-6 (10%) years of experience. Each group in each session had collectively many man-labour years of work experience in the cleaning sector.

The scores of the written Pre-test of the first period, were in the range between 0-50%. The Post-test1 for this period, showed a general improvement of the scores with 90% as the highest score. The mean score changed from Pre-test 11.85% (Std. dev. 11.81; 95% C.I. [10.02 13.68]) to post-test1 37.13%, (Std. dev. 20.02; 95% C.I. [34.09, 40.17]) respectively (Table 2). This change translates to over three times performance improvement from Pre-test to Post-test1 (Table 3).

The post-test2 in the first period gave a score range 20%-85% with a mean score of 54.20% (S.D. 15.74; 95% C.I. [50.87 57.54]). The significant difference between the Post-test1 and Post-test2 is probably attributable to the changed format from the written to MCQ, making it easier to give answers to the questions than when written answers were required. From the Pre-test, responses from 77 participants were rejected. These 77 had either not answered the questions or the answers were illegible. The same applied for Post-test1 with 65 responses rejected.

The cleaning workers in the second training period given the test in multiple-choice questions (MCQ) format for all the tests, had a slightly higher scores range with mean score of 25.88% (S.D. 17.70; 95% C.I. [21.60, 30.17]) and 51.49% (S.D. 20.06; 95% C.I. [46.60, 56.38]) for Pre-test and Post-test1 respectively, with all participants responding. From the mean values, one can see that the performance in Post-test1 was two times better than in the Pre-test. On repeating the test, Post-test2 with 62% of the cleaning workers in the second training period responding, the average score was 62.26% (Std. dev. 14.54; 95% C.I. 57.75-66.78).

Table 2. Results from the two training periods showing among others the mean scores and confidence intervals.

	N (valid)	Min. Score (%)	Max.score (%)	Mean score (%)	Std. dev.	CI of mean (95%)	Additional remarks
Tests in the first period							
Pre-test	162	0	50	11.85	11.81	[10.02, 13.68]	37% answered ≤5 questions; 77 participants rejected
Post-test1	169	0	90	37.13	20.02	[34.09, 40.17]	65 rejected
Post-test2	88	20	85	54.20	15.74	[50.87, 57.54]	52% of Post-test1. Written and MCQ used.
Tests conducted (in second period) with MCQ only:							
Pre-test	68	0	75	25.88	17.70	[21.60, 30.17]	All participants responded
Post-test1	68	15	90	51.49	20.06	[46.60, 56.38]	
Post-test2	42	35	90	62.26	14.49	[57.75, 66.78]	62% of Post-test1
Control group (CG)	31	0	45	17.10	14.54	[11.76, 22.43]	Supervisors/cleaners with VC; written and MCQ

N – Number of valid participants' responses; Max. – Maximum; Min. – Minimum; Std. dev. – Standard deviation; C.I. – confidence interval; MCQ – Multiple choice questions

*For those rejected, the questions were either not answered or the writing was illegible.

Table 3. Conceptualized performance ratio (P-ratio) comparing the performances change between the different tests.

	P- Ratio
For tests conducted by in the first period (1st):	
Post-test1: Pre-test	3.13
Post-test2: Post-test1	1.46
For tests conducted in the second period (2nd):	
Post-test1: Pre-test	1.99
Post-test2: Post-test1	1.21
Post2 (2nd Period): Post2 (1st Period)	1.15
Comparison between the trained and the control group (CG):	
Post-test2 (1st period): CG	3.13
post-test2 (2nd period): CG	3.64

Note: P-Ratio: Conceptualised Performance ratio indicating extent of performance change in the test mean scores compared to the previous one.

According to the ANOVA, mean scores for the first period differed significantly with F (2, 416) = 211.380, p= .000. Tamhane's post-hoc comparison of the three tests indicate that Pre-test (M=11.85%), Post-test1 (M= 37.13%), and Post-test2 (M = 54.20%), are all statistically significant at p<.05. Similarly, scores for the second period differed significantly in the ANOVA with F (2, 174) = 62.094, p=.000. For this period, Tamhane's post-hoc comparisons also indicated that the Pre-test MC (M = 25.88%), Post-test1_MC (M = 51.49%), and Post-test2_MC (M = 62.26%) were all statistically significant at p<.05**.** Comparison of the different tests in the two periods are shown in table 3 using a conceptualized performance ratio (P-ratio), ratio indicating extent of performance change in the test mean scores in relation to the previous one.

