Safety Science 146 (2022) 105538

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/safety

Safety Integrated Model-training (SIM-t) and its evaluation: A safety training proposal for mechanical companies

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ARTICLE INFO

Keywords:
Safety training
Knowledge
Attitudes
Behaviours
Perception of health
Tailored training

ABSTRACT

In the EU-28, the number of occupational accidents is still too high, with serious social and economic consequences. We have devised an intervention called Safety Integrated Model-training (SIM-t) with the aim of unifying the most effective training methods for adults in a single proposal. SIM-t involves the use of audiovisual materials (ad hoc products for each company), a participatory approach, and regular and lasting reinforcement in daily practice. The training intervention is divided into several sessions over several weeks. For its evaluation, we conducted a longitudinal study (September 2017–April 2018), with the participation of workers (n = 185) from mechanical companies in northern Italy. Measures relating to knowledge, attitudes, behaviours, perception of the health, and safety climate were collected at baseline and in subsequent follow-ups. Overall, the participants' average safety performance at the end of the training was significantly better than the initial level. In summary, the SIM-t and its evaluation methodology are an integrated intervention proposal providing companies with a safety training protocol and a test of its effectiveness. The contents that emerged from the study suggest extending this training intervention and the evaluation of its effectiveness to different contexts.

1. Introduction

In the EU-28, the number of accidents at work is still too high, with serious social and economic consequences. The data show 3552 fatal accidents and over 3.3 million non-fatal accidents in 2017, with a ratio of 1 in 942 (Eurostat, 2020). Overall, illnesses and accidents at work produce a cost equal to 3.3% of the gross domestic product (GDP) of the EU (476 billion euros each year; EU-OSHA, 2020). All this requires improving occupational health and safety strategies, policies, and practices.

To this end, we must consider that the absence of accidents is a less valid measure than the presence of safe behaviours (Beus et al., 2016) and that such behaviours are strongly influenced by individual and organizational factors (Kao et al., 2019). The main actions addressed to improving safety at work are risk assessment, targeted campaigns, effective training for risk prevention, and, above all, promotion of safe behaviours. This is conceivable only with the company's constant engagement towards safety combined with structured, formalized, and integrated systems for the management of health and safety in the workplace (Perttula and Aaltonen, 2017). Hence, training is not the only solution for all aspects of occupational health and safety (Brahm and Singer, 2013), although it is thanks to training that we can provide workers with the knowledge and skills to reduce illnesses and injuries. When workers do not comply with the safety procedures, there appears to be a critical aspect that – often – is the result of inadequate training (Lawton, 1998).

In fact, as evidenced by specific systematic reviews and *meta*-analyses (Burke et al., 2006; Robson et al., 2012; Ricci et al., 2016), training is not always effective in providing workers with adequate knowledge and skills, unless the interventions meet some specific criteria. Evidence suggests that safety training programs can be effective when more engaging, participatory, and hands-on training methods are used within a context that favours and encourages the application of safety knowledge and skills (Kao et al., 2019). Several studies indicate that the insertion of examples in the training facilitates the learning of concepts and the acquisition of skills (Merrill et al., 1992; Foshay, 2009). In particular, examples of both safe and unsafe behaviours have led to greater learning than training that used only one example of behaviours (whether safe or unsafe; Taylor et al., 2016). Furthermore, there are data supporting that videos can be an effective safety training method and that they can increase knowledge (Burke et al., 2006; Gummesson, 2016), with the advantage of access via smartphones (Lynch et al.,

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https://doi.org/10.1016/j.ssci.2021.105538
Received 5 December 2020; Received in revised form 16 September 2021; Accepted 11 October 2021
Available online 27 October 2021

2012). Visualization helps to understand the contents in detail and to implement preventive measures. Furthermore, the use of experiential methods – situations, assignments, roles in which the subject is an active protagonist – in training increases the interest and participation of learners in the activities (Feinstein et al., 2002). Moreover, the use of experiential methods involves situated learning; that is, it enables replicating situations that participants might encounter at work. In experiential learning, people learn from active engagement with the environment, and its efficacy stems from the union of personal commitment and didactic support, such as debriefing (Garris et al., 2002). This provides a good basis for improving workplace conditions using a participative approach (Rosén et al., 2005; Hedlund et al., 2016), going so far as to specifically deal with subjective hypotheses and fears (Dauer et al., 2006). Lastly, so that learning proves to be truly satisfactory, it must be reinforced in daily practice (Lawton, 1998).

Thus, factors such as examples, videos, a participatory approach, and reinforcement in daily practice, according to the principles of andragogy (Knowles, 1984), reduce the resistance to learning present in adult and experienced people. It is in everyone's interests to have motivated participants in the courses on safety, that is, keen, focused, committed, involved, consistent, interested out of voluntary choice, and finally, satisfied with what they are doing (Garris et al., 2002).

