Current motivation, self-efficacy, cognitive load, and hands-on performance of secondary school students during bystander-cardiopulmonary resuscitation training: A comparative interventional study between two teaching models

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Abstract

The implementation of educating "Basic Life Support (BLS) competences" in German schools is particularly affected by the often reported "implementational gap" –limited transfer of empirical findings into practice. This Design-Based Research (DBR) study evaluates two different methodologies for BLS teaching, generating implications for transfer. Students (N = 136) of a secondary school (11-13 years) were assigned to different methodological approaches. A test group (TG) received intervention implemented into regular biology lessons (10 units; n = 48); the control group (CG) participated in a basic instruction (2 units; n = 68). Both large-scale methods – subject-matter teaching (TG) and project activity (CG) – were compared regarding current motivation, self-efficacy, constructivist instruction, cognitive load, and practical skills. Data from n = 125 students (TG=48; TG=68) could be included into analysis (Mage=11,16; SD=.45; 55.2% female). Probability of success and interest increased, anxiety perception decreased (no group-interaction effect), whereas challenge perception remained constantly. Self-efficacy overall improved from before to after intervention, with TG reporting higher social self-efficacy and less negative outcome expectancies. No differences were found for practical BLS performance. MANOVA (after intervention) showed higher values for anxiety in TG, and for self-efficacy, CG has higher values for negative outcome expectancies (post hoc analysis). For cognitive load and constructivist instruction, no differences between groups were found. In conclusion, both methodological approaches seem to have their own pedagogical justification. Schools' implementation processes may benefit from combining (subject-matter) curriculum content with BLS information or content to facilitate time and resource-saving realization.

Keywords

DBR-research; basic life support; implementation, design, teaching, CPR

Introduction

The approach of teaching basic life support (BLS) to students during their schooling aims to avoid a considerable number of out-of-hospital cardiac deaths by creating an effect on future bystander resuscitation rates (Böttiger, Semeraro, & Wingen, 2017). However, this

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"matter of life and death" is imprinted with not only the demands of a serious medical content as indicated by Zinckernagel et al. (2016, p. 5) but also with the common challenges of innovative projects in educational institutions (Dumcke, Wegner, Böttiger, Kucknat, & Rahe-Meyer, 2019; Dumcke, Wegner, & Rahe-Meyer, 2021): An insufficient transfer of findings from educational research into schools' regular practice, with changes in daily routines, was frequently reported (Einsiedler, 2010; Schmiedebach & Wegner, 2021; The DBR Collective, 2003). A potential solution for those transfer difficulties in educational organizations was described and enhanced by introducing Design-Based Research (DBR) (Anderson & Shattuck, 2012; Fischer, Waibel, & Wecker, 2005).

For such an interprofessional perspective the DBR approach was determined as the fundament of the project "Saving Lives Meets Schools" (German original title: *LEBEN RETTEN MACHT SCHULE*). This contribution describes the repetitive design process as well as findings of a concept evaluation using two large-scale methods within the project.

The project aimed to increase the relevant knowledge on student education in BLS in the German educational system, recognizing that the implementation is still facing some barriers, negative considerations and lacking awareness (Dumcke, Wegner et al., 2019). Although BLS competencies should be available to every student across ethical, religious, and economic disparities, a solid approach is needed to foster scientific and educational large-scale progress since a subject like health education or first aid is not yet established part of curricula.

Compared to other European nations (Malta Hansen et al., 2017; Mpotos & Iserbyt, 2017) or the US (Brown, Lynes, Carroll, & Halperin, 2017), the implementation in Germany is – also due to the federal structure of the educational sector – still local and dependent on few persons' or initiatives' engagement (Rücker, Wingen, Rott, & Böttiger, 2022; Schroeder, Ecker, Wingen, Semeraro, & Böttiger, 2017). These circumstances have led to very heterogeneous concepts and practices up to an undermining of the benefits (Rücker et al., 2022) that CPR/BLS education in schools seems to be a promising instrument of improvement for resuscitation rates and outcome (Wissenberg et al., 2013).

Theoretical Background: Pedagogical Measurements of Learning

Current Motivation

Rheinberg and Vollmeyer (2012) emphasize the activating and energetic moment of motivation towards a positively valued target state. According to learning motivation in educational settings, it positively influences learning strategies and students' intentions to learn novel competencies to achieve certain learning outcomes (Schiefele & Schaffner, 2015). Motivation is supported by intrinsic (e.g. interest, exploration behavior) and extrinsic factors (e.g. social recognition, good marks). Current motivation refers to the reciprocal effect of persistent personal characteristics (motives) and situational stimuli, which can result in aligning and energizing behavioral consequences (Rheinberg & Vollmeyer, 2012; Rheinberg, Vollmeyer, & Burns, 2001). Current Motivation is characterized by dispositional motivational features, such as achievement motive, goal orientation and interest. The achievement motive can be divided into an approach motive ("hope/probability of success") and an avoidance motive ("fear of failure/anxiety") (Schiefele & Schaffner, 2015, p. 162). Whereas success represents positive assumptions about good outcome, avoidance relates to negative stimuli during learning caused by perceived pressure (Rheinberg et al., 2001). In terms of the theory of interest genesis (Krapp, 1998; Renninger & Hidi, 2011), (situational) interest is another disposition that is object-related, whereas challenge captures a person's ambition to perform a given learning activity (Rheinberg et al., 2001). According to BLS education, measuring current motivation can provide more distinct information about students' initial dispositional motives, as both, fear and disgust (e.g. Iserbyt, 2016) as well as general willingness and interest (Kanstad, Nilsen, & Fredriksen, 2011; Smedt et al., 2018) were reported.

Specific, situational self-efficacy

Self-efficacy and outcome expectancies are components of Bandura's (1977) self-efficacy theory. Self-efficacy is one's personal belief that strongly influences thinking, feelings, motivation, and action and is a strong indicator for change behavior. It describes an individual's confidence to master new or difficult tasks based on their own capabilities (Dumcke, Rahe-Meyer, & Wegner, 2021b). Believed consequences of action are a second dimension of self-efficacy theory. In context of specific situations (as cardiac arrest or emergencies), both components are directly related to certain tasks and the perceived competence to master it – CPR, for instance. Self-efficacy has subordinate dimensions, which are psychological, social and, for outcome expectancies, valence, temporal proximity and area of consequences (Fasbender, 2018), of which only valence (positive–negative) was addressed here. For more detailed information please refer to Dumcke, Rahe-Meyer, and Wegner (2021b).

Self-efficacy as a predominant indicator for changing intentions and the perception to act in stressful situations is important to investigate when teaching BLS in schools. However, evidence so far focused on less suitable concepts as self-confidence or addressed self-perception unsystematically (Felzen et al., 2018; Meissner, Kloppe, & Hanefeld, 2012; Wingen et al., 2018). With a specific instrument for BLS, certain crucial inhibitory or enhancing pattern of thought can be determined. Prior analyses revealed that negative associated consequences may persist for longer training periods than expected by the hands-on performance outcome (Dumcke et al., 2021b).

Constructivist Instruction and Cognitive Load

Process features, as well as cognitive load, are both methodological relevant factors that influence knowledge acquisition and flow experience in educational settings (Renkl, 2015).

Constructivist instruction is a paradigm in learning theory supposing knowledge to be individually developed and processed (Reinmann & Mandl, 2006). Following a moderate perspective, learning environments offer students open structures and opportunities to build up knowledge. Instruction should be an active, situated, social, self-determined, emotional and constructivist process (Basten et al., 2015). By investigating constructivist instruction with reference to BLS education, learning processes may be enhanced by looking at these features and compare "traditional" lecture formats with pedagogically advanced interactive formats.

Cognitive load (CL) is a common reported barrier to learning achievements (Paas, Renkl, & Sweller, 2003; Sweller, 2003). The basic assumption is that the acquisition of knowledge is limited because the working memory is unnecessarily burdened (Renkl, 2015). Cognitive load can be divided into these forms: intrinsic, extrinsic and germane. Whereas intrinsic and germane load are connected to cognitive enhancement, extrinsic load is ineffective. Extrinsic load is caused by activities of learners that are inherent to instructional design, e.g. information that is separated but belongs together, or if the level of language is not appropriate. Intrinsic load is caused by the complexity of a task itself (e.g. BLS algorithm) and germane load is the capacity needed to integrate schema acquisition and automation into learning (e.g. a certain sequence of action) (Paas et al., 2003). As especially for the training of BLS, with a certain chronological order, parallelism and narrow time frames, the restricted capacity of the learners working memory should be relieved by improved instruction (e.g. of materials, tasks, environment), as indicated by broad concepts (Groß, Böttiger, & Thaiss, 2019; Schroeder et al., 2023). An analysis of cognitive load in educational concepts can help to review the suitability of the content and the developed materials, as sometimes it is assumed that BLS, particularly in young students, is beyond their learning capabilities.