For the first period, there was a threefold improvement in performance from the Pre-test to Post-test1. Between Post-test 2 and 1 of the same period, P-ratio of 1.45 showing a score improvement by 45%, and good knowledge retention. For the second period, there was a twofold score improvement from Pre-test to Post-test1. The P-ratio for Post-test2 to Post-test1 shows also a 21% margin of improvement. This means that the scores were maintained, and with improvement, between the two Post-tests (1 and 2) in both periods. Comparing the Post-test2 in the first and the second periods, shows that the performance in Post-test 2 (2^{nd} period) was 16% better.

The CG had a mean score of 17.10% (S.D. 14.54) which was quite close to the Pre-tests, but lower than Post-tests 1 and 2 of the EG. Comparing the mean score Post-test2 to that of the CG, the trained cleaners had in the first period a 3.17 times better performance than the CG, while the second period was 3.64 times better.

Figure 2 shows the frequency distribution for the scores of the Pre-tests of the two periods. It is clear here that the distribution lies to the left, i.e. in the lower scores values. This conclusion applies similarly for both training periods.

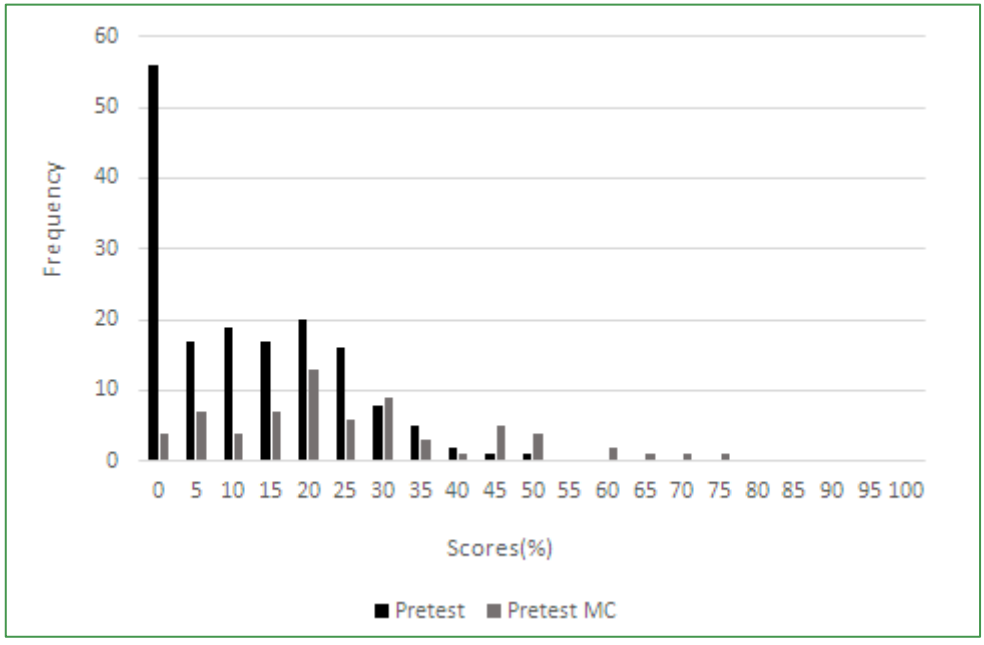

Figure 2. Comparison of distribution of scores of Pre-test and Pre-test MCQ

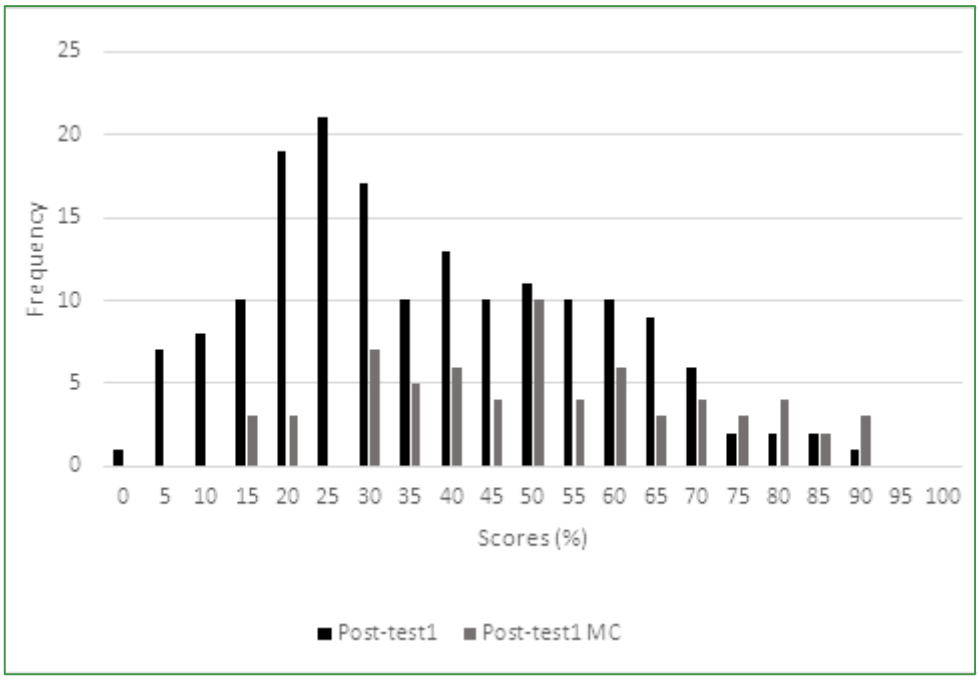