Occupational safety courses available ready-made on the market and potentially suited to every company of a certain sector attempt to implement these factors of efficacy but, so to speak, separately from one another. That is, starting from separate modules, a course suited to the client is designed, where there will certainly be videos, examples, and perhaps a trainer who will try to involve the public as much as possible. The client, partly because he is obliged by the laws in force, partly to save money, and finally because he is mainly interested in production, usually chooses a non-specific pre-packaged course. If a company wanted to invest more? According to this framework, there is not much to do except perhaps to lengthen the course and enrich it with new marginal topics to support the main ones. Otherwise, a company can think of a course to be constructed entirely from scratch, tailored to fit a certain particular situation and that overcomes the limits of the pre-packaged courses.

At present, there are some contextualised methodologies that have been put forward to achieve improvements in safety performance. One of these is the Safety Training Observation Program (STOP, Darvishi et al., 2015), a program for changes in behaviour that provides for the observation of people as they work to prevent the reiteration of unsafe actions, eliminating risky behaviours in the workplace and reinforcing safe behaviours. Another example is Safety Management for the Occupational Driver (SMOD, Newnam and Oxley, 2016), an intervention tied to safety at work, packaged in a tailored fashion for each specific organization: it comprises four group sessions, each one lasting 4 h, with a monthly frequency, for an overall period of 4 months. The method is above all based on the possibility for workers to interact to develop their own strategies and objectives, to the point of taking on personal responsibility in leading in safety. We can also mention the courses including presentations and discussions, based on the use of video PIMEX (Picture Mix Exposure, Rosén et al., 2005; Hedlund et al., 2016), whose material shows real-life cases of safe working behaviours and a high degree of participation among the workers. On the basis of these experiences, the importance of unifying all the most effective training methodologies in a single proposal emerged. For this purpose, an intervention – for workers in the mechanical sector – called Safety Integrated Model-training (SIM-t) was devised and tested.

In particular, we tried in each step to use and coordinate all the factors qualifying quality training. In Step 1, not only are videos used, but they include examples and promote a participative approach, representing scenes set in one's own workplace, where the actors are actually colleagues. In Step 2 there are no videos, but each person's individual behaviours are analysed, in a one-to-one trainer–learner relationship, where participation is at a maximum; the examples coincide with daily experience, and reinforcement in daily practice is distributed in time with a great deal of continuity. Lastly, in Step 3, the participative approach is again put into play to the maximum extent in the examples, through representations with theatrical modalities (instead of videos) and/or workgroups based on occurrences that really happened in the company or, in any case, that are very likely.

Unfortunately, today, there are still too few studies on the effectiveness of training in the field of occupational safety, even though the need to evaluate the efficiency and effectiveness of the contents and training methods is recognized (Robson et al., 2012; Cohen and Colligan, 1998). Beyond presenting the SIM-t, this research aims to contribute to this knowledge through evaluation of the effects of an intervention delivered with the SIM-t method for workers at mechanical companies. In this sector, this is the first Italian longitudinal study to evaluate the four levels of outcome considered in this field of investigation (Burke et al., 2006; Robson et al., 2012; Ricci et al., 2016). Furthermore, we aim to test whether and to what extent the safety climate is affected by the training provided. In fact, we know that safety climate is a contextual factor that contributes, as a distal antecedent of safety-related behaviours and consequent accidents, to determining effects (direct and indirect) on proximal antecedents, at both an organizational and individual level (Beus et al., 2016). Therefore, the safety climate influences knowledge, attitudes, behaviours, and health. Nevertheless, safety training is an organizational intervention that testifies to the importance that the company attributes to this activity aimed at workers, so it is necessary to check the effectiveness of safety training on safety climate improvement.

In particular, the following hypotheses were evaluated:

(H1): The SIM-t methodology produces, with respect to the baseline values, an improvement in knowledge and in favourable attitudes towards safe behaviours, associated with an increase in the frequency of safe behaviours and the perception of well-being and the values of the safety climate.
(H2): The satisfaction with training is proportionate to the outcome of efficacy.

Next, the article presents the SIM-t methodology and, after describing the materials and methods for the verification of H1 and H2, the results and discussion are presented.

2. Safety Integrated Model-training (SIM-t)

The SIM-t is a training methodology designed according to a constructivist approach, with reference to Kolb's (1984) experiential learning model. That method traces the acquisition of new knowledge, skills, and attitudes to four modalities: concrete experience, reflective observation, abstract conceptualization, and active experimentation. The framework of reference offered by experiential learning is necessary for designing in an appropriate and integrated training pathway that combines the main principles of andragogy: examples, videos, a participative approach, and reinforcement in daily practice.

By referring to these principles, a sequence of three distinct and separate steps was devised that define the SIM-t: i) specific audiovisual materials, ii) reinforcement of safe behaviours, and iii) analysis of adverse events (accidents/near misses/unsafe behaviours).