Research Objectives

The general research concern of the combined study can be stated as follows:

> Do two "resuscitation and health teaching" interventions – differently designed in content and length –lead to a different perception and performance of secondary school students?

The presented assessment was conducted at the final stage of a DBR evaluation phase and focusses on design development rather than on macro-implementation. The refined design solution (see educational structure) was carried out in-field, following a regular lesson schedule and environment (design = test group). It was compared to a standard short intervention, (= control group) as a classic "project activity" off the schedule.

To assess learning progression in general, as the primary measurement endpoint, we investigated global differences in (1) the current motivation, (2) self-reported self-efficacy/outcome expectancies, (3) measured BLS quality criteria (see study design) before (baseline, t0) and after (final, t1) intervention together with an interaction effect of group assignment. According to the interactive and reflexive design of the test condition, we assumed a better stimulation of self-related expectations in the training:

H1 Students performed better after intervention, independently of the group assignment for current motivation, self-efficacy scales and quality parameters, respectively.

Second endpoint was the comparison of the learning performance and process evaluation after the intervention for each condition (TG vs. CG), hypothesizing: TG students compared to CG students…

H2 …report an improved current motivation (cf. QCM, i.e. higher interest, probability of success, less anxiety)

H3 …report improved self-efficacy (cf. BLS-SET; i.e. higher self-efficacy; lower negative outcome expectations)

H4 …report a higher experience of constructivist features as well as less cognitive load (i.e. lower extraneous/germane load)

H5 …perform better in the assessed hands-on quality parameter (compression depth and frequency, full decompression).

Methods

The Design-based research approach

Design-Based Research (DBR) describes a research model that aims to enable a sustainable integration and transferability of innovations from theory-based, knowledge-oriented educational research into everyday classroom practice (Anderson & Shattuck, 2012;

Reinmann, 2005; The DBR Collective, 2003) by holistically looking at interactions between materials, teachers, and students (The DBR Collective, 2003, p. 5).

A general DBR principle is iterative cycles of testing and collaborative partnership between scientists and practitioners at their daily locations (e.g. Anderson & Shattuck, 2012; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Fishman, Penuel, Allen, Cheng, & Sabelli, 2013). The systematic DBR is globally divided into three phases (Plomp, 2013) (fig. 1).

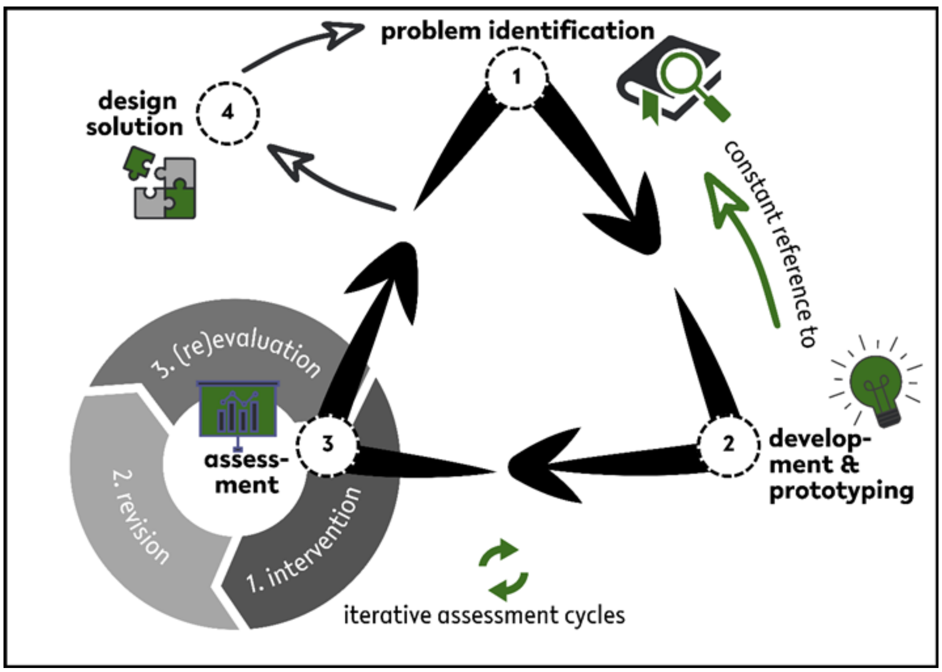


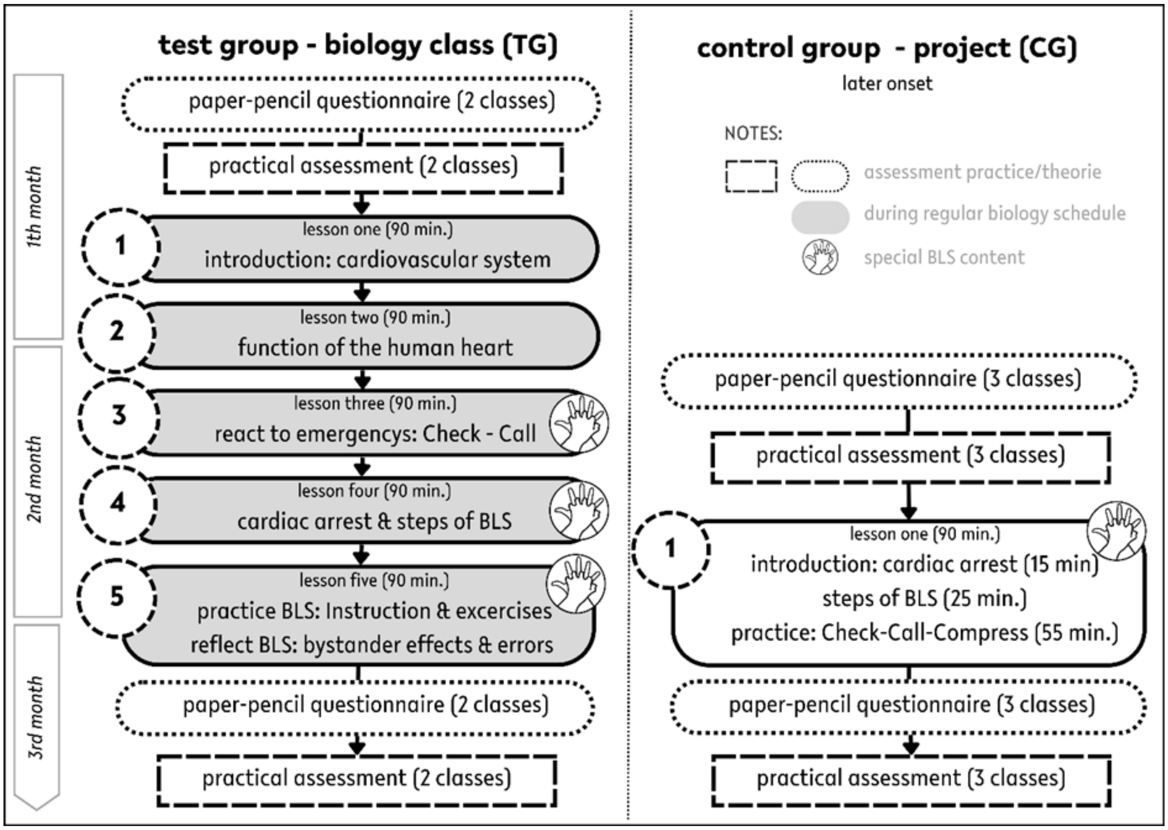
Figure 1: DBR-design process (modified from Schmiedebach & Wegner, 2021)

One recommended application of DBR is under the condition of missing "how-to-guidelines" for a certain implementation, insufficient literature analyses, for instance (Kelly, 2013, p. 137). Those typical negative "baseline conditions" (cf. Kelly, 2013, p. 138) are also found for the implementation of educational concepts in bystander resuscitation due to new (medical) knowledge or limited pedagogical expertise (Anonymized, 2019; Zinckernagel et al., 2016). From 2018 onwards, the project Saving Lives meets School aimed to facilitate the implementation of life-saving first aid into sustainable school routines and subject-matter teaching. To investigate contexts and causes of the mentioned "implementation gap", a multi-perspective and interdisciplinary DBR-collaboration of researchers with practitioners was initiated (Plomp, 2013, p. 23). These included intensive care physicians and paramedics, first aid instructors and educators. The whole implementation study's project design is given in the summary table in supplementary material 1.

Secondly, didactic-methodological questions for a successful teaching and learning process, which are caused by the specificity of BLS and medical knowledge required, were left unanswered. For this reason, a secondary objective was to evaluate educational resources and concepts on classroom level for application in school programs (Plomp, 2013, p. 23). Besides DBR, mixed methods according to Creswell and Plano Clark (2007, 2018) were applied (quantitative, qualitative), to triangulate or converge the information from implementation and design perspective.