Figure 3. Comparison of scores distribution between post-test1 and post-test MCQ showing a shift towards upper range than for the Pre-tests

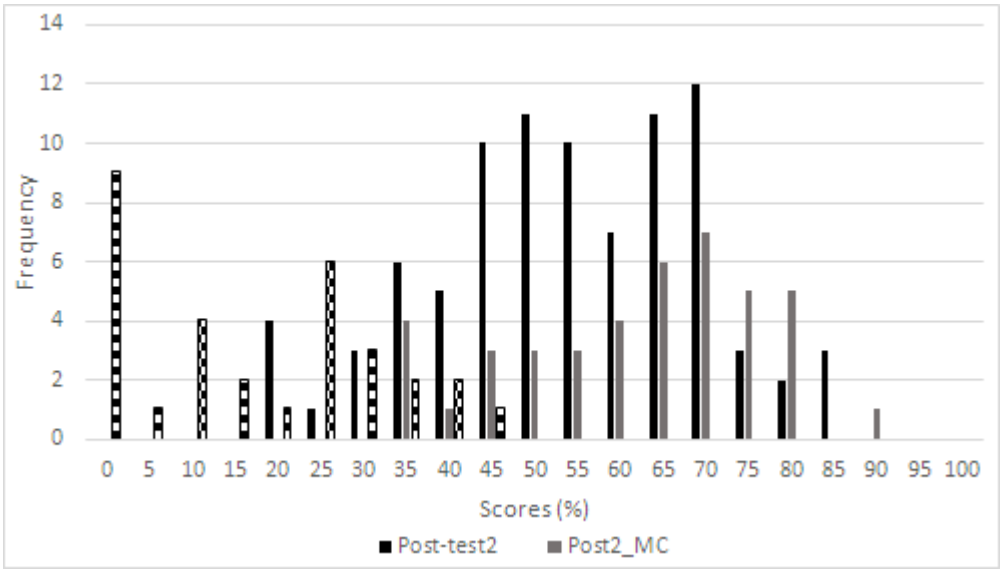

Figure 4. Distribution of scores for post-test2 and post-test2 MCQ compared to scores distribution of the control group (CG)

On the other hand, it is clear from figures 3 and 4 that scores of both the Post-tests 1 and 2 respectively in the two periods are distributed more evenly and clearly increase towards the higher scores than in the Pre-tests. The score distribution among the 90 and 42 participants, who took Post-test2 in the first and the second period respectively as shown in figure 4, is rather consistent and closer to the scores distribution shown in figure 3. The consistence in distribution between the repeat tests supports the earlier mentioned deduction on retention of the knowledge of the concepts learnt during the training. Furthermore, from figure 4, it is clear that the distribution of Post-test2 scores from both the training periods is on higher score values than the CG. The scores distribution of the CG shows similarities to the scores distribution shown in figure 2 for Pre-tests. This finding shows that the CG with their qualifications are more or less at the same knowledge level as those in the EG before the trainings. However, after completion of the training, the EG was more knowledgeable on the topics chosen for the tests than the CG.