Step 1 involves tailored audiovisual material in a group session in the classroom, lasting about 3 h. All the audiovisual materials must be made at the workplaces of the departments involved to foster the utmost identification possible by the workers. The scenes can be acted out by the learners' colleagues, previously trained for that purpose through a dedicated course, or by external experts. The content of the video may vary slightly from company to company, but the main topics and their sequence are fixed: situational awareness, manual handling of loads, personal protective equipment, use of Safety Walkways passing through the work areas, work-related stress, first aid. Every topic present in the

video allows for a sequence of unsafe and safe behaviours to be shown, with subtitles to reinforce the message (Giannini et al., 2013) and as affective markers, aimed at facilitating the attribution of meaning and the effective use of the information presented (Peters et al., 2004). The recordings and montage of the materials must be carried out by specialised personnel. The audiovisual material must be produced with modalities and quality such as to allow for the achievement of a good level of educational entertainment (Castaneda et al., 2013), aimed at both knowledge and entertainment. The final product must have a duration between 30 and 90 min, in relation to the complexity of the contents being dealt with. The trainer is an expert in andragogy who periodically interrupts the video to encourage reflection and discussion among the participants.

Step 2 involves individual on-the-job practice for the reinforcement of safe behaviours, 15 min a week for 8 weeks (about 2 h total). This activity is led by an expert identified with the consent of the company management (e.g., an external consultant specialised in safety or the health safety environment [HSE] company manager, or the person in charge/supervisor of the workers involved). Training on the job envisages the flanking of workers while they perform their activities, to create a dialogue on the behaviours implemented. The supervisor goes to the workers' place of work during the working week, watches them, encourages discussion, and initiates sharing on concrete aspects of everyday experience. In order to carry out his task, the supervisor follows a list of topics, partly adapted in order to address the specific requirements of the company and the intervention department. However, even in this case, the main contents of the list and their order are fixed: personal protective equipment, manual handling of loads, posture at work, pace of work. Only twice, at the beginning and at the end of Step 2, the list of topics is used for a data collection related to the behaviour (cfr. paragraph 3.3.). The aim is twofold: on the one hand, to accompany every worker in questioning his/her own limiting beliefs, and on the other, to reinforce the safe behaviours deemed to be priorities in the task.

Step 3 involves the study of personal cases in a group session in the classroom, lasting about 3 h. This step leads to a complete conceptualization of the factors involved, enabling analysis of the causes, definition of the take-home message, and the proposal of improvement actions. It can be performed according to the alternative modalities:

a. Theatrical representation of working accidents that really happened in the company. This entertaining dramatization can be classified as a live action role playing (LARP, Vanek & Peterson, 2016), with reference to the Theatre of the Oppressed (Boal, 2000) and the pedagogy of Paulo Freire (2018). Once the enactment of the accidents is complete, the trainer invites the students to replace the actors to repeat the scenes, with the aim of modifying them to avoid the adverse event (see annex picture 1a). The actors can be colleagues of the students, previously trained for that purpose through a qualifying course, or external experts (e.g. the community practice, Wenger, 1996, of "PratiCARE la sicurezza", 2015).
b. The first phase of individual reflection, in the course of which each worker must write schematically about a real case of injury or a near miss or unsafe behaviour of which he or she has first-hand knowledge; the second phase of case discussion, in sub-groups of about 5 workers (see annex picture 1b); closure in a plenary session, during which the spokesperson of each group presents the case chosen by consensus within their own group and, later, replies to questions and proposals of solutions put forward by the other groups. In agreement with the company, at the start, there can be a testimony provided by the victim of a work accident, trained to speak about the injury suffered directly.

Finally, in Fig. 1 the SIM-t method is presented as a flow chart.

In carrying out this training step, it is necessary to convey that, when an adverse event occurs, the important aspect is not who made the mistake but to understand how and why the organizational system failed in enforcing barriers and protections. Indeed, the errors are the consequence of upstream systemic factors, not causes originating from the perversity of human nature. Not being able to the change human condition, we must act on the conditions in which the workers operate (Reason, 2000).

In each phase of the SIM-t method, the training methods have been designed and managed considering the affective importance of personal experiences, which are quite efficacious for capturing attention and influencing the decision-making processes, above all addressed at the adoption of future behaviours (Peters et al., 2006).

The most effective result produced by non-traditional methodologies (e.g., videos, field support, personal case studies, the use of many short sessions rather than a few long sessions, and, again, continuous training over a long period) finds numerous confirmations in the field of safety education (Ricci et al., 2016; Ricci et al., 2018b). SIM-t combines all the factors qualifying quality training, through various coordinated training sessions. In Step 1, videos recorded in one's own workplace are used in a participative approach. Furthermore, the high involvement in a one-to-one trainer–learner relationship, during on-the-job practice, is the added value in Step 2. Lastly, in Step 3, the dramatization and/or workgroups based on real company events promote workers' participation in learning.

SIM-t can be freely adopted by any company, not only those in the mechanical sector (e.g., Ricci et al., 2018a), to deliver training or updating on the subject of work safety, as an alternative to less effective traditional methodologies (e.g., classroom lectures). The number of participants during classroom sessions can differ from case to case, but from our experience, it is better if they do not exceed 30 people.