Educational structure of the evaluation

The DBR-design outlined before was finally tested for feasibility in a learning environment. The study took place in the regular schedule of a German "gymnasium" from October to December 2021 and all sessions were taught by two scientifically instructed,



pedagogical persons as teaching tandem, supported by regular teachers.

Figure 2: Empirical setting according to the educational plan in test (TG) and control (CG) group.

The educational plan was different for both conditions (fig. 2). The CG received a standardized training according to the KIDS SAVE LIVES check-call-compress principle, which pronounces a simplified bystander algorithm for CPR, focusing on high-quality chest compressions only (Schroeder et al., 2023) – this algorithm is commonly used to reduce germane and extrinsic cognitive load. CG participants were lectured very basic information about circulation, cardiac arrest, brain damage and BLS-steps using a presentation; the procedure was demonstrated, followed by modular exercises on manikins (Little Anne QCPR, Laerdal, Stavanger) in groups of two or three. Each student practiced a) alone and b) alternating with his/her partner for 3 minutes. Between the exercises the previous task was shortly discussed for feedback.

The TG was part of regular biology classes and was embedded into the content domain "cardiovascular system and blood" of the 6th grade curriculum for German schools in North-Rhine Westphalia (MSB NRW, 2019, pp. 24–25). The units were designed following a situated, active and problem-oriented approach to enhance learning according to constructivist principles: Therefore, in the first lesson a short self-experiment (heart rate modulation), in unit two video sequences (human heart) and, in units 3 to 5, roleplaying (BLS-scenarios) and simulation techniques (with manikins) were used as alternating methods (cf. fig. 2). The TG was introduced into the BLS content more carefully by switching from the physiological function of the human circulation to the abnormal and life-threatening emergency. A special focus was laid out on behavioral change and communicative skills (e.g. call for help, recognize and express own limits…). This approach aims to incorporate sources of and promote specific self-efficacy. The check-call-compress hands-on activities in lesson five were identical to the CG (see above).

Participants and Sampling

In total 136 students between 11 and 12 years of a German 6th grade were included in the study. Two and three classes, respectively, participated in the test and the control condition. Figure 3 shows the participants' flow though the intervention. From N = 136 students, eleven did not provide any parental consent and were therefore excluded. From five classes n = 125 students were allocated to the two conditions. Overall, n = 8 students did not take part in the lessons and n = 5 participants were lost to follow-up after intervention. For data analysis 48 (TG) and 68 students (CG) were included, a total of 116 participants (fig. 3).

Sample characteristics are displayed in table 1. Results showed nearly balanced distributions of age and gender over the conditions. Due to organizational constraints, the biology-integrated TG was only applicable in two out of five classes.

Figure 3: Flow chart of the evaluation study. TG = test group. CG = control group.

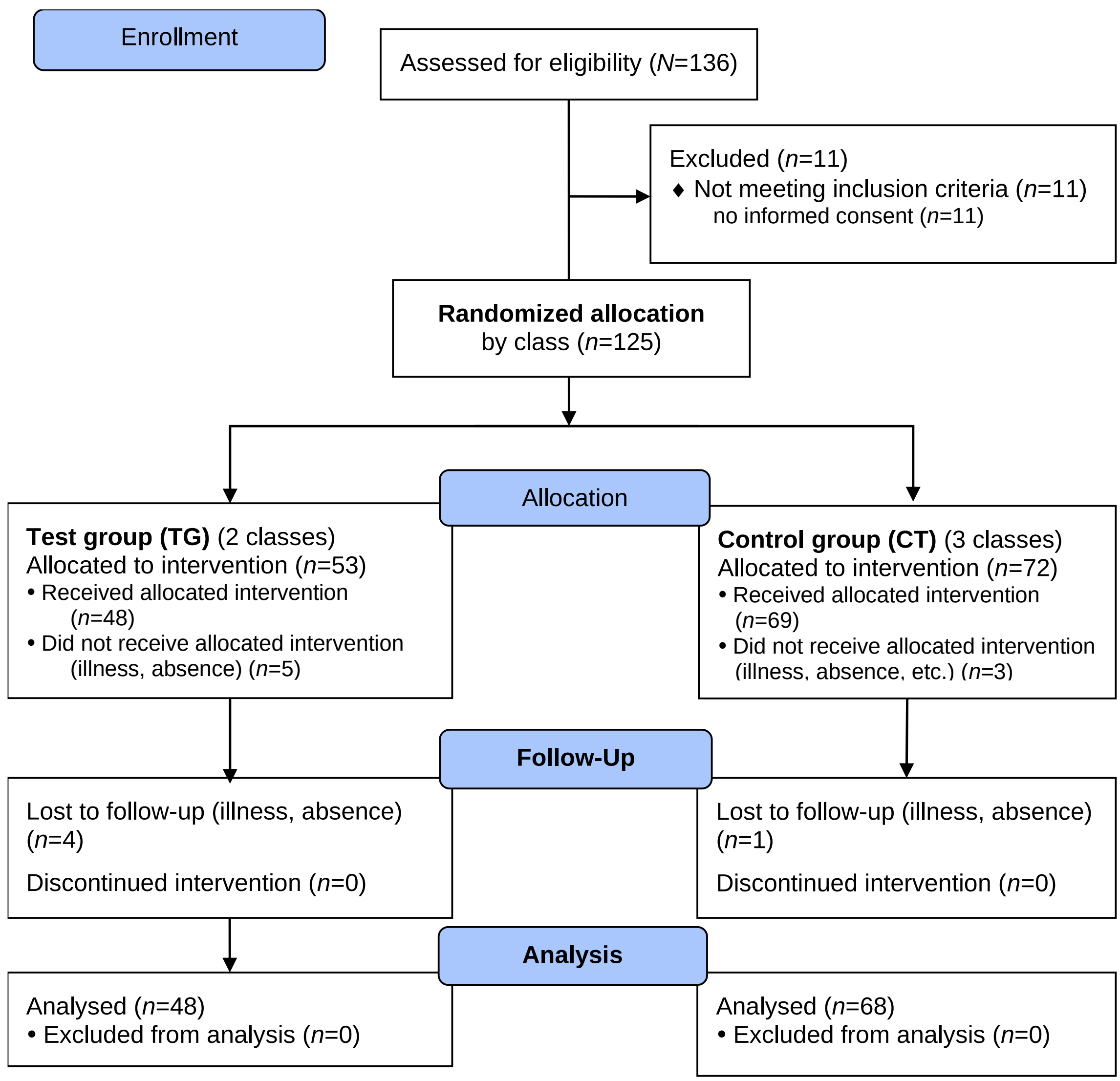


Table 1: *Overview of main sample characteristics.*

	TG	CG	total
N	48 (58.6%)	68 (41.4%)	116 (100%)
gender[1]			
f	27 (56.3%)	37 (54.4%)	64 (55.2%)
m	21 (43.8%)	30 (44.1%)	51 (44.0%)
n/a	0.0	1 (1.5%)	1 (0.9%)
age (*M*)	11.15 (*SD*=.47)	11,16 (*SD*=.45)	11,16 (*SD*=.45)
10-11	40 (83.4%)	57 (83.9%)	97 (83.6%)
12-13	7 (17.6%)	11 (16.2%)	18 (15.5%)
n/a	1 (2.1%)	0.0	1 (0.9%)
Witnessed CA	2 (4,2%)	6 (8.8%)	8 (6.9%)

[1] *Other gender affiliations were not given. TG = test group. CG = control group. CA = cardiac arrest.*

Research design and materials

The evaluation was assessed by two quantitative methods.

Questionnaire

The theoretical variables were assessed by a paper-pencil questionnaire given to the students approximately 7 to 10 days before the first and after the last lesson they received, respectively. Besides background data (i.e. Code-ID, group affiliation, age, gender) validated instruments in pedagogical research were adopted to evaluate both the learning and the didactic conceptualization (cf. table 2). For the German questionnaire development, we applied translated originals with careful modifications due to the young participants. Translation changes included some wording issues, as well as subscales were shortened by deleting items with lowest factor loads or discriminatory power.

Current Motivation Questionnaire (QCM)

The QCM (Rheinberg et al., 2001) was shortened to 12 of originally 18 items due to economic and motivational considerations reflecting the 6-graders' abilities (one item for each subscale except anxiety with two items reduced). Items were selected for deletion by semantic (Doublette) or statistical reasons (lowest factor loads). The phrase "task" was converted to "exercise" and post intervention analysis items were transferred into past tense. It contained four subscales: interest, challenge, probability of success, and anxiety (cf. tab. 2).

Situational self-efficacy BLS/CPR (SET-BLS)

Self-efficacy was measured as an indicator for perceptual change in important helping behavior. The SET-BLS questionnaire from Dumcke, Rahe-Meyer, & Wegner (2021b). was used without modifications and consisted of four domains, psychological (5) and social (4) self-efficacy as well as negative (5) and positive (5) outcome expectations (cf. tab. 2).