4. Discussion

The CATM was adopted for this study due to conception

of its utility. This, following earlier reports confirming attainment of good results with high retention of the knowledge of the concept learned several months after the conclusion of the trainings [15-20]. Further, the suitability of the method for vocational education [21, 22], and its effectiveness with older adults [26] is an added advantage. Moreover, the utility of the method in instructing learners with different development levels [23-25], further strengthen the decision to choose the method. The issues mentioned above are all very relevant for the target group, i.e. cleaning workers, considering that more than 90% of the cleaning workers in this study were older than 30 years, having varied educational backgrounds and some with language competence challenges. Cleaning workers with attained VC were considered a suitable CG because they are presumed, from their prior training and experiences, to be knowledgeable in chemicals and chemicals health hazards. The comparison of this CG with those who received the CA-training gives an indication of the effectivity the CA methodology, especially on knowledge retention, in contrast to existing convention training methods used during the certification process and other companies' internal training programs. Another valid supposition was that supervisors have a higher-level knowledge of chemicals and the associated health hazards because of their expected role of training their subordinates. Although few supervisors actually conduct trainings in the cleaning sector [9], their involvement in the cleaning workers' health and safety is a regulatory requirement, and knowledge of chemicals and hazards is thus essentially relevant. Consequently, their level of chemical health hazards competence gives a good point of reference for comparison.

In this study, a considerable majority of the participants spoke Norwegian and/or English well enough to communicate. The mode of testing the cleaning workers used, i.e. written and MCQ, was preferred because workers are time-constrained. Moreover, the written tests were done anonymously allowing the workers to not be under pressure. Alternative test method e.g. oral assessment would have been much more time consuming, and would have stressed the workers even more, probably resulting to yet poorer performances than seen here. All the training session were conducted during working hours, and the available time was only that which was agreed with the supervisors. The test method was changed from the short answers to multiple-choice questions due to a number of the workers not been able to satisfactorily answer the test questions with written short answers. Many of the participant managed well enough to take the written test, but there were altogether 77 and 65 responses for Pre-test and Post-test1 respectively, which were omitted from further consideration during the first training period. The omitted responses were due to illegibility of the responses, or test questions forms returned blank. No efforts were made to find out why some questionnaires were returned blank. Changing the format of the test from shorts answers to MCQs did not make a very significant difference in the scores range. Despite the 100% response in the Pre-test of the second period, the scores in the Pre-test and Post-test1 in the two periods were not very different. Moreover, the results of the short-answers questions were based on the responses from participants who were actually competent in writing in either Norwegian or English. In the second period where only MCQ format was used, where the trainees only had to cross against the correct answer and, one's writing skills was no longer relevant, the scores were only slightly better than those from the short answers written tests. The difference was not substantiating enough to conclude right out that the poor performance in the first period was entirely due to poor Norwegian/English writing skills. This is a confirmation that the low scores of the Pre-tests of the first training period were attributable to low knowledge level on the topics tested on.

Post-tests 2 were repeated a month after the conclusion of the specific training period. Repeating the tests (Post-tests2) after a longer period than the one month chosen here, e.g. after 6 months, would have given better indication of the level of retention with time. However, the fall-out after such a longer time might have been larger than the 47% and the 32% recorded after one month for the first and the second periods respectively. Lower number of repeat tests over longer times would have reduced the validity of the results, making the outcomes inconclusive.

From the distribution histograms in figure 3, in comparing the trained EG and CG, the difference in the level of knowledge between these two groups is apparent. The CA-method trained workers were better informed than both their counterparts who had attained VC and their supervisors.

Another likely limitation of the study could be the motivation of the trainees. In some of the training sessions, some of the workers, especially those with very long work experiences, were in the beginning, resistant to taking tests and the training, banking on their long experiences as sufficient for them to figure out what is required of them to work safely. Further, taking a written test for many, although done anonymously, was seen as a systematic evaluation of their performance. This could also be the reason that some did not answer the questions, or did not submit the filled test papers. The duration of the Pre-test, which was maximum 30 minutes, was probably insufficient for some of the cleaning workers, and they thus rushed to finish or chose not to exert any effort in answering the questions. However, the slight score difference between the written short answers tests and the MCQs tests does not support this deduction.

5. Conclusions

Using the teaching methodology of concept attainment as a training method for cleaning workers on chemicals information and chemicals health hazards gave good results with clear improvement on the level of knowledge among

those trained. The level of knowledge retention was also very high following the repeat of the test a month after completion of the training. The results are consistent with the earlier reported cases of good outcomes in different fields. The improved knowledge among the workers indicated by the improved scores following the conclusion of the training spells the effectivity of the method as a training tool.

The CA method is little known among most trainers in the cleaning sector as well as in many other sectors where workers handle chemicals. The use of the method has been limited to schools and in some few cases in universities and other higher learning institutions. It would be beneficial for trainers of workers, whether from external training institutions or those in-charges of companies' internal training programs to familiarize themselves with the method, and consider implementing it as part of their training programs. To achieve this goal, there is need to increase awareness of the method among the trainers and to inform those concerned of its effectivity as shown in this study. It is a sincere hope that this paper would positively contribute to that goal.

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