Below is an evaluation of the efficacy of the safety education delivered with the SIM-t method for the workers of four Italian companies in the mechanical sector.

3. Methods and materials

The methods and materials used in this study are described below, divided into study design and participants, measurements, procedure, and statistical analysis.

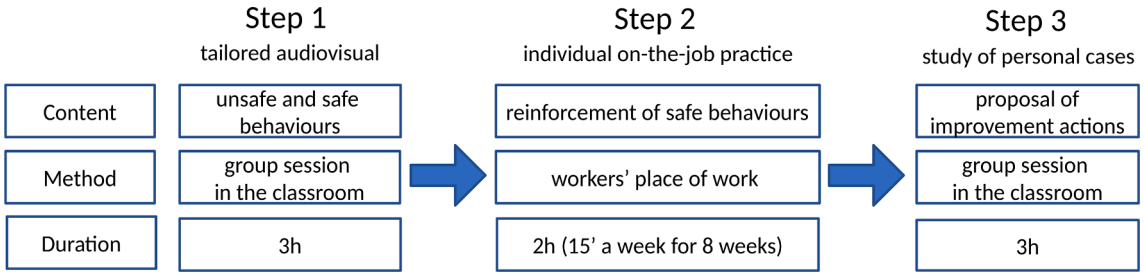

Fig. 1. Figure 1Flowchart presenting SIM-t method.

3.1. Study design and participants

One hundred and eighty-five workers from four mechanical companies based in northern Italy took part in this ecological longitudinal study. The four companies voluntarily joined the current research, and, inside each plant, the management identified the department to be involved. All of them are involved with the assembly of mechanical components (gardening machinery, electrical appliances, screen printing machines). The 185 workers belonging to the departments identified for the research were obliged to follow the SIM-t training to comply with the mandatory safety update required by Italian legislation. Each one of them freely agreed to take part in the study. Between the workers of the different plants, there were no professional relationships; each plant was run by different company management, and the sites were physically far apart from one another. Before proceeding to administer the measures featured in the study, the participants signed an informed consent form and provided their sociodemographic data. All the research activities were performed in total compliance with the ethical and deontological code of psychologists.

The methods of training delivery underwent some slight changes from plant to plant, for economic and organizational reasons. The duration of the various steps of the classical SIM-t model – audiovisual materials, on-the-job practice, personal cases – varied to a maximum of 20% (in a few cases, a whole step was skipped). In two cases, the management chose not to limit the duration of the training to the legal minimum (6 h; Plant 2: 9 h and Plant 3: 8 h).

In each company, the representative for workers' safety was actively involved in each phase of the research project and took part in the realization of the training.

3.2. Measurements

Following Robson et al. (2012), knowledge, attitudes, behaviours, and health perception are the outcomes considered to collect quantitative evidence of the effectiveness of safety training (H1). To these measures we have added the safety climate, as a contextual factor (see Introduction). Satisfaction with regard to the training is a further outcome chosen to estimate the correlation between satisfaction and efficacy (H2).

The instruments used are as follows:

- **Knowledge**: adapted version of the scale proposed by Ricci et al. (2018b), composed of three sub-scales: 2 items, recognition of the safe behaviours presented as a photographic stimulus (e.g., safety signage), with three alternatives and only one correct answer; 15 items , production – paper and pencil – of the correct answers to questions on the role of prevention and the safety procedures (e.g., "What is the safest behaviour to have in the event of an earthquake tremor?"); 3 items, recognition of the correct answer, among the four alternatives, on obligations and sanctions that the law imposes on the workers (e.g., "Breaking the obligation to correctly use the working equipment and the means of transport, as well as the safety equipment, will be punished with:").
- **Attitudes** towards the safe practices: self-evaluation questionnaire, made up of 4 items (e.g., "Applying the safety procedures at work prevents one from working well"), adapted from Ricci et al. (2018a), with responses given on a 10-point Likert-type scale (from 1 "completely disagree" to 10 "completely agree").
- **Behaviours**: original observation checklist for safe behaviours at work. Four indicators have been identified for each observation parameter, from 1 (describing the worst-case scenario) to 7 (pinpointing the optimal behaviour). The surveys were carried out at each company, upon request from the company management, by personnel experienced in observation tasks. The observers were trained by the lead researcher before proceeding with the execution of the scheduled activities. Examples of parameters are use of clothing, PPE, use of instruments, and compliance with the procedures.
- **Health perception**: VAS scale of EuroQol-5D (EQ-5D), an instrument for the measurement of quality of life (Balestroni and Bertolotti, 2012).
- **Safety climate**: Italian version in reduced form to 7 verbal items, rated on a 7-point Likert scale (from 1 "completely disagree" to 7 "completely agree"), of the NOSACQ-50 (The Nordic Council of Ministers, 2013). The items measure perception with respect to the actions of the management (4 items, e.g., "the management involve the workers in decisions concerning safety") and the colleagues (3 items, e.g., "the workers of this company help one another to work safely").
- **Satisfaction with regard to the training**: questionnaire made up of 5 items (Ricci et al., 2018a), rated on a 5-point scale (from 1 "wholly unsatisfactory" to 5 "wholly satisfactory").