Features of constructivist instruction - short version (s-FCI)

Constructivist instruction means a set of features which affect learning in the natural science education (Basten et al., 2015). The German short scale used here, consisted of 19 items in 6 subscales (cf. tab. 2). The subscales "constructivist" and "self-determined" were supplemented with one item each from Urhahne, Marsch, Wilde, and Krüger (2011) due to semantic ambiguities, number of items and limited loadings.

Cognitive Load Inventory (CLI)

The used CLI questionnaire was composed by combining two instruments (Klepsch, Schmitz, & Seufert, 2017; Leppink, Paas, van der Vleuten, van Gog, & van Merriënboer, 2013) in adoption to the issue BLS teaching, following the three dimensions of cognitive load (Sweller, 2003): intrinsic load, extrinsic load and germane load (cf. tab. 2)

Practical "hands-on" assessment

Identical simulation tests on a manikin with a presented cardiac arrest scenario were conducted at baseline and after intervention. At baseline, students were asked to perform anything they think is appropriate to help an unconscious and not normally breathing person. Afterwards, they were invited to react as they learned during intervention. Every single student was separated during the test (stopped after one minute), which was organized into small groups of six participants.

ERC-guideline compliant (cf. Olasveengen et al., 2021) and clinically relevant variables were measured by using the QCPR instructor app (Laerdal Medical, 2021) for Android: Mean compression depth (mm), mean frequency (min-1) as well as compressions that were of correct depth (= 50-60mm), frequency (= 100-120 min-1) and decompression of the chest (= fully decompressed) in percent.

Power and Randomization

A-priori power was calculated using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) and an online calculator (Hemmerich, 2018) for analysis of variance at an alpha level of α = .050 for two groups. Minimum power was set 80% according to Cohen (1988) and at a medium for educational settings (η2 ≥ .06) (Bortz & Döring, 2016). Total sample size was 125, resulting in 63 participants needed per group. This size was finally not met for TG (see limitations). Classes were cluster-randomized and assigned to both conditions using randomizer.org (5 numbers, range: 1-2, non-unique).

Data analysis

Statistical analyses were performed with *The Statistical Package for the Social Sciences* (SPSS v.29, IBM Corp., Armonk). Reliability scores (cf. tab. 2) were calculated using Cronbach's α. With a few exceptions, sufficient coefficients (α ≥ .70; Schmitt, 1996), were given. All scores (r >.50) are acceptable for group-based comparisons according to Lienert and Raatz (1998, p. 14 also see Schecker, 2014; cf. "limitations")

For the comparison of the time effect between the assessment cycles according to group affiliation (TG vs. CG) mixed ANOVAS were calculated (cf. supplementary material 4). The comparison of both, TG and CG were conducted with one-way multivariate comparisons (MANOVA) for each instrument and the BLS quality parameters (cf. supplementary material 3).

Homogeneity of variance-covariance was assessed with Box M test (α ≤ .001) according to medium sized groups n > 30 (Hahs-Vaughn, 2016; Verma, 2016) and by the robust Brown-Forsythe variant of the Levene's test (α ≤ .05) due to diverging group sizes (Sharma & Kibria, 2013). In MANOVA, unbalanced distribution and partial heterogeneity of variance was considered interpreting Wilks Lambda with α ≤ .05 (Ateş, Kaymaz, Kale, Tekindal, & Zhao, 2019). For time as well as TG and CG comparisons, means (M) and standard deviations (SD) were provided in supplementary tables. Effect size η2p was rated with reference to Cohen (1988, p. 285).

Table 2: Overview of assessment inventory, reliability and exemplary statements.

QCM: German Original: FAM; s-FCI = German Original: Prozessmerkmale gemäßigten Konstruktivismus, Kurzskala, Kurz-PgK; CLI: Cognitive Load Inventory is modified. [a] *Two values because two study populations were analyzed by Basten et al.*

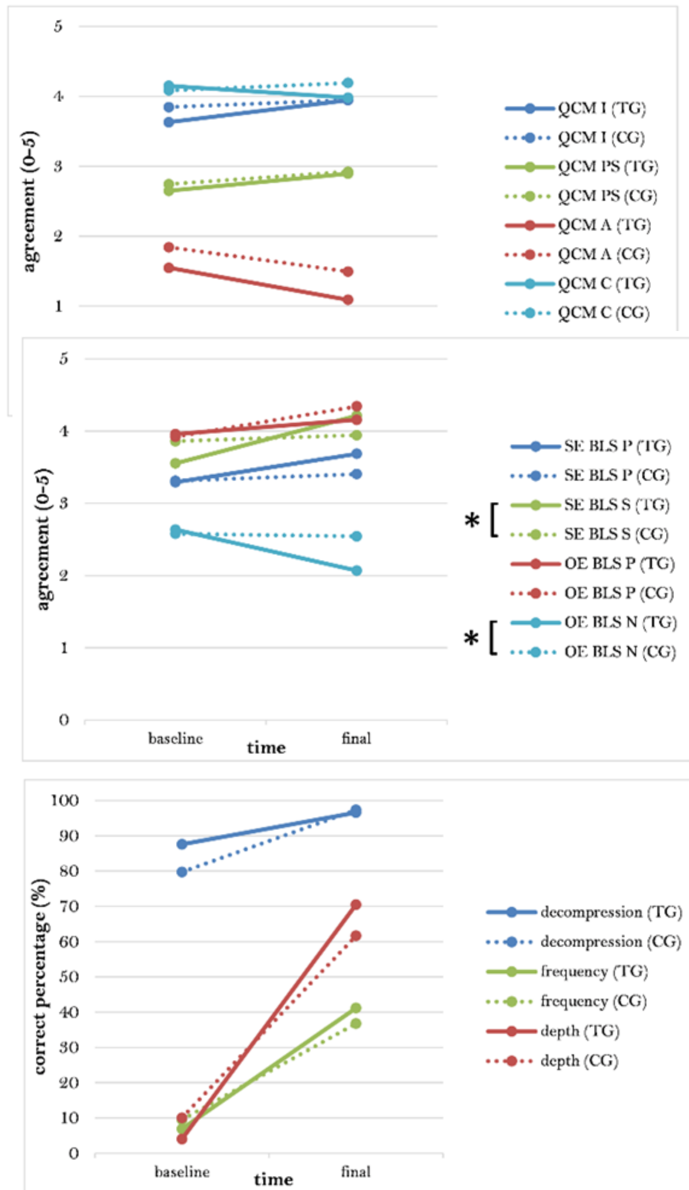
instrument	subscale(s)	No. items	Cr. α (t_0/) t_1	(ref.)	Original reference	example (translated into English)
Questionnaire of current motivation (QCM)	Interest (I)	4	.73/.75	(.74 [1])	Rheinberg et al., 2001, modified	*Anxiety:* "I was feeling under pressure to complete the tasks or activities well." 0 – fully disagree; 5 – fully agree
	Challenge (C)	3	75/.69	(.71 [1])		
	Probability of success (PS)	3	.58/.53	(.72 [1])		
	Anxiety (A)	3	.74/.64	(.83 [1])		
Self-Efficacy-Theory Scales for Basic Life Support (SET-BLS)	SE BLS (P)sychological	5	.78/.78	.81	Anonymized, 2021b	*Social SE: Instruction: I'm sure I can perform CPR even if…* …no one around me offers to help me voluntarily. *negative OE:* If I resuscitate someone, I can cause even more severe injuries. 0 – fully disagree; 5 – fully agree
	SE BLS (S)ocial	4	.80/.87	.85		
	OE BLS P(ositive)	5	.54/.55	.66		
	OE BLS N(egative)	5	.51/.50	.55		
Features of constructivist instruction- short version (s-FCI)	constructivist	4	--/.69	.69 / .74[a]	Basten et al., 2015, modified	*Situated: During the last lessons dealing with "Cardiovascular system, cardiac arrest and resuscitation"….* …I learned something that I can make good use of. 0 – fully disagree; 5 – fully agree
	self-determined	3	--/.67	.77 / .72[a]		
	active	3	--/.67	.77 / .84[a]		
	situated	3	--/.68	.82 / .89[a]		
	emotional	3	--/.75	.81 / .86[a]		
	social	3	--/.70	.79 / .68[a]		
Cognitive load inventory (CLI)	intrinsic	4	--/.61	.86	based on Klepsch et al., 2017 for items ICL 1,4; ECL 3,4; GCL 1,2; other: Leppink et al., 2013	*Extraneous:* The working tools accompanying the exercises were not helpful to actually learn anything. 0 – fully disagree; 5 – fully agree
	extraneous	4	--/.73	.80		
	germane	3	--/.72	.80		

Results

Learning progression and interaction of groups

Overall, results showed significant time effects in mixed ANOVA (for means and deviation, cf. supplementary material 4). In general, students reported reduced anxiety (QCM A; $F(1,114) = 14.05$; $p < .001$; $\eta 2p = .110$) and stated they were more interested (QCM I; $F(1,114) = 6.80$; $p = .010$; $\eta 2p = .056$) and could better achieve success (QCM PS; $F(1,114) = 12.56$; $p = .001$; $\eta 2p = .099$). However, after the intervention students felt still as challenged as before (QCM C; $F(1,114) = 10.12$; $p = .132$) on a high level which in case positively means, they still want to improve their knowledge and present their performance in BLS. Even if challenge perceptions in the TG lowered from baseline to final assessment (fig. 4), no significant interaction (time×group) was observed (cf. supplementary material 4).