3.3. Procedures

The entire data collection procedure was led by the researcher following the succession and timing shown in Table 1. However, being an ecological study, the delivery of the formation and the data collection took place with some small differences between the different sites, due to organizational and company reasons.

On the first day, the initial data were collected (T_1), the first training was carried out in the classroom with the audiovisual materials (Step 1), and a second data collection was conducted (T_2). Several days later, the on-the-job training was started (Step 2), with 8 short interventions of individual flanking on a weekly basis. On the second day of training in the classroom (no earlier than two months after the first encounter), the session with the study of personal cases was carried out (Step 3), at the start of which the satisfaction with the on-the-job training was surveyed, and, at the end, the third data collection was conducted (T_3). Only one of the four sites did not carry out this data collection. Lastly, around two months after $Step_3$ – and around four after the first step – a final data collection session was conducted at just one of the four sites (T_4).

The four data surveys took place with self-administered questionnaires within the collective sessions led by the researcher. The questionnaires were filled out in a rigorously anonymous form; however, to be able to pair the responses of the same participant in the different surveys, each one was asked to calculate a univocal – and still anonymous – code according to the criteria established by the researcher. The satisfaction with the training, of course, was not surveyed at T_1. To reduce the factors of distraction, at the beginning of each data collection session, the participants put their electronic devices in a dedicated place.

The data collection relating to the behaviour (checklist) was the only one not self-administered; it was carried out by someone appointed by the company and trained by the researcher. This observation and recording of behaviours, which lasted many hours, took place during the week prior to the T_1 meeting and in the week following the T_3 and T_4 encounters (the latter only for Plant 2).

3.4. Statistical analysis

In descriptive analyses, mean, standard deviation, counts, and percentages were reported for continuous and categorical variables, respectively. All tests were two-tailed, with alpha level $p < .05$. Cronbach's alpha was assessed for internal consistency of the outcome of all measurement instruments (knowledge, attitudes, behaviours, perceived health, safety climate, satisfaction with training). A repeated-measures ANOVA model was used to test changes over time. Variables of interest were all the measurement instruments, and random variables were subjects. The generalized eta squared (η^2_G; (Olejnik and Algina, 2003) Olenik and Algina, 2003) was used to measure effect size. Pearson's correlation was conducted to assess associations between satisfaction with training and training effectiveness. Statistical analyses were

Table 1
Procedure for data collection and training.

Name	Intervention type	Intervention Content	Duration of Intervention	Temporal sequence	Statistical unit
T_1	Data collection with self-administered questionnaires	All the scales excluding the satisfaction	About 30′	First encounter	185
$Step_1$	Training	Audio-visual	About 3 h	Same day, right after T_1	
T_2	Data collection with self-administered questionnaires	All the scales	About 30′	Same day, right after $Step_1$	185
$Step_2$	Training	On the job	About 2 h (about 15′ per week for 8 weeks)	Starts several days after T_2	
$Step_3$	Training	Self-cases	About 3 h	Several days after the end of $Step_2$	
T_3	Data collection with self-administered questionnaires	All the scales	About 30′	Same day, satisfaction per $Step_2$ immediate collection before $Step_3$, all the other measures straight after $Step_3$	123
T_4	Data collection with self-administered questionnaires	All the scales	About 30′	About two months after T_3	49

conducted with R ((R Core Team, 2020)R core Team, 2020) using the "DescTools" and "gtools" packages.

4. Results

At the first data collection (T_1), the sample was made up of 185 participants. Of these subjects, 21.1% were female, the mean age was 44.79 years (SD = 7.9), and the mean number of years of education was 10.34 (SD = 2.3). Company seniority was 15.87 years (SD = 7.4), and the prevention role was covered by 22.7% of the sample. The Cronbach's alpha values were, as a whole, satisfactory, ranging from 0.82 for the knowledge to 0.64 for the attitudes, 0.51 for the behaviours, and 0.83 for the safety climate. Table 2 reports the mean and standard deviation surveyed in time successions T_1-T_4. Overall, the data show an improvement in safety after the training according to the SIM-t method (see Fig. 2). In particular, knowledge showed a significant improvement (see Table 3 and Fig. 2) and a substantial effect size ($\eta^2_G = 0.49$). Similarly, the behaviours showed a significant growth pattern and an adequate effect size ($\eta^2_G = 0.32$, see Table 3 and Fig. 2). The mean value of the safety climate varied, reaching significance, but over time, the variable seemed to return to baseline (see Fig. 2). Both the attitudes and the perception of health did not show significant improvements, but the latter remained rather high overall. Lastly, the relationship between satisfaction with the training received and the repercussions of efficacy turned out to be practically zero. For example, by comparing the improvement of the five measures after Step 1 (T_2-T_1) with the related survey of the satisfaction, we obtained correlation values (Pearson's r) from −0.25 to 0.14. However, the presence of artefacts created by a clear ceiling effect seems evident, with the median satisfaction at T_2 and T_4 being 5, which is the maximum value of the scale.