The specific self-efficacy as behavioral change indicator was assessed with four subscales before and after the educational intervention, of which all showed significant time differences with medium effect ($\eta 2p$; Cohen, 1988). Highest effect was on the expectancies of positively-associated outcome (e.g. better survival, effectivity as team; $F(1,113) = 13.00$; $p < .001$; $\eta 2p = .104$); similarly psychological and social dimensions of efficacy perception improved, with higher values for social interactions ($F(1,113) = 6.15$; $p < .015$; $\eta 2p = .52$ and $F(1,113) = 9.79$; $p < .002$; $\eta 2p = .080$; fig. 5). Negative outcome expectancies (i.e. believed negative consequences of action) were rated on a medium agreement level and were lower after intervention ($F(1,113) = 9.43$; $p < .003$; $\eta 2p = .78$); Here, significant interaction was observed ($F(1,113) = 3.94$; $p < .008$; $\eta 2p = .062$): While the negative outcome perception (OE BLS N, fig. 4) decreased from 2.64±0.86 to 2.07±0.76 for students in TG, it stagnated in the control (2.58±0.83 vs. 2.54±0.94). Vice versa, an significant interaction effect was measured for social self-efficacy (SE BLS S) (e.g. teamwork, be a leader, refrained assistance): TG improved social self-efficacy afterwards as CG does not ($F(1,113) = 5.89$; $p < .017$; $\eta 2p = .050$; cf. supplementary material 4; fig. 5).



Figures 4-6: line chart comparing baseline and final outcome of a) QCM, b) SET-BLS and c) quality of BLS performance. Straight line indicates TG, dotted indicates CG.

For abbreviations see tab 2, means and standard deviation are given in supplementary material 3.
** indicates interaction effect (time×group): $p \leq .050$.*

For the practical skills, the interventions globally also led to improved measurements of guideline-relevant parameter with great effect ($\eta 2 > .14$): compression depth ($F(1,100) = 231.98$; $p < .001$; $\eta 2p = .699$), frequency of compressions ($F(1,100) = 6.46$; $p < .001$; $\eta 2p = .361$), and fully decompression ($F(1,113) = 11.46$; $p < .001$; $\eta 2p = .0.103$) increased. Students of both TG and CG performed significantly better after intervention, with no interaction effects, with correct compression depth being increased from less than 10% to over 60% (supplementary material 4).

Optimized drive: A look on current motivation and self-efficacy

Outcomes of the four QCM subscales for TG and CG, respectively, showed no significantly different omnibus tests in MANOVA ($F(4,111) = 1.63$; $p = .171$; Wilks $\lambda = 0.944$). However, if considering mean values and post-hoc ANOVA, anxiety was higher in CG that in TG ($M = 1.50 \pm 1.15$ vs. 1.09 ± 0.87; $F(1,114) = 4.25$; $p = .042$; $\eta 2p = .036$), whereas no differences were found for interest, probability of success and challenge ($p = .065$; .270 and .561; cf. supplementary material 3).

The combined subscales of the SET-BLS inventory showed a significant MANOVA, indicating a difference between CG and TG within the dependent subscales ($F(4,110) = 3.07$; $p = .019$; $\eta 2p = 010$; Wilks $\lambda = 0.900$). Of the subscales, however, none resulted in significant post-hoc ANOVAS ($p = .136$ for psychological; $p = .152$ for social self-efficacy and $p = .169$ for positive outcome expectation values), except negative outcome expectations. Students in the TG on average ($M = 2.07 \pm 0.76$) had lower agreement levels for negative consequences than the CG ($M = 2.56 \pm 0.94$) (ANOVA, $F(1,113) = 8.79$; $p = .003$; $\eta 2p = .074$; supplementary material 3).

Pedagogical value: The promotion of learning

For the assessment of a learner-oriented educational concept, constructivist features and cognitive load were surveyed. Multivariate testing including the six subscales of the s-FCI did not become significant ($F(6,104) = 158$; $p = .160$; Wilks $\lambda = 0.916$). Considering post-hoc analysis, only the rating of activity made a difference between CG and TG: CG students scored activity levels higher than TG's (4.27 ± 0.68 vs. 3.90 ± 0.97; ANOVA, $F(1,109) = 5.57$; $p = .020$; $\eta 2p.= 049$).

The CLI scale was without statistically different ratings of both, the students of TG and CG on multivariate level (MANOVA, $F(3,107) = 0.85$; $p = .469$; Wilks $\lambda = 0.024$) and also in post-hoc analysis (see supplementary material 3).

Hands-on effects: What about the quality

According to the ERC resuscitation guidelines of 2021 (Olasveengen et al., 2021), relevant parameter of chest compression-only BLS outcome (cf. practical "hands-on" assessment) were analyzed. Compared between groups after intervention, the interdependent proportions (%) of correct depth, frequency and pressure release did not differ significantly (MANOVA, $F(3,98) = 0.67$; $p = .572$; Wilks $\lambda = 0.980$).

Discussion

The DBR process can be used to introduce a more scientific and evidence-based culture of change in educational systems, because decisions are often made according to political interest rather than are they driven by transferred knowledge (Schmiedebach & Wegner, 2021, p. 2). This article adds information on the small body of evidence which used in-field designed concepts for study conduction and analysis. As far as known, different large-scale methods (regularly subject-matter vs. project activity) were not analyzed for the implementation of BLS student education. The more potential learning outcomes of BLS education are widely documented (Plant & Taylor, 2013; Schroeder et al., 2023; Wingen et al., 2021), the less is known about processes and organization at the meso- and micro-level of teaching (= school and classroom). The results of this DBR assessment not only view at if and how behavioral beliefs and skills are influenced by method, but also review pedagogical quality.

The participating students profit from the learning opportunity. An intervention with both, subject-matter and project approach, generated learning progress (accept H1). The success of short-term trainings (45-90 min.) was already reported by several studies, e.g. for self-confidence (Wingen et al., 2018) or BLS performance (Meissner et al., 2012) or by peer-tutors included (Beck, Issleib, Daubmann, & Zollner, 2015). Especially motivational factors – interest and challenge – showed high agreement and remained on similar levels, also in both conditions (rejecting H2). Accordingly, as Kanstad et al. (2011, p. 1054), for instance, reported, 80% of 16-19-year old students wished more BLS education to avoid "unnecessary death." BLS as topic may evoke more genuine excitement and curiosity than it is an emotional burden. However, decreasing of interest may be an indicator for loss of interest and the influence of novelty effects, respectively: since the students assumably had no contact to BLS before, the situation induces a strong baseline effect, which reduces by time. Thereby, interest may be overestimated in typical cross-sectional designs – which would favor shorter and more frequent units.

In contrast, self-efficacy dimensions were all promoted by intervention, but single interactions between CT and CG were observed (partly accept H1). Bandura (1977) describes self-efficacy as motor of change for behavior. To react and promptly solve a medical problem, one requires a self-effective mindset, which best can be supported by mastery experience (e.g. try BLS on a manikin) or verbal persuasion (i.e. talk, reflect, get feedback). Less self-efficacious persons also focus on problems and doubts, so that they are more likely to surrender to challenges. Statistically, social self-efficacy (SE BLS S) and negative expectations (OE BLS N) of emergency behavior were dependent from being in TG or CG. Additionally, negative expectations were also significantly different when comparing TG and CG at final assessment (t1) (partly accept H3). Iserbyt (2016) reported a non-affected level of willingness to e.g. perform BLS on strangers, which was assessed before and after a skill-focused 50 min. BLS training for n = 313 students (12-18 years). A reason for this observation, matching our results, could be the character of social or outcome-related factors. Interactive challenges or ethical questions cannot be trained on a manikin or with software. Skill based, short interventions therefore do methodologically and by time limitations do not offer the required promoting opportunities: Longer, integrated learning arrangements beside practice, also offer social and communicative experiences. In roleplays students are able to build up a self-determined handling of interactive scenarios, or special task cards address real, frequent anxieties or related uncertainties of people. Thus, a sustainable BLS education should not only view at psychomotor skills, but holistically at the whole context of the situation (Iserbyt, 2016). Consequently, the recent ILCOR statement explicitly incorporates "motivational aspects" (Schroeder et al., 2023). Despite, negative considerations seem to be particularly more persistent (Dumcke et al., 2021b, cf.) than the acquisition of motor- and treatment processes, even for relatively young students (Dumcke, Rahe-Meyer, & Wegner, 2021a).