5. Discussion

The discussion begins with an analysis of the intervention (5.1). Thereafter, limitations and methodological implications are discussed (5.2), followed by practical applications and further research (5.3).

Table 2
Mean (standard deviation) of all the measures surveyed T_1, T_2, T_3 e T_4.

Measures	T_1	T_2	T_3	T_4
Knowledge	11.5 (4.4)	23.4 (6.3)	20.18 (6.1)	24.18 (4.7)
Attitudes	5.7 (1.9)	6.1 (2.0)	5.6 (2.0)	5.9 (1.8)
Behaviours	5.3 (1.0)	6.1 (0.6)	6.2 (0.6)	6.7 (0.3)
Perceived health	65.6 (21.5)	67.0 (21.5)	68.0 (19.8)	64.9 (18.9)
Safety climate	5.7 (0.9)	6.0 (0.8)	5.7 (0.9)	5.8 (0.6)
Satisfaction with training	NA (NA)	4.6 (0.5)	4.5 (0.5)	4.6 (0.5)*

* recorded at the end of T_3

5.1. Analysis of the intervention

The data support H1. In fact, the SIM-t methodology produced, compared with the baseline values, an improvement in knowledge and an increase in the frequency of safe behaviours. The attitudes also improved initially, but over time, the variable seemed to return to the starting point without achieving significance (see Fig. 2). Analogous is the trend in the safety climate, with a slight initial improvement that, however, was lost in the course of time. Only the perceived health was be unchanged with respect to the pre-training measure.

The SIM-t methodology was shown to be efficacious, and its outcomes endure over time because it is built on the actual needs of the participants and is based on the principles of adult learning. The results indicate that the integrated methodology facilitated the development of knowledge and the implementation of safe behaviours, determining a proactive orientation that allows for the maintenance of learning over time. This is of great applicative interest, given that the efficacy of the training is mainly defined in terms of behaviours maintained over time, surveyed with periodic follow-ups, rather than as immediate learning (Warr et al., 1999). Naturally, it is almost inevitable that with the lengthening of the surveys in time, the number of participants can decline, but the concrete indications that can be drawn well make up for any limitations. Furthermore, detected Cronbach's alpha values seem good overall, with an exception for the behaviour tests, probably because these aspects – as compared with others – are less tied to one another, and there could be situations where a safe behaviour is flanked by a dangerous one.

The advantages stemming from the application of the SIM-t methodology are coherent with the action theory (Hacker, 1985), according to which learning is facilitated by action, so it would be easier to learn something about one's own environment by carrying out actions rather than simply observing them (Frese and Zapf, 1994). Additionally, the management's choice not to limit the duration to the legal minimum (Plant 2 and Plant 3) offers concrete proof to the participants of the substantial value attributed to safety. This is in agreement with studies that show that improvements are more sensitive to voluntary investments, deriving from company choices and finalized to reducing specific well-known risks, as compared with the obligatory investments imposed by law and with actual standards that might not be effective for every type of company (Feng, 2013).

The weak effect of the training on the safety climate is understandable, as the data of this measurement are close to the maximum values already at baseline. Moreover, the pool of companies that took part voluntarily in this research showed excellent levels of safety performance and a management strongly motivated to raise the level of attention with regard to the prevention of adverse events. Similarly, the training resulted in limited efficacy with respect to improvement in favourable attitudes towards the safety behaviours. In this case, we must consider the fact that an important *meta*-analytic study (Robson et al., 2012) did not show clear effects for this measurement, eventually