The quality of education, as well as practical BLS outcome, did not result in significant differences between TG and CG (rejecting H4-5). That no cognitive overload neither by extraneous (task cards, instructions, manikins, information overload) nor intrinsic (e.g. BLS procedure itself) or germane factors (e.g. complex case scenarios/roleplays) were found, is good news: Hands-on lessons may remain short and sharp but can be framed by instruction in regular class without negative influence on learning. That students of the CG rated their 90 min project-course more activating than those who also learned physiological background and were cognitively engaged to reflect over five weeks, is quite expectable (i.e. "memory effect") and should not derogate teaching BLS in subject-matter sequences.

Design Recommendations for BLS teaching

What can be considered as implications of the evaluative assessment?

The core of DBR is steady revision. Taking the meso-level (i.e. school), common implementation challenges (Gräsel, 2010) and the results into perspective, both methods have their own justification:

- Project-based activities detach lessons from curricular obligations and place less of a burden on subjects and topics that are relevant to exams. Even many students can be integrated in a short period of time with little organizational effort (see e.g. Wegner, Peperkorn, & Dumcke, 2020, with 5 stations).
- In addition to the material and room requirements of simultaneous conducted BLS activities, the pedagogical benefit of subject-matter teaching must be considered: cognitive and self-reflective instruction can be reliably integrated (see materials e.g. Dumcke, Rahe-Meyer, & Wegner, 2023 for biology).

The preliminary solution to reduce concerns (Dumcke, Rahe-Meyer, & Wegner, 2019; Wingen et al., 2021) and deficits in learning is to creatively include the content of BLS into mandatory elements of the curriculum. When a subject-specific method should be built (e.g. writing a report), BLS can be its content dimension. Thus, curriculum goals and BLS implementation at the same time must not contradict each other.

Figure 7 shows a possible application of both methods across school years 5-10 considering an increasing and/or alternating level of complexity. The alternating implementation of subject-integrated (6th grade, biology), cognitive-reflective sequences and skill-focused project activities (9th grade, themed day) may be a viable proposal. Following this path, annual repetitions also operate the action memory considered important to develop routine (Lukas et al., 2016; Schroeder et al., 2023).

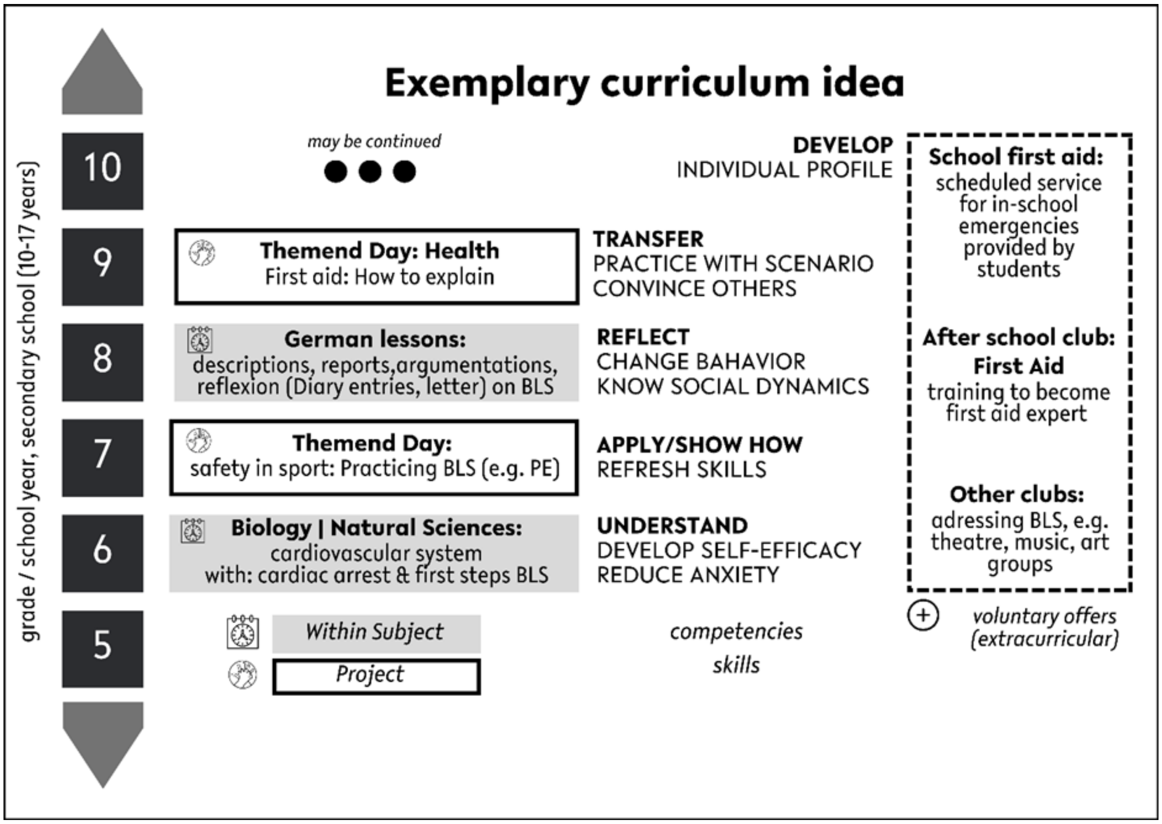


Figure 7: Prospective conversion of both methods into a secondary curriculum.

Limitations

The study has limitations. First, due to COVID-19 regulations and infections, the calculated sample size per group was not reached in TG, which may subsequently have resulted in missed detection of significant differences at medium effect sizes. A second weakness is partly unsatisfactory internal consistency (Schmitt, 1996) for some subscales. However, the intraclass coefficient may be also achieved by other desirable properties according to Schmitt (1996, p. 352) and Schecker (2014, p. 5) as it is no indicator of homogeneity (=unidimensionality). Homogeneity was assumed by using (adopted) validated and established instruments. Regarding QCM scales (probability of success, anxiety) and CLI intrinsic cognitive load, we assume that due to the novelty of the issue BLS, the students lacked a benchmark for assessment and that variance reduced the consistency of the scales. We decided to retain them either way. The operationalization of outcome expectations (BLS OE) was complex (Dumcke et al., 2021a) and broad content coverage was reasonably preferred over consistency (cf. Schmitt, 1996) – because as shown in BLS literature, relevant factors originate from many dimensions (e.g. Becker et al., 2019; for students: Smedt et al., 2018). The s-FCI scales self-determined, active, situated showed discriminatory power higher than .40 and were retained for correct didactic coverage. However, semantic misunderstandings may occur, because BLS was not understood as something useful for “everyday life”, as one item for situatedness stated (if deleted, α = .78).

Thirdly, by cluster randomization per class biased nested data must be considered. However, it is unlikely to occur because the content of the intervention was new to all of the students. Furthermore, we deleted risk factors: a) compensatory equivalization by the same instructors over both groups and in all classes, b) resentful demoralization by not announcing treatment and control assignments and c) practical inequality by applying same core exercises (e.g. manikin practice) to both groups.

Nevertheless, to enhance study power and generalizability, the concept can be re-evaluated and upscaled including more schools on meso-level to reduce c-RCT effect and to identify general practicability under alternating local conditions.

References

Anderson, T., & Shattuck, J. (2012). Design-Based Research. *Educational Researcher*, 41(1), 16–25. https://doi.org/10.3102/0013189X11428813

Ateş, C., Kaymaz, Ö., Kale, H. E., Tekindal, M. A., & Zhao, Y. (2019). Comparison of Test Statistics of Nonnormal and Unbalanced Samples for Multivariate Analysis of Variance in terms of Type-I Error Rates. *Computational and Mathematical Methods in Medicine*, 2019, 2173638. https://doi.org/10.1155/2019/2173638

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, 84(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Basten, M., Greiff, S., Marsch, S., Meyer, A., Urhahne, D., & Wilde, M. (2015). Kurzskala zur Messung gemäßigt konstruktivistischer Prozessmerkmale (Kurz-PgK) im Biologieunterricht. In D. Krüger, P. Schmiemann, A. Möller, A. Dittmer, & L. Kotzebue (Eds.), Erkenntnisweg Biologiedidaktik 14 (pp. 43–57).

Beck, S., Issleib, M., Daubmann, A., & Zollner, C. (2015). Peer education for BLS-training in schools? Results of a randomized-controlled, noninferiority trial. *Resuscitation*, 94, 85–90. https://doi.org/10.1016/j.resuscitation.2015.06.026

Becker, T. K., Gul, S. S., Cohen, S. A., Maciel, C. B., Baron-Lee, J., Murphy, T. W., . . . Alviar, C. L. (2019). Public perception towards bystander cardiopulmonary resuscitation. *Emergency Medicine Journal: EMJ*, 36(11), 660–665. https://doi.org/10.1136/emermed-2018-208234

Bortz, J., & Döring, N. (2016). *Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften* (5. vollständig überarbeitete, aktualisierte und erweiterte Aufl.). Springer-Lehrbuch Bachelor, Master. Heidelberg: Springer-Medizin-Verl.

Böttiger, B. W., Semeraro, F., & Wingen, S. (2017). "Kids Save Lives": Educating Schoolchildren in Cardiopulmonary Resuscitation Is a Civic Duty That Needs Support for Implementation. *Journal of the American Heart Association*, 6(3), e005738. https://doi.org/10.1161/JAHA.117.005738

Brown, L. E., Lynes, C., Carroll, T., & Halperin, H. (2017). Cpr Instruction in U.S. High Schools: What Is the State in the Nation? *Journal of the American College of Cardiology*, 70(21), 2688–2695. https://doi.org/10.1016/j.jacc.2017.09.1101

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design Experiments in Educational Research. *Educational Researcher*, 32(1), 9–13. https://doi.org/10.3102/0013189X032001009

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2. ed.). [Hillsdale, NJ u.a.]: Erlbaum.

Creswell, J. W., & Plano Clark, V. L. (2007). *Designing and conducting mixed methods research*. Thousand Oaks: SAGE Publ.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (Third edition). Thousand Oaks, California: SAGE.

The DBR Collective (2003). Design-Based Research: An Emerging Paradigm for Educational Inquiry. *Educational Researcher*, 32(1), 5–8. https://doi.org/10.3102/0013189X032001005

Dumcke, R., Rahe-Meyer, N., & Wegner, C. (2019). Wiederbelebung im Biologieunterricht: Was passiert bei der Herzdruckmassage im menschlichen Brustkorb? Vorstellung eines Funktionsmodells. *MNU Journal.* (6), 451–455.

Dumcke, R., Rahe-Meyer, N., & Wegner, C. (2021a). Does age still matter? An age-group comparison of self-efficacy, initial interest and performance when learning bystander resuscitation in secondary schools. *International Journal of First Aid Education,* 4(1), 5–22. Retrieved from https://oaks.kent.edu/node/14543

Dumcke, R., Rahe-Meyer, N., & Wegner, C. (2021b). Self-efficacy and outcome expectancies of secondary school students in performing basic life support. *Journal of Health, Environment, & Education,* 13, 1–12. https://doi.org/10.18455/13001

Dumcke, R., Rahe-Meyer, N., & Wegner, C. (2023). Wenn die "Pumpe" schlapp macht: Drei Kreislauferkrankungen mit Fallbeispielen erkennen. *Schulmagazin* 5-10. (3/4), 76–78.

Dumcke, R., Wegner, C., Böttiger, B. W., Kucknat, L., & Rahe-Meyer, N. (2019). The process of implementing cardiopulmonary resuscitation training in schools: A review of current research. *Journal of Innovation in Psychology, Education and Didactics* (JIPED), 23(2), 141–166.

Dumcke, R., Wegner, C., & Rahe-Meyer, N. (2021). Die Implementierung von Reanimationsunterricht: Eine Befragung von Biologielehrkräften zu Einflussfaktoren und Gelingensbedingungen. *HeiEDUCATION Journal*, 7(1), 143–175. https://doi.org/10.17885/heiup.heied.2021.7.24443

Einsiedler, W. (2010). Didaktische Entwicklungsforschung als Transferförderung. *Zeitschrift Für Erziehungswissenschaft*, 13(1), 59–81. https://doi.org/10.1007/s11618-010-0106-y

Fasbender, U. (2018). Outcome Expectancies. In V. Zeigler-Hill & T. K. Shackelford (Eds.), *Encyclopedia of Personality and Individual Differences* (Vol. 64, pp. 1–3). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-28099-8_1802-1

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39(2), 175–191. https://doi.org/10.3758/BF03193146

Felzen, M., Lambrecht, L., Beckers, S. K., Biermann, H., Heussen, N., Rossaint, R., & Lenssen, N. (2018). Konzept und Evaluation eines 45-minütigen BLS-Trainings an Schulen. *Notfall + Rettungsmedizin,* 83(5), 619. https://doi.org/10.1007/s10049-017-0404-5

Fischer, F., Waibel, M., & Wecker, C. (2005). Nutzenorientierte Grundlagenforschung im Bildungsbereich. *Zeitschrift Für Erziehungswissenschaft,* 8(3), 427–442. https://doi.org/10.1007/s11618-005-0149-7

Fishman, B. J., Penuel, W. R., Allen, A.-R., Cheng, B. H., & Sabelli, N. (2013). Design-Based Implementation Research: An Emerging Model for Transforming the Relationship of Research and Practice. In National Society for the Study of Education (Ed.), *Yearbook of the National Society for the Study of Education: 112(2). Design-based Implementation Research: Theories, Methods, and Exemplars* (pp. 136–156). New York: Teachers College, Columbia University.

Gräsel, C. (2010). Stichwort: Transfer und Transferforschung im Bildungsbereich. *Zeitschrift Für Erziehungswissenschaft,* 13(1), 7–20. https://doi.org/10.1007/s11618-010-0109-8

Groß, R., Böttiger, B. W., & Thaiss, H. M. (2019). Laienreanimation in Deutschland: Das Nationale Aktionsbündnis Wiederbelebung (NAWIB). *Notfall + Rettungsmedizin,* 22(8), 715–722. https://doi.org/10.1007/s10049-019-0615-z

Hahs-Vaughn, D. L. (2016). *Applied Multivariate Statistical Concepts.* New York, NY: Routledge. https://doi.org/10.4324/9781315816685

Hemmerich, W. (2018). *Online-Calculator: Stichprobengröße für die einfaktorielle ANOVA berechnen.* Retrieved from https://statistikguru.de/rechner/stichproben groesse-einfaktorielle

Iserbyt, P. (2016). The effect of Basic Life Support (BLS) education on secondary school students' willingness to and reasons not to perform BLS in real life. *Acta Cardiologica*, 71(5), 519–526. https://doi.org/10.2143/AC.71.5.3167494

Kanstad, B. K., Nilsen, S. A., & Fredriksen, K. (2011). Cpr knowledge and attitude to performing bystander CPR among secondary school students in Norway. *Resuscitation*, 82(8), 1053–1059. https://doi.org/10.1016/j.resuscitation.2011.03.033

Kelly, A. E. (2013). When is Design Research Appropriate? In T. Plomp & N. Nieveen (Eds.), *Educational design research: An introduction* (pp. 134–151). Enschede, the Netherlands: SLO.

Klepsch, M., Schmitz, F., & Seufert, T. (2017). Development and Validation of Two Instruments Measuring Intrinsic, Extraneous, and Germane Cognitive Load. *Frontiers in Psychology,* 8, 1997. https://doi.org/10.3389/fpsyg.2017.01997

Krapp, A. (1998). Entwicklung und Förderung von Interessen im Unterricht. *Psychol., Erz., Unterr.*, 44, 185–201.

QCPR Instructor App (Version 3.13.1) [Computer software] (2021). *Stavanger* (Norway): Laerdal Medical: Laerdal Medical. Retrieved from https://laerdal.com/de/products/simulation-training/resuscitation-training/qcpr-app/

Leppink, J., Paas, F., van der Vleuten, C. P. M., van Gog, T., & van Merriënboer, J. J. G. (2013). Development of an instrument for measuring different types of cognitive load. *Behavior Research Methods,* 45(4), 1058–1072. https://doi.org/10.3758/s13428-013-0334-1

Lienert, G. A., & Raatz, U. (1998). *Testaufbau und Testanalyse* (6. Aufl., Studienausg). Weinheim: Beltz, Psychologie-Verl.-Union.