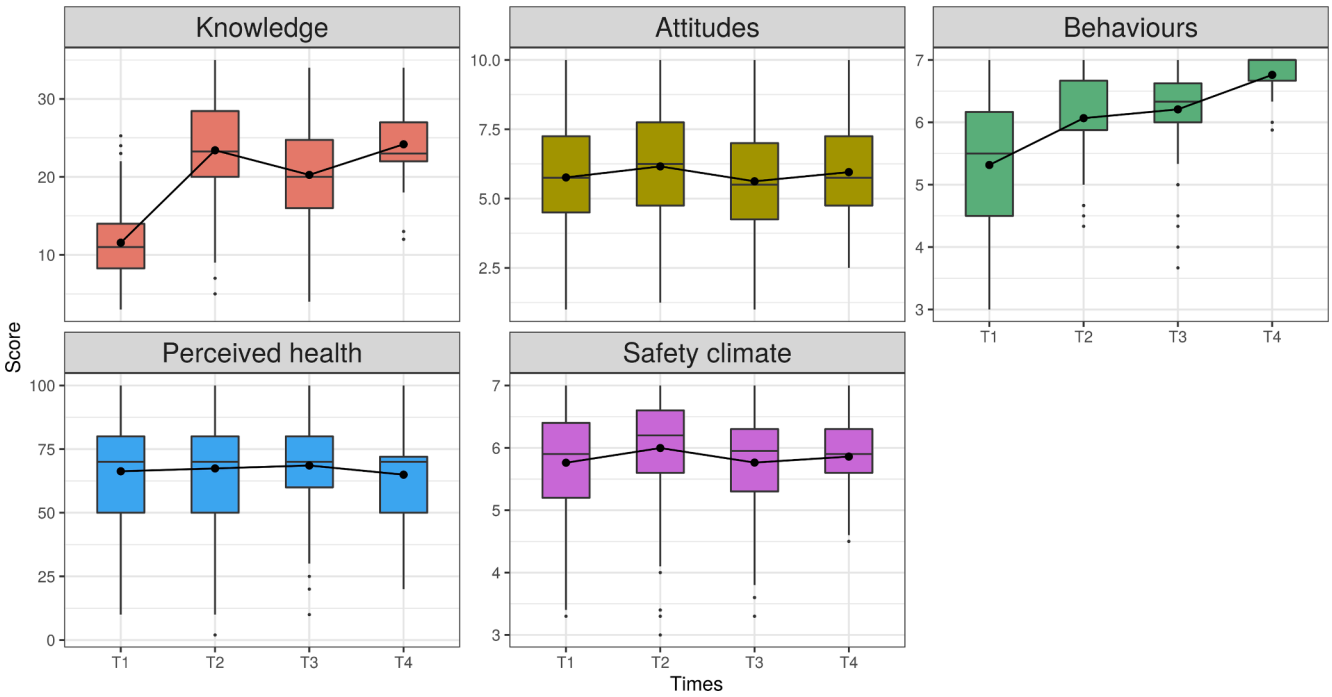

Fig. 2. Figure 2Mean (standard deviation) of all the measures surveyed T1, T2, T3 e T4.

Table 3
Repeated-measure ANOVA model with generalized eta squared

Measures	Variable	Df (Num)	Df (Den)	F	P	η^2_G
Knowledge	Time	3	354	455.3	<0.001	0.49
Attitudes	Time	3	346	1.74	0.158	0.01
Behaviours	Time	3	295	108.5	<0.001	0.32
Perceived health	Time	3	354	1.60	0.188	0.002
Safety climate	Time	3	354	6.33	<0.001	0.02

classifying the proof of the attitudes as insufficient. It should be added that a recent study (Ricci et al., 2018a) found unsatisfactory results for the same measure, showing, at the end of the training, the presence of a more favourable safety attitude, although the values in the follow-up had returned to the initial level.

Regarding the unchanged perception of well-being, the datum is in agreement with recent *meta*-analytic studies that showed an effect in some cases modest and in others absent (Ricci et al., 2016), except for interventions of broad duration and long-lasting. Other authors believe that it is not possible to demonstrate the impact of training on workers' well-being (Robson et al., 2012). In the case of research similar to this, the measure of perceived well-being showed a positive change at the end of the training, returning to baseline values three months after the end of the intervention (Ricci et al., 2018b). Improvement in health is an ambitious objective, and training alone might not be sufficient to bring about significant effects.

H2 was rejected, as no relationship was present between the satisfaction measures for the training and the efficacy repercussions. However, this is likely because the level of satisfaction, for all three steps, was very high. These extremely positive values confirm the quality of SIM-t but do not allow us to detect the expected relationships due to the ceiling effect.

Our hypothesis was formulated according to the indications of Kirkpatrick (1976), who observed positive affective reactions correlated with learning. However, subsequently, the *meta*-analysis of Alliger et al. (1997) did not show a relationship between affective relations and training results. In the same way, three models of training evaluation do not propose relationships between the reactions and other evaluation methods, agreeing on the fact that positive reactions to training are not a predictor of learning (Holton, 1996; Kraiger, 2002; Tannenbaum et al., 1993). It should not be excluded that, in the absence of a ceiling effect, as in the case of the current study, it is necessary to examine more differentiated indicators of reaction (Warr et al., 1999). What emerges from analysing the scores of satisfaction with the different steps is a slightly lower value, albeit still high, for satisfaction with the on-the-job training (present only for Plant 2 and Plant 3). We can hypothesize that this is related to the fact that the flanking was conducted, by choice of the management, by expert staff who, unlike what occurred in Steps 1 and 3, were not full-time trainers. Hence, it is fundamental, as from previous evidence (Ricci et al., 2018a), to resort to professional trainers, experts both in the content and in methods for transmission to expert adult people.

The results of this study confirm the importance of delivering the training according to the actual needs of the participants, via the use of effective methods for adult learning. The SIM-t methodology aligns with these principles exactly and allows us to achieve favourable lasting outcomes regarding knowledge improvement, implementation of safe behaviours, and an increase in safety performance.

5.2. *Limitations and methodological implications*

Given the nature of the ecological study, the training and data collection involved a convenience sample of companies that cannot be considered representative. However, bearing in mind the necessary caution in generalizing the results, all the workers employed in the chosen departments participated in the longitudinal study. The reduction of the sample in time is simply due to the organizational choices defined by the management of every company headquarters; in other words, there was none of the experimental subjects dropped out. Some companies chose to partially complete the training pathway. Specifically, at T1 and T2, all the plants took part (n = 185); at T3, Plant 4 (n = 123) was not present; and at T4, only Plant 2 (n = 49) was not involved. Furthermore, on-the-job training was only delivered for Plants 2 and 3.

Having demonstrated the quality of SIM-t, a limit to the study is not

having quantified the difference with respect to traditional methods. However, it would not have been possible to exclude some of the companies that voluntarily joined the SIM-t experimentation, imposing the adoption of a clearly less efficacious and less interesting training intervention.

Finally, we do not exclude the possibility of expanding the measures adopted, with the aim of further analysing the effects of the intervention on the various outcomes and, of course, of improving those used. However, the choice of measures was made also in relation to the actual time availability of the plants taking part in the study. It is also necessary to consider the cultural level of the participants and their familiarity with social research. More complete and reliable instruments, but more onerous from the perspective of the commitment required and the time needed for the administration, would not have been suitable for this kind of experimental research.

5.3. Practical applications and further research

The results of this study provide scholars and professionals with an innovative model to unify different training methods and to implement effective interventions for learning about safety and health at work. The SIM-t course that simultaneously combines examples, videos, a participative approach, and a long enhancement in everyday practice will overcome the limits of the pre-packaged courses. Unfortunately, today, there are still few cases in which the effectiveness of occupational health and safety training interventions is really detected and pursued. In this regard, the presented research provides further elements that allow for improving the quality of training and avoiding errors in the delivery of these courses. In particular, this assumes a great value for a high-risk sector such as the mechanical one. Finally, this research represents the first Italian longitudinal study that evaluates, in the specific sector, the four levels of outcome considered in this field of investigation (Burke et al., 2006; Robson et al., 2012; Ricci et al., 2016).

The experimentation of the SIM-t methodology and the measures used in this study offer an intervention proposal that allows companies to realize quality training and to test its efficacy. In this way, SIM-t offers participants positive support that can produce consensus towards safe behaviours. Hence, applying the “nudge theory” (Thaler and Sunstein, 2003) to safety performance, SIM-t influences safety motivation at the individual and group levels, acting on factors that foster certain behaviours, without obstructing the decision to opt for different choices. Like a SIM card, the methodology proposed works when it is inserted inside a device that allows it to work: a unique number associated with a specific user. In our case, SIM-t does not work without a company with which it is associated univocally, which is made to measure, but at the same time, it is necessary to insert this intervention, unique for each user, so that the company can function properly.

Finally, the results that emerged from the evaluation of the effectiveness of SIM-t training encourage its extension to different occupational contexts. The construction industry and manufacturing sector are areas where the probability of illnesses and accidents at work is greater. Applying SIM-t training to these areas and verifying its effectiveness appears to be the most promising avenue for further research.

6. Conclusions

Companies usually ask themselves if the training provided is of any use, or if it is just a waste of time and money. However, a real evaluation of the effectiveness of the various outcomes (knowledge, attitudes, behaviours, health) is often not conducted. This places serious limits on the evidence-based identification of the strengths and weaknesses of training.

The data collected help to reduce this knowledge gap and provide researchers, corporate decision makers, government agencies, and international bodies with an innovative proposal that has been evaluated for effectiveness. SIM-t is an effective instrument for occupational safety training, contributing to improving the interfaces between technology, people, and organizations.

SIM-t and its evaluation method were shaped on the evidence that emerged from the systematic reviews and *meta*-analytic studies carried out in the occupational safety training effectiveness research area. Therefore, this package (SIM-t and related measures) should encourage companies of many sectors to realize quality training and test its efficacy. This method can be freely adopted by any company, not only those of the mechanical sector, to deliver training or updating on the subject of occupational safety, as an alternative to less effective traditional methodologies (e.g., classroom lectures).

Furthermore, the excellent satisfaction scores in every step, testifying to the quality of the intervention, show a ceiling effect that does not allow us to detect its relationships with efficacy repercussions. However, it is interesting that the highest levels were reached when the intervention was delivered by professional trainers, experts in andragogy.

Finally, the results of this study confirm the importance of delivering training according to actual needs of participants, via the use of effective methods for adult learning. The SIM-t methodology aligns with these principles exactly and allows us to achieve favourable lasting outcomes regarding knowledge improvement, implementation of safe behaviours, and an increase in safety performance. An important practical aspect is given by the clear evidence that the effects of training can be maintained only by envisaging interventions performed with continuity and in close relation with everyday reality, instead of being limited to illustrating normative obligations.

Credit authorship statement

F. Ricci conceived of the presented idea. F. Ricci and M. Nucci contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This work was carried out within the scope of the project ``use-inspired basic research'', for which the Department of General Psychology of the University of Padova has been recognized as ``Dipartimento di eccellenza'' by the Italian Ministry of University and Research.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssci.2021.105538.

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