Lukas, R.-P., van Aken, H. K., Molhoff, T., Weber, T., Rammert, M., Wild, E., & Bohn, A. (2016). Kids save lives: A six-year longitudinal study of schoolchildren learning cardiopulmonary resuscitation: Who should do the teaching and will the effects last? *Resuscitation*, 101, 35–40. https://doi.org/10.1016/j.resuscitation.2016.01.028

Malta Hansen, C., Zinckernagel, L., Ersboll, A. K., Tjornhoj-Thomsen, T., Wissenberg, M., Lippert, F. K., . . . Folke, F. (2017). Cardiopulmonary Resuscitation Training in Schools Following 8 Years of Mandating Legislation in Denmark: A Nationwide Survey. *Journal of the American Heart Association,* 6(3), e004128. https://doi.org/10.1161/JAHA.116.004128

Meissner, T. M., Kloppe, C., & Hanefeld, C. (2012). Basic life support skills of high school students before and after cardiopulmonary resuscitation training: A longitudinal investigation. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine,* 20, 31. https://doi.org/10.1186/1757-7241-20-31

Mpotos, N., & Iserbyt, P. (2017). Children saving lives: Training towards CPR excellence levels in chest compression based on age and physical characteristics. *Resuscitation,* 121, 135–140. https://doi.org/10.1016/j.resuscitation.2017.10.024

MSB NRW (2019). *Kernlehrplan für die Sekundarstufe I Gymnasium in Nordrhein-Westfalen [Curriculum for the lower secondary education level Gymnasium North-Rhine-Westphalia]: Biologie* [Biology]. Retrieved from https://www.schulentwicklung.nrw.de/lehrplaene/lehrplan/197/g9_bi_klp_%203413_2019_06_23.pdf

Olasveengen, T. M., Semeraro, F., Ristagno, G., Castren, M., Handley, A., Kuzovlev, A., . . . Perkins, G. D. (2021). European Resuscitation Council Guidelines 2021: Basic Life Support. *Resuscitation,* 161, 98–114. https://doi.org/10.1016/j.resuscitation.2021.02.009

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive Load Theory and Instructional Design: Recent Developments. *Educational Psychologist*, 38(1), 1–4. https://doi.org/10.1207/S15326985EP3801_1

Plant, N., & Taylor, K. (2013). How best to teach CPR to schoolchildren: A systematic review. *Resuscitation,* 84(4), 415–421. https://doi.org/10.1016/j.resuscitation.2012.12.008

Plomp, T. (2013). Educational Design Research: An Introduction. In T. Plomp & N. Nieveen (Eds.), *Educational design research: An introduction* (pp. 10–51). Enschede, the Netherlands: SLO.

Reinmann, G. (2005). Innovation ohne Forschung? Ein Plädoyer für den Design-Based-Research-Ansatz in der Lehr-Lernforschung. *Unterrichtswissenschaft,* 33(1), 52–69.

Reinmann, G., & Mandl, H. (2006). Unterichten und Lernumgebungen gestalten. In A. Krapp & B. Weidenmann (Eds.), *Lehrbuch. Pädagogische Psychologie: Ein Lehrbuch* (5th ed., pp. 615–658). Weinheim [u.a.]: Beltz, PVU.

Renkl, A. (2015). Wissenserwerb. In E. Wild & J. Möller (Eds.), *Springer-Lehrbuch. Pädagogische Psychologie* (Vol. 16, pp. 3–24). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-41291-2_1

Renninger, K. A., & Hidi, S. (2011). Revisiting the Conceptualization, Measurement, and Generation of Interest. *Educational Psychologist,* 46(3), 168–184. https://doi.org/10.1080/00461520.2011.587723

Rheinberg, F., & Vollmeyer, R. (2012). *Motivation* (8., aktualisierte Aufl.). Grundriss der Psychologie: Band 6, Ed. 8. Stuttgart: Kohlhammer.

Rheinberg, F., Vollmeyer, R., & Burns, B. D. (2001). FAM: Ein Fragebogen zur Erfassung aktuller Motivation in Lern- und Leistungssituationen. *Diagnostica,* 47(2), 57–66. https://doi.org/10.1026//0012-1924.47.2.57

Rücker, G., Wingen, S., Rott, N., & Böttiger, B. W. (2022). Der aktuelle Umsetzungsstand von Wiederbelebungsunterricht in Schulen in Deutschland – Umfrageergebnisse einer Abfrage der Ministerien aller Bundesländer. *Notfall + Rettungsmedizin*. Advance online publication. https://doi.org/10.1007/s10049-022-01010-2

Schecker, H. (2014). Überprüfung der Konsistenz von Itemgruppen mit Chronbachs α (Online-Zusatzmaterial). In D. Krüger, I. Parchmann, & H. Schecker (Eds.), *Lehrbuch. Methoden in der naturwissenschaftsdidaktischen Forschung* (pp. 1–7). Berlin [u.a.]: Springer Spektrum. Retrieved from http://static.springer.com/sgw/documents/1426184/application/pdf/Cronbach+Alpha.pdf

Schiefele, U., & Schaffner, E. (2015). Motivation. In E. Wild & J. Möller (Eds.), *Springer-Lehrbuch. Pädagogische Psychologie* (Vol. 64, pp. 153–175). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-41291-2_7

Schmiedebach, M., & Wegner, C. (2021). Design-Based Research als Ansatz zur Lösung praxisrelevanter Probleme in der fachdidaktischen Forschung. *Bildungsforschung,* 19(2).

Schmitt, N. (1996). Uses and Abuses of Coefficient Alpha. *Psychological Assessment*, 8(4), 350–353.

Schroeder, D. C., Ecker, H., Wingen, S., Semeraro, F., & Böttiger, B. W. (2017). „Kids Save Lives" – Wiederbelebungstrainings für Schulkinder: Systematische Übersichtsarbeit ["Kids Save Lives"-resuscitation training for schoolchildren: Systematic review]. *Der Anaesthesist,* 66(8), 589–597. https://doi.org/10.1007/s00101-017-0319-z

Schroeder, D. C., Semeraro, F., Greif, R., Bray, J., Morley, P., Parr, M., . . . Böttiger, B. W. (2023). Kids SAVE LIVES: Basic Life Support Education for Schoolchildren: A Narrative Review and Scientific Statement From the International Liaison Committee on Resuscitation. *Resuscitation,* 109772. https://doi.org/10.1016/j.resuscitation.2023.109772

Sharma, D., & Kibria, B. M. G. (2013). On some test statistics for testing homogeneity of variances: a comparative study. *Journal of Statistical Computation and Simulation,* 83(10), 1944–1963. https://doi.org/10.1080/00949655.2012.675336

Smedt, L. de, Depuydt, C., Vekeman, E., Paepe, P. de, Monsieurs, K. G., Valcke, M., & Mpotos, N. (2018). Awareness and willingness to perform CPR: A survey amongst Flemish schoolchildren, teachers and principals. *Acta*

Clinica Belgica, 1–20. https://doi.org/10.1080/17843286.2018.1482087

Sweller, J. (2003). Evolution of human cognitive architecture. In *Psychology of Learning and Motivation*. (Vol. 43, pp. 215–266). Elsevier. https://doi.org/10.1016/S0079-7421(03)01015-6

Urhahne, D., Marsch, S., Wilde, M., & Krüger, D. (2011). Die Messung konstruktivistischer Unterrichtsmerkmale auf der Grundlage von Schülerurteilen. *Psychologie in Erziehung Und Unterricht,* 58(2), 116–127. https://doi.org/10.2378/peu2011.art06d

Verma, J. P. (2016). *Repeated measures design for empirical researchers* (1st ed.). Hoboken, New Jersey: John Wiley & Sons, Inc. Retrieved from https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=1896010

Wegner, C., Peperkorn, C., & Dumcke, R. (2020). Reanimation und Erste Hilfe: Laienreanimation in der Schule als Stationentraining umsetzen. [Resuscitation and first aid: Implementing bystander resuscitation as a learning circle]. *Schulmagazin* 5-10, 2020(10), 40–49.

Wingen, S., Jeck, J., Schroeder, D. C., Wingen-Heimann, S. M., Drost, R. M. W. A., & Böttiger, B. W. (2021). Facilitators and barriers for the implementation of resuscitation training programmes for schoolchildren: A systematic review. *European Journal of Anaesthesiology*. Advance online publication. https://doi.org/10.1097/EJA.0000000000001643

Wingen, S., Schroeder, D. C., Ecker, H., Steinhauser, S., Altin, S., Stock, S., . . . Böttiger, B. W. (2018). Self-confidence and level of knowledge after cardiopulmonary resuscitation training in 14 to 18-year-old schoolchildren: A randomised-interventional controlled study in secondary schools in Germany. *European Journal of Anaesthesiology*, 35(7), 519–526. https://doi.org/10.1097/EJA.0000000000000766

Wissenberg, M., Lippert, F. K., Folke, F., Weeke, P., Hansen, C. M., Christensen, E. F., . . . Torp-Pedersen, C. (2013). Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. *JAMA,* 310(13), 1377–1384. https://doi.org/10.1001/jama.2013.278483

Zinckernagel, L., Malta Hansen, C., Rod, M. H., Folke, F., Torp-Pedersen, C., & Tjornhoj-Thomsen, T. (2016). What are the barriers to implementation of cardiopulmonary resuscitation training in secondary schools? A qualitative study. *BMJ Open,* 6(4), e010481. https://doi.org/10.1136/bmjopen-2015-010481